Volume 97, n. 2

Marzo - Aprile 2006

Rivista fondata nel 1901
da Luigi Devoto

Issn 0025 - 7818

La Medicina del Lavoro

RIVISTA BIMESTRALE DI MEDICINA DEL LAVORO E IGIENE INDUSTRIALE
ITALIAN JOURNAL OF OCCUPATIONAL HEALTH AND INDUSTRIAL HYGIENE

REDAZIONE La Medicina del Lavoro
Clinica del Lavoro «L. Devoto»
Via San Barnaba, 8 - 20122 Milano (Italy)
Tel. 02/50320125 - Fax 02/50320126

CASA EDITRICE Mattioli 1885 spa - Casa Editrice
Via Coduro, 1/b - 43036 Fidenza (PR)
Tel. 0524/84547 - Fax 0524/84751
e-mail: edit@mattioli1885.com
www.mattioli1885.com (CCP N. 11.286.432)

Associato
all'Unione Stampa
Periodica Italiana

Pubblicazione bimestrale
Direttore Responsabile Prof. Vito Foà
Autorizzazione del Presidente
del Tribunale di Milano 10/5/1948 - Reg. al N. 47

La Medicina del Lavoro è recensita su:
Index Medicus/MEDLINE; Embase/Excerpta Medica; Abstracts on Hygiene; Industrial Hygiene Digest; Securité et Santé au Travail Bit-CIS; Sociedad Iberoamericana de Informaciòn Cientifica (SIIC)

LA MEDICINA DEL LAVORO

WITH THE PATRONAGE OF:

International Labour Organization

World Health Organization

European Commission

Presidenza del Consiglio dei Ministri

Ministero della Salute

Ministero del Lavoro
e delle Politiche Sociali

Ministero dell'Istruzione dell'Università e della Ricerca

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ICOH
International Commission on Occupational Health

SIMLII

ISPESL
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CIIP
Consulta Interassociativa Italiana per la Prevenzione

U.N.A.M.S.I.
Unione Nazionale Medico Scientifica di Informazione

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MILANO

Med Lav 2006; *97*, 2: 95-97

Contents

99 Introduction *V. Foà, J. Rantanen*

100 Concerning the First International Congress on Work-related Illnesses - Milan 9-14 June 1906: Success - News - Reports - Motions *F. Carnevale, A. Baldasseroni, Valentina Guastella, L. Tomassini*

114 Some contribution from the doctor of the miners in the Simplon tunnel *G. Volante*

Monday - June, 12 2006

125 Plenary
- OHS and globalisation, challenges for today *J.L. Marié*
- The changing nature of work: workplace stress and strategies to deal with it *C.L. Cooper*

137 Semi Plenary
- Aging and globalization *D.H. Wegman*
- Towards a longer and better working life: a challenge of work force ageing *J. Ilmarinen*
- Social protection sustainability, prolongation of working life and greater participation of women in the labour market *M. Barea, G. Cesana*
- Occupational inequalities in health: do occupational risks matter? *G. Costa, A. D'Errico*
- Psychological well-being and work attitudes across a range of employment status categories *S. Anderson, A. Winefield, P. Delfabbro, M. Dollard, J. Metzer, S. Trainor, J. Saebel*
- Emerging aspects of psychosocial risk: violence and harassment at work *R. Gilioli, P. Campanini, G.P. Fichera, S. Punzi, M.G. Cassitto*
- The longer term health impact of war service *M. Sim*
- Evaluation of scientific evidence in law, adjudication and policy: when occupational health takes the witness chair *T.L. Guidotti*

Tuesday - June, 13 2006

175 Plenary
- Prioritizing future resources for epidemiologic research on old and newly emerging occupational hazards *H. Checkoway*
- Work-related musculoskeletal disorders: is the burden equitably distributed? *Laura Punnet*
- Health risks of exposure to non-ionizing radiation - Myths or science-based evidence *Maila Hietanen*

189 Semi Plenary
- Is occupational epidemiology necessary in poor countries? *D. Rees, I. Wesseling, R. Loewenson*
- Epidemiology in risk management for chemicals *D. Coggon*

- Refining the focus of construction injury surveillance *Judith Glazner, Hester Lipscomb, Jessica Bondy*
- Recent developments in human biomonitoring: non-invasive assessment of target tissue dose and effects of pneumotoxic metals *A. Mutti, M. Corradi*
- Nurses' health, age and the wish to leave the profession – findings from the European NEXT-Study *H-M. Hasselhorn, P. Tackenberg, Angelika Kuemmerling, J. Wittenberg, M Simon, P.M. Conway, P.A. Bertazzi, Beate Beermann, A. Büscher, Donatella Camerino, J.F. Caillard, W. D'hoore, Madeleine Estryn-Behar, Marina Fontenla, Dinah Gould, Beate van der Heijden, Malin Josephson, P. Kiss, Maria Kovarova, K. Kuhn, Marjukka Laine, O. Le Nezet, P. Lindberg, Halszka Oginska, J. Pokorski, Joanna Pokorska, P. Radkiewicz, M. Rimarcik, Esther van der Schoot, Stephanie Stelzig, Sabine Stordeur, G. Wickstroem, Maria Widerszal-Bazyl, B.H. Mueller*
- Risks of occupational exposure to optical radiation *D.H. Sliney*
- Mobile phones. Precautionary options *D.R. Black*
- The development of clinical prediction guides requires reproducible decision-making outputs: a field study *G. Franco, A. Franchi*

Wednesday - June, 14 2006

233 PLENARY
- The new structure and contents of employers' juridical responsibility for workers' health and safety in the post-industrial system *P. Ichino*
- Integrating Occupational Health, safety and worksite health promotion: opportunities for research and practice *G. Sorensen, Elizabeth M. Barbeau*

258 SEMI PLENARY
- The stress-disequilibrium theory: chronic disease development, low social control, and physiological de-regulation *R. Karasek*
- Cardiovascular risk as a paradigm of the negative consequences of stress at work: a large amount of data and huge problems *G. Cesana, Cristina Menni*
- Work and cardiovascular disease *P.L. Schnall*
- Flexibility of working hours in the 24-hour society *G. Costa*
- Occupational Health and general practice: from opportunities lost to opportunities capitalised? *C. van Weel, Karin Orbon, J. van der Gulden, P. Buijs, H. Folgering, B. Thoonen, T. Schermer*
- The occupational physician and chemical disasters: old problem, new threats *S.W. Borron*
- Low-cost risk reduction strategy for small workplaces: how can we spread good practices? *K. Kogi*

Thursday - June, 15 2006

313 PLENARY
- The contribution of occupational risks to the global burden of disease: summary and next steps *Marilyn Fingerhut, Deborah Imel Nelson, T. Driscoll, Marisol Concha-Barrientos, Kyle Steenland, Laura Punnett, Annette Prüss-Üstün, J. Leigh, C. Corvalan, G. Eijkemans, J. Takala*
- Toxicogenomics and environmental diseases: the search for biomarkers predictive of adverse effects *R.S. Paules*

324 **Semi Plenary**
- Guidance values for the biomonitoring of occupational exposure to metals. State of the art *A. Aitio*
- Behavioral toxicology: from historical background to future trends *A. Iregren*
- Framework for considering genetics in the workplace *P.A. Shulte*
- A harmonised approach to setting OEL's *F. Fox*
- Occupational hygiene: where from and to? *M.P. Guillemin*
- Low-dose occupational exposure to asbestos and lung cancer risk *P. Gustavsson, M. Albin*
- CASH - An innovative approach to sustainable OSH improvement at workplace *S. Pingle, S. Shanbhag*

Friday - June, 16 2006

369 **Plenary**
- Lessons from SARS in an age of emerging infections *Peng Lim Ooi, S. Lim, K.W. Tham*
- Is globalisation outpacing ethics and social responsibility in occupational health? *Kuku Voyi*
- The scientific basis of a total asbestos ban *B. Terracini*

393 **Semi Plenary**
- From clinical activities to didactics and research in Occupational Medicine *L. Alessio, Michela Crippa, S. Porru, R. Lucchini, Donatella Placidi, O. Vanoni, D. Torri*
- Emerging opportunities to prevent occupational lung disease *Kathleen Kreiss*
- Occupational asthma *Cristina E. Mapp, Deborah Miotto, Piera Boschetto*
- Indoor air quality and health in offices and other non-industrial working environments *G. Abbritti, G. Muzi*
- The emerging infectious disease *M. Moroni*
- Occupational Health and Safety in agriculture: situation and priorities at the beginning of the third millennium *P. Bulat, Chiara Somaruga, C. Colosio*
- Risk assessment and management of occupational exposure to pesticides in agriculture *M. Maroni, Anna Clara Fanetti, Francesca Metruccio*
- The occupational physician in the post-modern world *R. Facci*

Med Lav 2006; *97*, 2: 99

Introduction

The 1906 "Universal Exhibition" - the world's fair celebrating the achievements of human ingenuity in science, technology and arts - was organized in Milan, Italy. That exhibition was marked by a special event: the official opening of the Simplon tunnel linking Milan to Switzerland and France, an astonishing success of the work of man, which however took a heavy toll in terms of number of deaths, injuries and diseases among the workers. A group of physicians and scientists, concerned of these consequences, decided to convene an international meeting on occupational health and safety devoted to three main issues: work-related physiology, pathology and hygiene; prevention of work-related diseases; and social assistance. 300 delegates attended the Congress which was closed on 13 June 1906 with the creation of the International Permanent Commission on Occupational Health, currently known as the International Commission on Occupational Health, ICOH. Aim of the Commission was to promote research on occupational diseases worldwide and disseminate the available knowledge to the entire scientific community, to physicians, employers and workers. To achieve these goals it was further decided to regularly hold a congress every three years. In 2006, a century after its foundation, the ICOH will organize, on the very same dates (11-16, June), its 28th International Congress back in its birthplace, Milan, Italy. During these one hundred years, significant improvements in working conditions have been achieved, and certainly occupational health professionals have contributed thereto. At present however, the occupational health community must tackle new problems the solution of which requires new research, new methods and new practices. Changes in the world economy, the process of globalization, new technologies, different types of employment and work contracts constantly affect health and safety at work. Small and medium-sized enterprises and the self employed do not often have the necessary financial and technical resources to adequately assess risks and ensure appropriate protection. Developing countries and countries in transition lack access to those services that would be required to assess and control occupational hazards. Against this background, and given the current scenario, for its 2006 Centennial Congress the ICOH coined the motto "Renewing a century of commitment to a healthy, safe, and productive working life", thereby emphasising its dedication to responding to the new century's challenges. ICOH members are determined to co-operate in the field of research and in practice to ensure healthy and safe work environments to the workers throughout the world and intend to do so by following the principles of sound science, excellent practice and highest professional and ethical standards. We believe that, in so doing, we will also contribute to eliminate poverty caused by unnecessary, preventable occupational diseases and injuries, promote the development of work ability and improve productivity.

In this issue of *La Medicina del Lavoro* the invited lectures delivered in plenary and semiplenary sessions of the Congress are hereby collected and offered to our readers and to all the participants of the 28th ICOH Congress. In such a way they will represent a point of reference, dated 2006, of each up-dated theme which were discussed during the entire week of work.

A comment and review of the first 1906 Congress on Occupational Diseases introduce the collection of the printed lectures together with three short papers written by Dr. Giuseppe Volante who was the physician taking care of the workers at the South part of the Simplon tunnel.

Vito Foà
President of 28th ICOH Congress

Jorma Rantanen
President of ICOH

La Medicina del Lavoro

Med Lav 2006; *97*, 2: 100-113

Concerning the First International Congress on Work-related Illnesses - Milan 9-14 June 1906: Success - News - Reports - Motions(1)

F. Carnevale, A. Baldasseroni, Valentina Guastella*, L. Tomassini*

Health Agency Florence

* University of Bologna

A successful Congress

There were many significant reasons for the extraordinary success of the First International Congress on Work-Related Illnesses, first and foremost the demands being made by the workers themselves who were represented both by political parties and trades unions; indeed the Confederation of Labour was officially established in Milan in 1906 (Pepe, Iuso and Loreto, 2003).

The context was also being fostered by the slow inexorable development of the various national welfare organisations which in those years were all in the future. It was also helped by a feeling shared by European nations that they were dealing with issues on safeguarding working class living conditions through the "Association Internationale pour la Protection Légale des Travailleurs". Social security, the modern day form of mutual aid against the general risks faced by the working classes which had been promoted by the more enlightened governments (Musso, 1999) was yet unborn and still embryonic. From the 1880s onwards, several international congresses had been held on these issues in various European countries, in particular Switzerland, France, Belgium, Germany and Italy.

Significant strides forward had also been made in insurance coverage against work risks, first and foremost injuries, also through the most enlightened industrialist associations. In Italy, "The Association for Medical Assistance for Work-Related Injuries" was established in Milan in 1894 by industrialists like Senator De Angeli and a number of engineers who were establishing firm contacts throughout Europe. The first "Congrès International des Accidents du Travail et des Assurances Sociales" was held in Paris in 1889 and other congresses followed, mainly every three years and then in Milan in 1894. These congresses debated the technical aspects of machinery safety, industrial hygiene and the economic and political aspects of protective legislation to be adopted at national level but which had to be harmonized among all the industrialised countries. Again in Milan at the Blue-Collar Work Exhibition of 1894, De Angeli decided to exhibit the machinery and production processes for preventing injury of his factory at the Maddalena (Vergine, 2004).

Caught between reform and demands for social renewal, doctors working on workers' health had still not managed to make their voice heard more clearly or directly since they were more often having to side either with industrialists or with workers' organizations instead of being actors in a specific and important sphere of science.

The congress of Milan marked the beginning of an independent discipline and science in the study

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(1) This paper is part of a broader ongoing research project on the origins and development of the Employment Inspectorate in Italy, which is partly funded by ISPESL

of professional illnesses which, insofar as was possible, launched a debate unfettered by political contexts or national peculiarities such as had been the case, for example, in Victorian-Edwardian England. The strength of the small group of doctors behind the initiative lay in being able to prove that the issue of workers' health protection actually existed and then being able to sway how politics addressed it. This strength was amply confirmed especially at international level by how it affected the development of the scientific bases used by the League of Nations and then the International Labour Organization in promoting policies to safeguard health at the workplace.

Hereunder are reported a series of original statements taken from the Acts of the congress or from preparatory material in the annals of "Il Lavoro" of 1905 and 1906. The numerous citations which for simplicity's sake do not have the corresponding number of the page of the Acts (Atti, 1906), serve to shed light on less well-known but equally important scientific issues addressed in the notifications. In particular, we think that the motions proposed and carried by congress participants are very interesting. They give a complete picture of the problems that doctors involved in workers' health felt most strongly about. They also point to a still intact belief in scientific "truths", namely the scientific evidence produced in a series of reports which, it was deemed, would be able to promote social legislation and spur the legislator. Within a few short years the stupidity of World War I and its unspeakable carnage brought that season of reforming optimism and unquestioned faith in the force of scientific reasoning to a close (Carnevale and Baldasseroni, 1999).

In reporting the facts of the Congress, we have taken into account the opinions expressed by only a few direct witnesses who recorded their impressions immediately (Anon, 1906; Anon, 1906a; d. s. b., 1906; Giglioli, 1907) or later (Devoto, 1928). The direct writings on the congress or about people like Devoto and De Cristoforis, by a few contemporary authors (Berlinguer, 1997; Carnevale e Baldasseroni, 2002; Forti Messina, 2003) are interesting.

NEWS FROM THE CONGRESS

It is evening on 13 April 1902 at the social event hosted by the Milan city council for the members of the "7th National Congress of Hydrology and Climatology"; *The hon. De Cristoforis welcomed guests and drew the attention of one and all to the magnificent event of quite recent times:, the Simplon tunnel, which would open new avenues to benefit the grand flows of civilisation and become the grand avenue for people foreseen by Cattaneo, and destined yet to claim more victims from among those who go to work there. I cannot find it within myself to drink a toast, he added, but instead I feel in my heart a thought I wish to share with you all. It seems to me that the best way to celebrate this great triumph of labour which will be built on not a few victims will be to invite all those in Italy and elsewhere who study and have studied clinical and hygiene issues related to work to an international congress.*

The first meeting of the congress "Promoting Committee" established immediately by the president by acclamation Prof. Malachia De Cristoforis, with its location assigned by the city council of Milan in via Filodrammatici, 16, was held on 5 May 1902. *This gathering was addressed by many illustrious citizens including Senator De Angeli, who proposed setting up a special session on prevention and social assistance*. The complete list of the "Promoting Committee of the Congress" makes very interesting reading: *Dr. Garibaldi Arcellaschi, Milan – Dr. Prof. Pietro Avoledo, Milan – Ing. Luigi Baseggio, Milan – Ing. Luigi Belloc, Rome – Dr. Luigi Bernacchi, Milan – Dr. Ambrogio Bertarelli, Milan – Cav. Luigi Bertarelli, Milan – Dr. Carlo Biaggi, Milan – Dr. Prof. Guido Bordoni Uffreduzzi, Milan – Dr. L. C. Burgonzio, Milan – Ms. Elisa Boschetti, Milan – Ing. Giuseppe Camperio, Milan – Dr. Ettore Candiani, Milan – Mr. Costanzo Cantoni, Milan – Avv. Corrado Carabelli, Milan – Dr. Luigi Carozzi, Milan – Hon. Prof. Angelo Celli, Rome – Avv. Angelo Confalonieri, Milano – Sen. Ernesto De Angeli, Milan – Sen. Dr. Malachia De Cristoforis, Milan – Hon. Carlo Dell'Acqua, Legnano – Prof. Dr. Francesco Denti, Milan - Prof. Enrico De Renzi, Naples – Dr. Angelo De Vincenti, Milan – Prof. Luigi Devoto, Milan – Dr. Lorenzo Ellero, Milan –- Ing. Carlo Esterle,* *Milan – Dr. Riccardo Fabris, Milan – Prof. Gioele Filomusi-Guelfi, Pavia – Dr. Francesco Gatti, Milan – Prof. Giuseppe Gianoli, Milan – Dr. G. Y. GigIioli, Florence – Dr. Alfonso Giordano, Lercara (Palermo) – Prof. Ulisse Gobbi, Milan – Prof. Guglielmo Koerner, Milan – Dr. Giulio Lanzillotti, Milan – Dr. Prof. Giovanni Loriga, Roma – Comm. V Magaldi, Rome – Ing. Emilio Magatti, Milan – Ing Effren Magrini, Turin – Ms. Ersilia Mayno-Bronzini, Milan – Ing. Achille Manfredini, Milan – Prof. Sen. Luigi Mangiagalli, Milan – Prof. Eugenio Medea, Milan – Mr. Max Meyer, Milan – Prof. Angelo Menozzi, Milan – Dr. Carlo Momo, Milan – Prof. Giovanni Montemartini, Rome – Prof. AchilIe Monti, Pavia – Prof. Angelo Mosso, Turin – Ing. Adolfo Mrach, Milan – Ing. Giovanni Battista Pirelli, Milan – Ing. Luigi Pontiggia, Milan – Hon. Prof. Luigi Rava, Rome – Prof. E. Rossoni Rome – Mr. G. fu Luigi Rusconi, Milan – Hon. Prof. G. Santarelli, Bologna – Dr. Alessandro Schiavi, Milan – Ing. A. Scontietti, Legnano – Dr. Alberto Secchi, Milan – Ing. Giovanni Silvestri, Milan – Dr. Riccardo Sonzogno, Milan – Ms. Rina Sullam Rignano, Milan – Ing. Carlo Vanzetti, Milan – Dr. Luigi Veratri, Milan – Dr. Luigi Viganò, Milan – Dr. Umberto Zanni, Rome.*

At the first meeting of the "Promoting Committee" an "Executive Committee" was set up the office bearers of which were Prof. Angelo Menozzi Vice Chairman, Prof. Luigi Devoto General Secretary, the industrialist Cav. Luigi Bertarelli Cashier, and Drs. L. Secchi, G. Lanzillotti and L. Vigano Secretaries. *Professional commitments prevented Drs. Secchi and G. Lanzillotti from taking part in the committee's work continuously and profitably, and in Autumn 1905 they were obliged to tender their resignations from the office of secretary and in their place Chair called upon Drs. L. Veratti and L. Carozzi*. Amongst the secretaries Ing. G. Camperio also made an appearance at one point. The office of the secretary of the "Ordering Committee" was later moved to via Manforte, 14.

The Executive Committee's Circular N° 1, probably drafted at the end of the May 1902 meeting was headed with the definitive title of: "International Congress on Work-Related Illnesses", stated the aims of the initiative: *To examine and discuss what work-related physiology and pathology can point out, to review the most up to date and effective procedures of industrial prevention, to assess the results of the experiments conducted abroad and in Italy in the*


CONGRESSO INTERNAZIONALE
PER LE
MALATTIE DEL LAVORO
MILANO 9-14 Giugno 1906
(VILLA REALE - Via Palestro)

Biglietto d'Invito

rilasciato al Signor ....
per intervenire, il giorno 9 Giugno 1906, alla SEDUTA INAUGURALE ed alle sedute successive del Congresso.

IL PRESIDENTE DEL COMITATO
Sen. M. DE CRISTOFORIS

IL SEGRETARIO GENERALE
L. DEVOTO

IL VICE-PRESIDENTE
Prof. A. MENOZZI

Figure 1 - Invitation ticket

fields of social security and assistance and to suggest initiatives in this field. Hereafter follows the programme of the three sections in which the congress of 1905 will be divided: 1 work-related physiology, pathology and hygiene; 2 prevention of work-related illness; 3 social assistance.

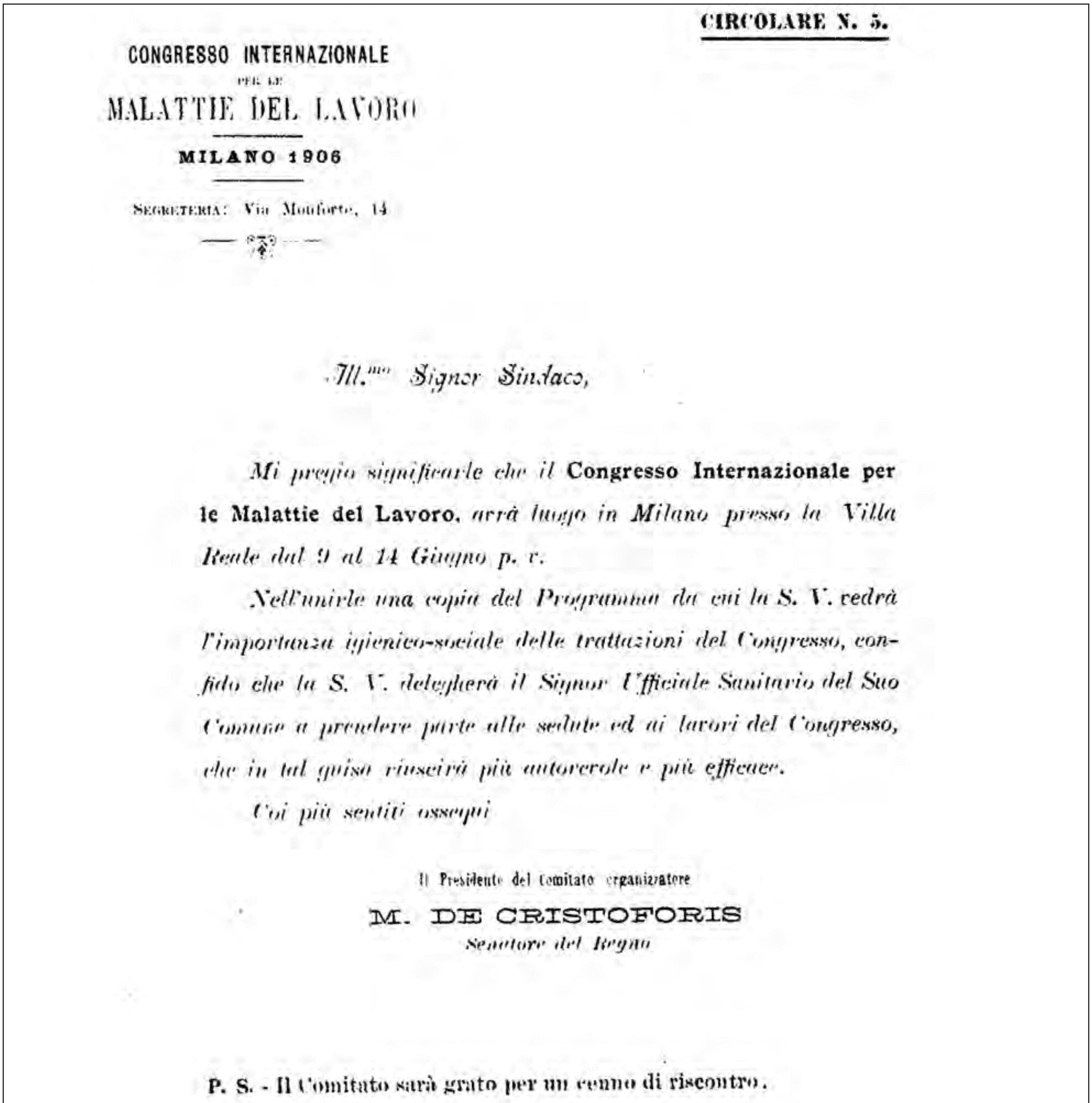
Circular N° 2, probably dated 1904, which was addressed to university professors ("Dear Professor"), was a call for papers for *a congress in which work-related or professional illnesses will be dealt with at specialist level by Italian and foreign scholars*. It is pointed out that no reports or notifications will be accepted that deal with trauma-surgical cases incurred at work and participants are urged to *promote the study in your institute on the most pressing and interesting work-related physiological, clinical and hygiene issues, and to draw the attention of your students to the physiological and pathological conditions of workers in the industries which are widely and prevalently distributed in your region. … and we shall have shown foreign scholars that in Italy, too, the teachings of our immortal B. Ramazzini live on.*

The same Circular states the strategic significance of the Congress: *Its guiding principle is to supply the legislator with effective secure information which will lead to a code of work hygiene, provide industrialists and technicians with norms for limiting damage or for purifying work. One could talk badly of the congress's work if it merely consisted in a simple inventory of what had been achieved in the field of work-related pathology. An exact and diligent review of the goals reached will certainly be advantageous but much more useful will prove the fruits of original study aimed at clarifying and resolving some of the countless questions still open in the fields of work-related physiology, pathology and hygiene which have concurred to render civil legislation more difficult and thus heighten the demand for them, now held dear by many enlightened minds.* The same circular announced the postponement of the Congress to 1906.

Circular N° 3 bears the date of February 1905 and is aimed at far more recipients ("Dear sir") and calls for applications to participate in the congress of Spring 1906 *making some contributions in work-related physio-pathology and hygiene, or towards the prevention of professional illnesses, or in social assistance to workers.* In a post scriptum the Circular reminds readers that *the Congress of Milan of 1906 was the first to deal exclusively with professional illnesses and the suitable means for preventing or mitigating the consequences and that "sound contribution to the success of the congress may be made by doctors who from now will embark on a study of the less common professional illnesses, or any other matter relating to work-related physiology, pathology and hygiene and communicate their findings to this congress, engineers who notify the results of their studies and observations regarding innovations in building, plant, and the most efficient equipment for preventing professional illnesses, industrialists and factory managers by inviting municipal doctors or teachers of the nearest faculty of medicine to study the phenomena of morbidity which they will have observed among their employees, pointing out whether employees of a certain industry are more or less liable to contract certain illnesses rather than others.*

Circular N° 4 is dated September 1905 and has the same main objective ("common duty") of the congress, … *to achieve the composition of a work code in which the requirements of physiology are based on mediated expressions of social assistance* and confirms the three sections of the original programme, *1 work-related physiology, pathology and hygiene; 2 prevention of work-related illness; 3 social assistance*. At the same time, the Circular mentions the "warm and generous welcome" the initiative had already been given by scientists and industrialists, and it gave a list of the topics that were to be "dealt with and discussed during the gatherings" *The physiological contraindications of night work; forms of neuroses suffered by railway workers, work pathologies in environments using pressurised air, pathologies suffered by deep sea divers and new means of prevention, mental deficiency and delinquency in relation to irrational work situations; professional illnesses and non-traumatic pathologies of hearing; sulphur workers' pneumoconiosis; illnesses suffered by grain mowers; illnesses specific to acid factories manufacturing acids and chemical products in general; individuality and professional illnesses; hygiene in tunnels; manifestations of morbidity in compensative physiological deficiency; work-related illnesses observed in southern Italy and Sicily; tuberculosis and labour legislation; spread of hookworm disease and its prevention, female labour and safe-*

guarding maternity; traumatic neuroses in sulphur miners; hookworm and eelworm in relation to the main illnesses of labourers, peasants and masons; prevention and treatment of asphyxiation by illumination gas in the factories where it is produced; balance of nourishment and labour; illnesses of the manufacture of superphosphates and drawbacks of hydrofluoric acid; factories of copper sulphate; manual labour and sclerosis of the peripheral blood vessels; the material exchange in exertion; the effect of artificial light on respiratory exchange; alterations to the respiration tract in coal porters; neuro-muscular strain neuroses; working in high- and low-temperature environments; pathology of cement workers; professional poisoning and the depreci-



CIRCOLARE N. 5.

CONGRESSO INTERNAZIONALE
PER LE
MALATTIE DEL LAVORO

MILANO 1906

SEGRETERIA: Via Monforte, 14

Ill.mo Signor Sindaco,

Mi pregio significarle che il **Congresso Internazionale per le Malattie del Lavoro**, *avrà luogo in Milano presso la Villa Reale dal 9 al 14 Giugno p. v.*

Nell'unirle una copia del Programma da cui la S. V. vedrà l'importanza igienico-sociale delle trattazioni del Congresso, confido che la S. V. delegherà il Signor Ufficiale Sanitario del Suo Comune a prendere parte alle sedute ed ai lavori del Congresso, che in tal guisa riuscirà più autorevole e più efficace.

Coi più sentiti ossequi

Il Presidente del Comitato organizzatore
M. DE CRISTOFORIS
Senatore del Regno

P. S. - Il Comitato sarà grato per un cenno di riscontro.

Figure 2 - De Cristoforis' circular to the Mayor

ation of the race; alcohol and muscular labour; tobacco and muscular labour, nicotine intoxication; professional infections; the diet of the labourer; exertion in pathology; prevention in professional illnesses; social assistance in work-related illnesses; and other matters of no less importance.

Having decided to publish the Acts before the date of the congress, 31 December 1905 was set as the deadline for "the receipt of original notifiications"

Other Circulars (attaching the congress programme) were addressed to "Mayors of the Municipalities of Italy" (Circular N° 5, undated, but of 1905) which requests that sanitary officials be encouraged to attend the congress; to the "colleagues" of the president of the organizing committee in public administration in German (Circular N° 6 undated but of 1905) and in French (Circular N° 7, undated but of 1905); to the Camere del Lavoro e Società operaie (Circular N° 8 of 10 March 1906) in which the congress title is extended with the subtitle "Physiology and pathology – Prevention – Social Assistance", and on sending the programme, it is mentioned that *The committee would highly appreciate this programme being communicated to other companies with relations or links with yours in order that additional practical observations be contributed by the doctors of the companies and that the doctors take part in the discussions of the congress*; furthermore, the same missive notified that the committee had deliberated *to grant a complimentary entrance card to congress sessions for a delegate from each company.* Circular N° 9 of 12 May 1906 was addressed "To the Industrialists" who were asked to adhere to and enrol in the congress sending the sum of 10 lire. The last Circular, N° 10, given to the Acts was a request to the "Mayors of the Municipalities of Italy" who had not yet done so, *to send to the congress in Milan one of the sanitary officials employed by you … so that also the noble city which you so worthily preside can one day declare its satisfaction at having sent one of its technical officials to take part in this congress which is being held in Milan for the first time.*

(fronte)

N.

CONGRESSO INTERNAZIONALE
PER LE MALATTIE DEL LAVORO

Milano 9-14 Giugno 1906
Villa Reale (Via Palestro)

Il Signor

è regolarmente iscritto al Congresso.

Timbro

Il Presidente
Dott. M. DE CRISTOFORIS.

Il Segretario Generale
Prof. L. DEVOTO

Il Cassiere
L. BERTARELLI

Figure 3 - Certificate of participation to the International Congress on Occupational Diseases

Reports from the Congress

As the documentation contained in the Acts if the Congress show, many recipients of the various circulars responded to them. Among these were the "Camera del Lavoro of Milan" that notified its representatives (Dr. Giovanni Allevi and Avv. Carlo Testori) and the representatives of the "Associations" (Drs. Edoardo Bonardi, Luigi Bernacchi, Angelo Filippetti, Eugenio Baila, Alessandro Schiavi, Giovanni Pirri, the lawyers Eliseo Porro, Francesco Beltrami, Arnaldo Agnelli and the engineers Felice Mazzocchi, Adolfo Vallabrega and Nino Mazzoni. The "Camera del Lavoro of Monza and environs" delegated Prof. Achille Monti to be its representative; The "Camera del Lavoro of Gallarate" appointed its secretary Giovanni Bitelli and its legal advisor Avv. Francesco Buffoni, while "Riscatto Ferroviario – Society of Rail and Tram workers of Milan" appointed Dr. Giovanni Petrini.

In the end, there were 17 foreign representatives at the congress; most were from Germany, Switzerland, Austria and Hungary and none from Britain. This is the list published in the acts of the congress: *Dr. Anders Backlund, Stockholm; Dr. Elmer De Szegedy Maszak, Budapest; Dr. Désiré Glibert, Brussels; Prof. Martin Hahn, Munich; Prof. J. P. Langlois, Paris; Prof. W. Oldright, Toronto; Dr. Eugenio Bonzanigo, Bellinzona; Dr. Achielle Costantini, Trieste; Dr. Allan MacLean, Koeningsberg; Dr. Eugenio Neisser, Berlin; Prof. Otto Roth, Zurich; Mr. Hermann von Schrotter, Vienna; Dr. and Mrs. Ludwig Teleky, Vienna; Dr. J. Rambousek, Trieste; Prof. Bruns Hayo, Gelsenkirchen; Dr. E. Kaestner, Steinbach Hallemberg; Prof. G. Friedrich, Budapest.*

There were 41 municipalities represented or enrolled in the congress and 32 representatives, mostly sanitary officials, took part; Rome was one of the municipalities not represented.

The acts show that there were 295 regularly enrolled attendees. They were mostly doctors, with few full-time or almost full-time work doctors, Devoto, Pieraccini, Carozzi and Giglioli. Most were clinicians mainly from universities and hygienists including many sanitary officials; there were 20 engineers, mostly industry managers or industrialists, 8 lawyers, and 19 *commendatori, cavalieri*, aristocrats MPs and diplomats; there was even a clergyman, Natale Bormetti of Como.

The opening session of the congress was help on Saturday 9 June 1906 at 11 a.m. in the ground floor hall of Villa Reale (Villa Belgiojoso-Bonaparte). After the welcoming speech by the mayor of Milan, Malachia De Cristoforis made a long introductory speech ending as it had begun with great emphasis: *"It is necessary that the drive to hygienic prevention and sociophilia become an institution. In that case the laws we pass will live long in the awareness of peoples. We work. The time is right. It is not a modern, gentle thought that while art and industry reign supreme in the galleries of the international exhibition which glorify Milan we are moved to take up arms against that which is evil and deadly. Obscure victims, unaware of the steel monsters or deafening anvils or the mines or the looms or the graphic arts or mental tasks, work: Here, we think not only of the great cries of Courrières or elsewhere but also of every un-noted moment of your laborious existence that draws your blood, youth, happiness and genius. I really feel proud to be a citizen and a scholar; may Italy, may Milan welcome with my salutation what will be a noble success, dear sirs, of your investigations and your suggestions. And with these thoughts of philanthropy, join me in raising a hymn to work and to humankind"*. There followed the greetings of Austria, then those by Hermann von Schrotter, the Inspector-in-Chief of the Belgian Ministry of Labour, Glibert Desire, Prof. Langlois of Paris University representing the French Ministry of Trade and Labour, Dr. Anders Backlund, for the government of Sweden, the delegate of the government of Bavaria Prof. Martin Hahn, Prof. C. Bozzolo who, as council member responsible for hygiene, brought the greetings of the city of Turin. This was followed by a long speech by Hon Prof. Sanarelli who spoke on behalf of Minister Cocco-Ortu.

There is also an interesting passage in Langlois's speech: *But despite what happens, industry will always be a source of victims, and a society worthy of the name will be unable to abandon them to public charity. All these social problems bring financial complications and new charges for industry, and faced with such intensive world-wide competition a state no matter how benevolent cannot consider taking legislative measures* *for the destitute or embark upon reparations which are not seen in the same light by other states as charges to be perceived as part of the life of the individual.*

Sanarelli however was firm in his view that in the field of work-related preventative health legislation it is hard to lay down "uniform and general norms of law" and reminded government of its commitment to learn about the reality of facts and stated that on the congress's results, *our work-related health policy will be built* which will therefore *give support the idea that illness is the pain of others; this is what science is teaching and hence the intellectual and ethical development of mankind because all the scientific conquests of today are almost a single body with present-day civilisation … .*

Congress attendees were taken to visit the Guzzi and Ravizza factory in which attention was drawn to a new kind of aspirator *which is gaining in popularity among industries with much dust*; there was also a visit to the Pacchetti factory that processed animal hair.

To the success of the congress *contributions were made by Società Umanitaria, Milan. 500 lire; Pirelli e C., Milan 100 lire; Società Italiana Tessuti Stampati, Milan 100 lire; Riva Monneret e C., Milan 50 lire, Cotonificio Crespi, Milan 50 lire; Bertelli e C., Milan 100 lire; Carlo Erba e Visconte di Modrone Conte Giuseppe, Milan 100 lire; and finally the Milan town council with very elegant generosity gave its wholehearted moral and material support as is mentioned elsewhere in the volume.*

There were 90 reports and notifications on the topics suggested in two sections and 14 sessions overall. There were also a further 18 notifications which were not read but which were published in the acts of the congress. The main topics touched on and the speakers were: "Regularisation of work and rest periods on the basis of exact physiological data" (Carozzi, Gardenghi, Pieraccini); "Nourishment conditions of the worker" (Albertoni et al.); "Alcohol, combined ethylic and professional intoxication" (Pieraccini and Gasperini); "Physical conditions of the working environment and professional illnesses caused by pressurised air" (Schrotter, Giglioli); "Effects of high temperature on workers"; "Infections and work"; "Tuberculosis as a social disease" (Massalongo, Teleky); "Anthrax" (Ascoli, Langlois); "Professional illnesses cause by parasites" (Bruns, Perroncito, Vaccini et al.); "Phosphorism" (Menozzi); "Early diagnosis of lead poisoning" (Rambousek, Hahn, Glibert); "Antimony intoxication in Sardinian mines" (Biondi); "A case of aniline polineuritis in a young dyer" (Medea); "Professional nicotine poisoning" (Giglioli); "Rice fields" (Pezza), "Cement and lime" (Rota); "Large scale chemical industries" (Piccinini); "Boatmen" (Vitali); "Cotton workers" (Pierotti); "Work Inspectorate" (Hahn, Glibert, Langlois, Giglioli); "Insurance for work-related illnesses" (Magaldi, Gobbi, Fabris, Teleky); "Advanced studies on work-related pathologies". Giglioli's comments voiced during the debate on this latter report are noteworthy: *Official and advanced teachings on work-related pathology are thorny issues for us too and we are aware that higher consultative echelons in Minerva are contrary to special appointments and teaching specialisations in this sense. We are fully aware that the establishment of a work clinic, similar to that in Milan, where other general medicine clinics have already been established would merely be superfetations like those which unfortunately already exist in our universities; but there could well be supplementary teaching for clinics and legal-medical and hygiene institutes by setting up special hospital shifts as has been done in Florence … there should be no lack of means for giving specialist training to adequately prepared doctors by setting up additional courses and supplementing the university legal medicine syllabus with a course for hygiene officials who could become useful and active work inspectors.* On the work of the Simplon, the declared reason for the congress, there was the communication published among those "not read" (but according to a contemporary reviewer presented d. s. b., 1906) by Giuseppe Volante, the company doctor on the southern approach who, being a hygienist, highlighted the victory against hookworm and the thus improved conditions in which the works were carried out compared to those of twenty years earlier at the St. Gotthard. Momo also spoke indirectly of the Simplon in regard to the toxic gases produced by explosives, drawing a distinction between the acute and chronic forms of tunnel illnesses or "poiano" the symptoms of which, according to the author, are similar to those of CO poisoning.

On 13 June, at the congress conclusion the Permanent International Commission for Work-Related Medicine was set up. The following are the decisions taken and published in the acts of the congress: *In view of the generous contributions from many different parts of the world to the great issue of purifying work the congress deems scientifically necessary, practical and socially economical that these meetings be repeated with collective contributions leaving each centre freedom of action. A permanent international commission is hereby set up which is requested 1 to supplement its ranks with representatives of the nationalities absent from the congress; 2 to select the venue for the 2nd international congress on work-related illnesses to be held in 1908, obtaining suitable information from various states; 3 to keep in contact with the local ordering committees of the 2nd congress; 4 to suggest issues of general interest within the overall topic to the local committees and to receive proposals made to it by all and pass them on to the local committee.* Langlois then spoke saying: *On behalf of the foreign delegates and without wishing to impose ourselves on our Italian colleagues, we think that because of the indisputable success of the first congress on work-related illnesses we find it impossible not to propose Senator De Cristoforis as chairman and Prof. Devoto as Secretary to the permanent committee.* The assembly applauded and approved Prof. Langlois's proposal, and then the Chairman, to the assembly's applause, proposed *that Messrs. Langlois (France), Eulenburg and E. Roth (Prussia), O. Roth (Switzerland), Backlund (Sweden), M. Hahn (Bavaria), H. von Schotter and Kaupp (Austria), Széyèdy and Fodor (Hungary), Glibert (Belgium), Vintkens (Holland), Oldright (Canada), League (Britain) be considered forthwith members of the committee,* (although the person concerned was probably Thomas Legge), and requested the assembly for the committee to be authorised to include representatives from other foreign countries to which the assembly agreed. Then Prof. Foà requested the assembly to authorise *the number of Italians on the committee to be raised to three and, to the unanimous approval of congress attendees, that Dr. Prof. Pieraccini be appointed the third member of said committee.*

Before the Chairman declared the issue closed, he expressed the hope that the permanent central committee set up that day would in time publish a "Bulletin".

The motions proposed for the Congress

First section – First session

The Chairman, Senator M. De Cristoforis, after the presentation of the first four reports and especially that of Luigi Carozzi on Contraindications of night work, and after a broad discussion, read the following motion: *Having heard the report by Dr. Luigi Carozzi and considering the results of the discussion, the congress affirms that night work is antiphysiological and moves that females of all ages and males under 18 be permanently barred from it; and when superior and technical reasons require it for adults, adequate conditions (shifts, temporary leave, changes in working hours, exclusions after medical examinations etc) be applied*. The motion was signed by Ms. Ersilia Majno, Dr. Carozzi, Dr. Gasparini, Prof. Monti, Dr. Gardenghi, Prof. Pieraccini, Prof. Zoia, Dr. Giglioli, Dr. Petrini and was carried unanimously

First section – Second session

The Chairman Prof. A Menozzi, read the motion presented by Profs. Menozzi, Pieraccini, Treves and Dr. Petrini: *"The congress, having heard the report of Prof Pieraccini* ("The real external production curve among manual and intellectual workers measured on site") *and appreciating the significance of the results and without prejudice to the curtailment of working hours for women and children, moves that an international conference be convened to study and propose maximum time limits for adult males in the various industries and industrial procedures also indicating pauses where necessary. It also resolves that the tutelary authorities demand these reductions which have proved necessary for both physiology and economy"*. The motion was carried by majority vote.

First section – Third session

After the presentation of the reports by Dr. Lussana ("Alcohol and muscular work") and Dr. Canarini ("Experimental contribution on the effect of alcohol on muscular work") the Chairman, Prof. A. Menozzi, announced that Prof. Monti would present the following motion which the speaker had already accepted: *Alcohol is not a required part of the worker's diet; it is deleterious in particular for work in-*

volving exertion and leads to phenomena of intoxication. It is not damaging in small doses and produces a transitory sensation of well-being; its useful effects in the worker's diet, can be profitably replaced by sugar, coffee or tea. The motion was carried by 22 votes to 19 with 6 abstentions. Dr. Gasperini's motion: *The international congress for work-related illnesses, considering that the use of alcoholic beverages would be better replaced by foods of a more economic nature, especially for those whose work is prevalently intellectual, moves that it be completely abolished for workers subject to any professional intoxication* was therefore not put to the vote .

First section – Fourth session

The speaker, Massalongo, who had spoken on "Tuberculosis and work legislation", a topic also discussed by the speaker who followed, Teleky, together with others, presented the following motion: *The international congress for work-related illnesses held in Milan from 9–14 June, seeing that tuberculosis prevention is the most important, biggest and most emotion-wrought problem of work-related pathologies, solidly expresses the urgent need for work-related health legislation to protect every aspect of workers' health including all aspects of his physical, economic and moral poverty, and safeguard him from this endemic infection,. In order to achieve this goal, and considering that tuberculosis is essentially a social disease, the congress moves that states intervene directly in the fight against tuberculosis, coordinating and integrating their actions with those of the bodies and public initiatives already present in this struggle. In addition, it moves that the state apportion adequate funding and call upon local bodies and industry to contribute.* The motion was signed by Teleky, Gasperini, Giglioli, Pieraccini, Allevi, Pirri, Petrini and Crisafulli. After ample discussion Chairman Devoto put the motion to the vote and it was unanimously carried. Giovanni Loriga also spoke and he insisted that a congress on work-related illnesses limit itself to general principles of prevention on industrial hygiene alone.

First section – Fifth session

The topic was hookworm. During the discussion, the session chairman (Devoto) said that *he was happy to note the presence of Dr. Giuseppe Volante to whose diligence is owed the Simplon tunnel being completed without miner's anaemia making its appearance.* The congress praised the work of Dr. Volante.

First section – Sixth session

When D. Glibert's report on "The effect of low-pressure pressurised air on work" had been read Chairman Devoto, reminded the congress that it had appointed a committee to draft peremptory norms for work in the presence of pressurised air and it was the members of this committee who presented the motion on: *In working under pressurised air, decompression is assuredly the most dangerous stage. Not wishing to deal with less controversial issues regarding the physiological age of the worker, compression, breathing, the duration of the task etc., we believe that the essential point must be emphasized namely the conditions of decompression. Scientific calculations, experimental data and observations made in practice agree in establishing that to prevent decompression sickness as much as possible, decompression must take place at one tenth bar per minute at the most. In tasks conducted at 1:500 pressure and higher a heated rest room is absolutely necessary as well as a recompression chamber equipped with oxygen apparatus. It is desirable that for work under high pressure, workers be accommodated near the site. These precautions are indispensable, for even with a decompression of one tenth bar decompression sickness is still possible. When a decompression chamber cannot be counted on for deep sea divers oxygen breathing apparatus would be advantageous.* The motion was signed by all the members of the committee, Glibert, Langlois, Giglioli and Schrotter. In the ensuing discussion a disagreement arose in which Dr. Belli was obliged to admit that Giglioli's criticism of one of the rules for deep-see divers by the navy was justified.

Again in the sixth session, after Boveri's reports "Tobacco and muscular work, nicotine intoxication" and Figlioli his "The question of professional nicotine poisoning", Prof. Pieraccini presented a motion stating that: *The International congress on work-related illnesses moves that governments persevere in and accelerate improving premises where tobacco is worked and tobacco products manufactured* which was unanimously carried.

First section – Seventh session

After the opening report on the pathology of cement and lime workers delivered by Dr. Rota also on behalf of Dr. Finzi, Prof. Devoto *Moved that the assembly accept the conclusions of Drs. Finzi and Rota on excluding individuals less resistant to working cement.* The motion was carried.

At the end of the report "On the dangers of the match-making industry", the author A. Menozzi, said that *It is obvious that no complete result can be arrived at without international agreement, which is why the 1903 International Congress on Applied Chemistry in Berlin when our learned colleague Mosler on behalf of Landin of Stockholm proposed the following motion: «The congress deems that steps must be taken towards the complete international prohibition of white phosphorus in the manufacture of matches». The was the international understanding aimed at in the 1905 Berne conference when the following preliminary basis was laid: Art. 1. From 1 January 1906 it is forbidden to manufacture, import and put on sale matches containing white phosphorus. Art. 4, however, lays down that the convention entering into force is subordinated to its ratification by all the states represented at the conference, plus Japan. Now, while the representatives of Austria, Belgium, France, Germany, Italy, Luxembourg, Holland, Portugal, Spain, Switzerland and Hungary adhered to the basis of convention, the delegates from Denmark, Britain, Sweden and Norway abstained, which meant that the proposal remained inoperative. I believe that a congress like ours must express its opinion on this matter and stand up and be counted in order that the desired objective be achieved and I propose the following motion that in part supplements that of other congresses.* The author therefore proposed the following motion: *The Congress, mindful of the disastrous effects on the health of workers of the use of white phosphorus in the manufacture of matches moves that the technical bodies and governments of the various states leave no stone unturned in order to reach an international agreement for the complete prohibition of the use of white phosphorus in the manufacture of matches.* The Chairman, M. De Cristoforis, put the motion to the vote and it was unanimously carried. The records show that the famous zoologist Giambattista Grassi, who was very interested in the phosphorus question spoke twice, probably to challenge the content of the motion but it is not known with what argumentation because the acts of the congress state "he did not give a summary of his argument".

First section – Eighth session

This session was noteworthy for the delivery by V. Magaldi "Concerning insurance for work-related illnesses", head of the Inspectorate General of credit and welfare at the Ministry of Industry, Agriculture and Trade listing initiatives which, however, were never brought to completion. At the conclusion, the Chairman M. De Cristoforis, proposed the following motion: *The congress moves that the government present a draft bill on insurance against illnesses of every kind for workers in industry in accordance with the agenda already agreed on by the two chambers of parliament.* The motion was carried.

In the same session, Francesco Pezza delivered a detailed report on "The pathology of the rice field" which was followed by a truly broad discussion in which Grassi who in this case also "gave no summary of his argument" and others including Angelo Celli, and Monti took part. Two motions were presented, one by Dr. Vaccino: *The International congress on work-related illnesses, having heard the report on malaria and regretfully noting that after three years of anxious wait the promised law on working in the rice fields is still not forthcoming moves that this law be produced swiftly in order to remove the present state of affairs*; a second motion was presented by Biondi, Foà, Pieraccini, Gasperini and Orte: *the congress expresses its satisfaction for the results achieved in applying the law on malaria and moves for government initiative and medical information to extend prevention with state quinine supplemented with mechanical prevention.* Both motions were carried by the assembly.

At the end of this session Dr. Vasta of Favara spoke "On the deformed chest of Sicilian sulphur mine workers". The acts of the congress make no mention of it but the minutes reported in the Journal of the Royal Society of Hygiene show that Vata presented *a motion moving that the state regulate the transport of sulphurous material* The motion was carried unanimously (undated, 1906).

First section – Ninth session

In this session D. Glibert delivered his paper "Organisation and workings of work-related medical inspection in Belgium" and Giglioli his "Prevention of professional illnesses in Britain" with a discussion afterwards on professional infections. Dr. E. F. Neisser of Berlin and Prof. C. Zenoni of Milan presented the following motion on the former which was carried unanimously: *The first international congress on professional illnesses has deliberated on the importance of the work inspectorate for studying professional illnesses namely that the institute and especially the need for cooperation on the part of doctors in work inspection be an integral part of the topics of the next congress. The first congress delegates the international committee in Milan to call for papers on how the medical service carried out by work inspectors functions and develops in the various countries*. Monti, Pieraccini, Bernabei, Giglioli and Gasperini presented the following motion on professional infections: *The Italian attendees of the international congress deem that anthrax, glanders, tetanus, foot-and-mouth disease, actinomycosis, syphilis and other infections contracted at the place of work, and tropical malaria, the plague, yellow fever, cholera and other exotic infections contracted by seamen in service are to be considered work-related injuries and as such governed by the Italian law in force on injuries*. The motion was carried.

Again in the sphere of this discussion, other motions were formulated. One by the Chair, De Cristoforis: *Sunstroke at work is a work-related injury*, was carried; a second motion which was also carried was put forward by Perroncito, Monti Gasperini and Bernabei: *The congress for Italy moves that vaccination against anthrax be made obligatory everywhere there is an anthrax infection and be repeated annually at the expense of the municipality, province or government in order to prevent farmers neglecting it after having benefited for some years from the immunity that derives from the temporary disappearance of the illness while the germs survive for a more or less long period in the soil.* Biondi and Bernacchi's motion, instead, which moved that: *The congress deems that in certain conditions infections take on the substance of injuries in accordance with the laws in force in certain countries, including Italy,* was rejected

First section – Tenth session

The tenth session, again chaired by De Cristoforis is to be mentioned, if for no other reason than Devoto's suggestion, carried by acclamation, to send a telegram to Senator De Angeli, the industrialist and engineer very active in the sphere of innovatory techniques and insurance for preventing injuries. De Angeli must have been ill and therefore prevented from taking part in the congress. Dr. Petrini, who had been invited to the congress by a workers' association was happy to be associated with Devoto's motion *the more so since the speaker was from an opposing political camp.*

Second section – First session

This important and far-.reaching session was on protecting maternity. Before specifying the motions it is interesting to note the enthusiasm with which the only active woman attendee received the report by Dr. F. Pestalozza. Ersilia Majno suggested that that report *highly noble in its scientific and concept be read as a useful and necessary programme one evening so that ladies and workers may listen to reports and discussions on an issue of fundamental importance for society which was today heard and discussed by too few invitees while people need to be convinced*. The Majno proposal triggered an interesting debate. While responding *that the agenda had been published for some days and that those who interested in this section could have come* De Cristoforis *certainly did not reject the proposal but rather accepted it and will set a date for a conference when the working classes could attend to hear the summaries of the reports and discussions on the topics listed in the agenda of that section*. Prof. La Torre., instead, said that *without wishing to contradict Ms. Majno's important suggestion but it seems to the O. that we should not be speaking to the women workers – they know perfectly well that they need better treatment – but rather to persuade other classes of people. Ms. Majno's suggestion can be accepted for an extra-congress conference. Dr. Pestalozza in turn responded by wholeheartedly agreeing to the Majno suggestion making himself available to the proponent"*. Pestalozza's report was followed by that of G. Merletti, "Development of the foetus in relation to the profession of the mother", then F. La Torre's "Development of the foetus and mortality in relation to the state of health of the worker". This was followed by those in the same vein by Calderoni, Mosucci, Mocchi and Peri. Debate was lively, and ended with a motion proposed by Dr. Zamorani: *The maternity section of the congress for work-related illnesses, having heard the reports, notifications and discussions on protecting the mother and child vis-à-vis the work relationship affirms that there is a peremptory social need and duty on the part of the legislator and private and non-profit organisations to cooperate with all their strength towards improving culture and making hygienic, sanitary and economic protection adequate for working mothers.* The motion was carried unanimously.

Second section – First session

The assembly unanimously carried a motion after hearing reports and discussions on the effects of lead on workers. The motion, presented by Crisafulli, Gasperini, Giglioli, Pieraccini and Allevi reads*: The Congress moves that legislation be carried out to substitute lead products with products in zinc everywhere this is advisable and in any case there be a sanitary official responsible to whom to entrust monitoring and safeguarding the health of workers in industries in which contact with lead products is inevitable.*

Second section – Fourth session

The assembly heard the report by Prof. Bernabei of Siena on "Sunstroke with ensuing death at work" and discussed three different motions. All concerned marching and military manoeuvres in summer in a very hot climate with the risk of sunstroke. The motion carried was proposed by Allevi, Galbarini and Bernabei, and read: *The congress moves that marching competitions in the army be disciplined in accordance with the laws of physiology and hygiene and that major manoeuvres only be carried out in autumn as occurs in other countries*

Communications not read

In point of fact there was a further motion contained within a "teaching lesson", "Teaching mining hygiene", which was not delivered but published in the acts of the congress by Alfonso Giordano of Lercara, the social doctor who wrote and did so much for the sulphur mines and the Sicilian sulphur workers. The report ends with the following motion: *The International Congress for work-related illnesses having acknowledged that technical training is a contributory factor in building prosperity, and that the real requirements for today's social evolution, namely industrial pathology and rules of hygiene should be made known among workers in addition to being taught in specialisation courses moves 1 that independently of the most effective legislation aimed at industrial progress and protecting health and life of all those employed passed by government and under common understanding, greater scope be given for development and increase of the courses in work-related hygiene and pathology, reorganizing and expanding those already existing; 2. that in the principal mines of the world there be set up a permanent health service with publicly employed doctors with the two-fold task of working together with technical staff towards the exact observance of monitoring and guiding the workers on the risk of work and the means for assuring safety and wellbeing*, The acts do no say whether the motion was ever discussed and carried.

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ACKNOWLEDGEMENT: *Grateful thanks to Dr. Alessandro Spallanzani of the Library of the "Luigi Devoto" Clinic for Work-related Illnesses in Milan for his valued and ever-prompt assistance*

Med Lav 2006; *97*, 2: 114-123

Some contribution from the doctor of the miners in the Simplon tunnel

Similarly to Daniele Pometta (1869-1949) on the northern front, Giuseppe Volante (1870-1936) from Turin, a valid clinician and hygiene expert was the field doctor for the firm of Brandt, Brandau e C., on the southern part of the Simplon tunnel for the whole period of its excavation (1898-1906). He meticulously organised and carried out with determination the main mission entrusted him which was to prevent the hookworm epidemic which a mere twenty years earlier had cast its shadow over the St. Gotthard tunnel. Volante also authoritatively directed the first aid post and the hospital that the company built at Nante. Evidence of Volante's vast medical experience was seen in the scientific works he published as well as in a report published in the acts of the International Conference on Work-related Illnesses (Volante, 1906a) and then in a comunication at 3° Italian Congress on Work-related Illnesses in Turin (Volante, 1911).

There are three interesting works reproduced here (Volante, 1906b-c-d) which are substantially aimed at a broad readership and which clearly illustrate the work carried out, the experience gained and also the author's cultural background.

Volante's remarks and the data he supplies are "official" but show no sign of partiality; they convey the grandness of the work he contributed towards creating and in some ways also the "generosity" of the company towards the labour force who "only" went on strike three times for better pay, fewer hours and improved working conditions. Volante's opinion on the low morbidity and mortality of the workers is certainly motivated although it is still relative, first and foremost because he had the tragedy of the St Gotthard as a yardstick, but also because it was swayed by the idea, widespread at the time, of fatalism about the potentially negative effects of the type of work.

During the International Conference in 1906 Violante was awarded a gold medal for the work he had conducted, and for three years afterwards he worked under Luigi Devoto (1864-1936) in Milan. After that, he returned to his native Turin where he practised urology. According to his direct descendents, he died aged 64 from respiratory insufficiency the causes of which included a "pneumoconiosis" diagnosed by Prof. Quarelli (1881-1954), a renowned doctor of work-related illnesses, which he had obviously contracted in the period when he had been the doctor of the miners (Gius Volante, 2006).

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The most human of victories

G. Volante

In modern allegories, labour is represented as a strong naked man with his hands resting on a hammer like the god Thor. Whether well or ill-expressed, the idea is always the same. But when the labour of miners is represented, in which strength is pitted against stone and earth, then the artist girdles the chest of our symbolic worker with a cuirass of rock flakes, covers his head with a helmet and arms his left hand with a shield. The ideal representation of labour shows them as warriors standing balanced, dressed for combat, assault, and defence. The allegory is perfect. If winning a war means removing an obstacle which stands against movement, not only by weight of its inertia but which also offends and reacts, then great works of excavation are veritable wars with their weapons of offence and defence, a general plan, with skirmishes, man-to-man combat, flights, defeats, pursuits, truces, heroisms and victims. The enemies are known but they lie in wait hiding, ready to pounce roaring and threatening, and they must be fought as though they were live forces like Achilles against the Scamander. The genius and perseverance of man is assuredly crowned with victory and cannot fail to bring success in the end. But there is often a lengthy space between one victory and the next in which the fallen must be counted.

The prizes won by money and constancy can be enormous, those of science marvellous and highly useful, but the most human, the most noble and glorious is the prize of mourning fewest victims and the greatest joy that of preserving the flower of life.

When work began on the Simplon, there was a sinister spectre that haunted the minds of those concerned with the problems of human life; an evil memory of former times and former works: the hookworm epidemic. Then, if the enemy forces were reviewed and the dangers of the enterprise calculated and the strategies and arms to use against them pondered, all uncertain and yet all probable, above them all towered the memory of the deaths and illnesses whose greatest number was reached in the Gotthard.

I shall not repeat the painful history of those epidemics nor shall I recall how they developed and by which means science attempted and managed to fight them. I shall merely say this: the Simplon tunnel is complete and there is no memory of epidemic nor of high mortality to darken the joy of the finished work. Indeed the clinical record of illnesses of the labourers of the Simplon bears no mention of hookworm.

When the first gangs of labourers arrived in the work's early stages, and the valley began to fill up with families and houses and lilac, when unaccustomed liveliness was seen in the area, and life was budding blossoming and growing ever more quickly, I would ask myself anxiously how it was all going to finish. The valley is very narrow, swept by strong winds, frozen in winter and an authentic kiln in summer when the sun bakes the rock faces, and, worst of all, rock that has had no sun all through the coldest months. From October to March the nurturing rays of the sun never reaches the valley bottom and its light only shines on the mountain tops.

Melancholy thoughts for those charged with the health and life of people engaged in a tiring and dangerous job threatened by a thousand adversaries, whether overt and violent or hidden ready to betray! Not even the most optimistic could have foreseen such a happy and comforting outcome short of a miracle. And in a certain sense a miracle occurred, performed by the company. I say miracle in the sense of the authentically innovative and extraordinary fact of a company concerning itself scrupulously with the health and life of its workers. This consideration, which should be uppermost often, unfortunately, is but the last and is the most neglected when one thinks about it because what the law now demands is very little compared to what should be done.

From the very beginning of the works, Brandt, Brandau e C. had an eye to the most important issues and to the most recent discoveries in hygiene, and an ear to all the advice and suggestions from science. I add that the doors of the coffers were opened and no expense was spared in providing for the health and well-being of the labourers with elegant liberality and generosity.

The story of how and by which means Brandt, Brandau e C. provided for this noble cause would be too long to tell here and I shall give a more detailed account at some later date. It will clearly show how the blossoming health of the labourers during the long period of the Simplon works was not at all due to a fortuitous coincidence but to foresight, constant thought and the rational and scientific application of science and reason to questions of hygiene. These, if you will are simple, not at all complicated but clear and understandable by everyone, but nonetheless many years went by and many lives were lost before a company arose that would implement them and make them its torch of glory. Yes, glory, which in civil society is no less than having completed the most colossal project ever carried out by man, and if in the battles of times gone by greatness was measured by the number of enemy slain, and greatness was heightened as the number of slain increased, in this battle of modern times of civilisation and work, the noblest prize is knowing how many lives were spared. And I could say nothing more eloquent than show here in dry statistics the diagram of mortality during the works of the Simplon.

Take these deaths compared to the number of the labourers who worked there and measure them against those of other companies in the past, then see if this is not the most human victory, conquered not by mere genius but also and above all by the heart. I think of the painful, sad testimony left to us by the labourers who worked on the Gotthard, their pale faces, their dull eye, their scrawny limbs hardly able to wield their work-tools. I can still see these looks poisoned by the illness, wasted away by fever working slowly without any glimmer of enthusiasm, with no impetus born of strength and with no song of joy. A worker would fall by the wayside, or at the rock-face during his labours and his companions would carry him to the hut where his family awaited an invalid or a death and where all outside was misery. In his bloodless veins, the virtues of work were snuffed out. But then I recall the happy squads of our workers at the Simplon, swift and full of life, whom I would see passing every day filling the valley with their chorus, strong-limbed, full-muscled with happy families, and I congratulated civilisation for once in a while not paying just lip service but for wholeheartedly applying the lofty noble idea of respect and love for work and life.

The Provinces of Italy to the Simplon tunnel

G. Volante

In the feverish building of railways linking cities in all of the civilised and partly civilised world which took place in the second half of last century and the early part of the this one, Italian labour undoubtedly held a leading position, and the Italian labourer was rightly sought after and appreciated. This was the cause of mass emigration from the homeland which flowed continuously from the mother country along two main channels: one towards countries overseas and the other toward regions of Europe and the Mediterranean. The complex issue of emigration has always interested scholars of social phenomena whether as a troubled mark of our economic hardships or as a normal part of the existence of a robust and fertile people seeking new ways to expand abroad. In his work on emigrants, Angelo Mosso holds that within social dynamics emigration is a war fought without weapons; it is not a haemorrhage but a fortifying remedy, not a damaging crisis but a fever of growth. However it is seen, it does not occur every day that one branch of this current, which tends to leave the country, comes up against an obstacle at the frontier which stops it and holds it back suggesting it stand still, or, in other words, that these workers, so usually willing to emigrate, find at home the work they seek abroad and earn the money for which they would cross the Alps and sail the seas. This is what occurred at the Simplon tunnel; a centre of work was created within Italy where thousands of its sons were able to sell their dynamism and energy transformed into labour at the current price of foreign markets.

As soon as the signal for work to commence was given, more than 25,000 workers came to the pleasant Ossola valley, up to the foot of Monte Leone against which the war had been declared, mixing and fraternizing in the colossal work, doubly happy not to have to leave their motherland and to be able to contribute to a task that would bring new sources of wellbeing and new horizons for trade and industry to their homeland.

This army of workers, which from 1898 to 1906 invaded and occupied the green basin of Varzo and the Iselle gorge spoke the hundred dialects of Italy, wore the thousand traditional dresses and brought the customs of all the different provinces to this far-off reach of the homeland while keeping their origins intact.

Accommodation was a difficult problem in the early days. Local inhabitants crowded together to make room for the newcomers and every cowshed and every filthy cubby-hole made inhabitable and accommodation sometimes reached exorbitant prices. But then the far-sighted company began to erect the pristine little houses which served to balance out the exorbitance of speculation and empty the hovels, placing the numerous families into comfortable accommodation all of which brought great benefits in terms of hygiene. Where the origins of the inhabitants can be seen more clearly and better, however, were the countless temporary wooden cabins, white plaster painted on the outside, which lined the Napoleonic road, transforming the green meadows with their centuries-old chestnut trees and the dry gravel beds of the river into strange villages with streets vaguely reminiscent in aspect of old Japan. Already the signs of the inns indicated where the keeper and customers came from; there was an abundance of Canavese-style eating places, Romagna-type hostelries, Tuscan-style inns etc. But most of all they were distinguished by the painting and ornamentation that decorated the façades which could be seen to have been done by the same hand, that of a wandering artist who for a few coins would depict a recollection of the far-off city of origin according to the proprietor's taste.

On the front of a cabin frequented by Tuscans the artist had painted a hilly landscape adorned with vineyards and the occasional characteristic cypress tree here and there. In a corner, set like trophies, the wine flasks with the word "Chianti" clearly written on the labels. A Piedmontese inn has a sign showing the traditional figure of Gianduia astride a barrel with the inevitable bottle of Barbera d'Asti.

The Calabrians preferred epic subjects and alongside a cabin showing two armed warriors duelling there are others which show a number of interesting scenes in the life of the legendary Musolino. There was nothing more curious than these wooden cabins whose rooms were separated by thin wooden panels, so badly connected that not only could the happenings of one room be heard in another but also be seen. Standing in a room in the middle, the deafening shrieks of babies, the yells of children playing and old people coughing would reach your ears mingled with the occasional curse in Tuscan, a whispered promise of love in Piedmontese, an argument in Romagnolo and the sad lilt of an discordant harmonica playing music for young Calabrians who were dancing keeping time by stamping the floor with their metal soled boots.

It is natural that misanthropes and lovers of a quiet life viewed these noisy lodgings askance; I observed some making their home under outcrops of rock closing them round with wood and stone. There was one patient Calabrian who built himself a little den with planks taken from packing cases of dynamite and oil. This modest hut looked terrifyingly revolutionary because every alternate strip of wall bore the legends dynamite and oil, and the haphazard planks were later discovered to conceal some tens of thousands of lire in forged banknotes that the ingenious Calabrian was busy circulating in his spare time.

Germinal by Zola gives a very good idea what can occur within the walls of such dwellings.

With some practice, the eye gains confidence in distinguishing immediately and at first sight what part of Italy the single labourers come from. Let us stand for a moment at the street corner and witness the procession of squads moving towards the tunnel. The serious *patres familias* walk together discussing blows, transporting the material mined, and patron saints while the unruly, roving young lads talk of quarrels, love and politics.

Most are dressed well and will change into working clothes in the bathrooms. They carry oil lamps which are assuredly old in fashion, eschewing the modern trend in means of illumination, but which however are cheaper and more practical.

Here, now, approaches a group of men singing; tall and strong in their wide knickerbocker trousers; with the red sash wound several times their waist, polished boots, their jackets slung negligently over one shoulder. They can be seen right away as Piedmontese and from the Canavese area in particular. They are the archetype miner. Happy and almost carefree, they go to work as though going to a celebration; they love to eat and drink well and enjoy themselves wildly from time to time. Their good nourishment naturally brings forth strength and stamina and this is why the miner from the Canavese is one of the most sought after on the labour market. Peaceful and good-natured, lovers of the family and law-abiding when he hasn't drunk too much; he becomes quarrelsome and all too ready to wield a knife when the fumes of wine begin to addle his brain.

Piedmont is the region with the highest contingent of labourers at the Simplon. Expressed in figures they amount to some 17 per cent.

Then, small and wiry, come those from Romagna. Champions at cursing and inventors of the most bizarre and unusual swear-words, but sober in eating and drinking, they take little heed of their dwelling but take pride in dressing elegantly and on feast days they are seen appropriately dressed in black with the trousers rolled up for affectation, and shod with showy, bright yellow shoes. They talk enthusiastically of politics and have set up a number of republican and socialist clubs where they love to meet, and lucky is the man who with ease of discourse manages to make himself heard and receive the applause of his companions. The provinces most represented are Forlì, Modena, Parma, Ravenna, Bologna, Reggio, Pesaro and Ancona, with a percentage of between 15 per 100 for Emilia and 9 per 100 for the Marche.

The Republic of San Marino provides approximately one worker every hundred. They come from the glebe and are mostly employed as earth movers and unskilled labourers.

After them come the Tuscans, in many way the aristocrats of the class. Their voices are loud and their pronunciation clear so that the lower classes hear the beauty of their language. They look after their homes, covering the walls with postcards and illustrated newspapers. They love Chianti wine and olive oil from Lucca. Most of the come from the provinces of Florence, Arezzo, Lucca, Massa and Pisa, in all equal to 8 per 100.

Those giants hard now on their heels now are from Bergamo.

They look a lot like the men from the Canavese but they are completely different as befits the different make-up of the region, and even different from the other Lombards like those from Pavia who they do not resemble either physically or morally. The latter resemble more the Ligurians whose region they border on and they work away from their home area in winter and then return to their fields when summer comes round again. They are parsimonious in eating and never did I see one inebriated. They do not bind easily with those from the other provinces but keep themselves to themselves and give each other mutual aid with fraternal affection. They save as much as they can and there were even some who despite earning five or six lire per day limited their upkeep expenditure to eighteen or twenty lire per month. The Lombard provinces of Bergamo, Brescia, Pavia, Mantova and Cremona supplied 14 per 100 of the workers.

Do you now see these men who come on, hurried and cold with a flimsy scarf around their necks and shoulders, looking terrified at the snowy mountain tops and icy rocky crags? They are from

Calabria and their eyes yet see their hills gilded with the sun and the limitless blue of the sea.

Obedient and respectful, they occupy the lowest rungs and are paid the poorest because since their nourishment is the poorest – mainly comprising of bread and dried figs sent to them from home – they are not tough enough and have a low resistance to work. These are the ones who were most prone to fall ill and who weighed heaviest on the resources of the Health Aid Fund. They help themselves and are bound by constraints under a chief who watches over the whole community and over each individual.

To get an idea of the unchallenged authority of these chiefs I recall that one of their number was once taken to hospital very seriously injured and died soon afterwards. Immediately, the square outside the hospital filled with a crowd claiming to be brothers and cousins of the deceased and who thronged to enter to see their loved one. Their number, however, was excessive and it would have jeopardised the other patients to let that unending flow of people in all together. I therefore took one of the more insistent ones aside, one who was an elder of the community and setting him by the door I ordered him to send the crowd back and only to let them in one at a time, and only those whom he knew to be relatives or friends of the deceased. The storm ceased as if by magic and never was a service provided with more orderliness and with fewer mishaps – all happy that I had chosen one of them to perform that task and ready to support him if others attempted to force the issue, and proud he for having deserved so much trust. In numbers, the Calabrians are 13 per 100 of the workers.

The men from the Abruzzi have much in common with the Calabrians; to use a modern term, however, I would describe them as being more evolved.

And here I would like to declare a legend false. Apart from the always numerous exceptions, it is not true that these people have no love for cleanliness and take little care of their dwellings which remained at least as clean as those of the people from other regions. They also have a developed sense of orderliness and a special feeling for linen and it was always with a sense of pride and contentedness that they offered the doctor a pristine towel with its freshly washed perfume. The sons of the Abruzzi working on the Simplon were 9 percent of the total workforce.

These two dark individuals now appearing with such elongated heads, who do not deign to keep the company of their fellows turn out to be Sardinians and, together with a handful of Sicilians, are the few representatives of Italy's islands. Their overall number is perhaps 1 percent.

The men coming after are from the region of Veneto and the provinces of Belluno, Treviso, Verona and Padova and make up 6 per 100 of the labourers. Excellent workers, they like to change jobs often and rarely stay long with the same company.

The other regions of Italy make up the remaining percentages. Lastly unruly and noisy comes the cosmopolitan squad of the so-called *leggiera*, an informal mix of the most heterogeneous provinces the ballast that makes up the workforce of this kind, always late for the train which they often miss and with it their day's wage. Unstable, always pushed by the need to change trade and country, a breeding ground for delinquency, the bane of hostelries they frequent and torment of the police stations.

But see, the little train starts up and the thick smoke at the black mouth of the tunnel swallows up this human avalanche. In there, in the dark infernal cavern all come together and mix with no distinction between provinces and dialects; men are teeming and the voices of the chiefs who guide and direct all this energy towards a single objective echo with deafening roar amidst the smoke and water.

The steel blades screech as they grind the rock away; the hammer blows echo against tools, the explosion of the dynamite shakes the bowels of the mountain and the tunnel widens, moves forward and progresses and, radiant, the genie of work is present.

The family of the miner at the Simplon

G. Volante

Again a glance before the sound dies down and the memory passes of the years spent in fatigue for which in these days Lombardy is rejoicing, and a spontaneous outpouring of affection brings all Italy close together in a new pact of peace. Again a glance at the happenings and at the people who have passed.

These recollections will also fade with time and as life goes on. Many things have been talked about; it is also worthwhile to mention a little of those men who were the means towards such a noble thing; no a blind means but an intelligent force and necessary, too. It is right and beautiful to mention, but not hyperbole or rhetoric. The statues and imagery portraying work have multiplied even too much, which is only right. As recognition of so much effort towards images and concept to see the labourers and miners of the Simplon a little, not transfigured but as they were in real life in the constant sacrifice of every day with their poverty and their maladies amongst which there also shone for the discerning eye of those who know how to observe it so much pleasant light of constancy and goodness. Whosoever thought that the families of miners were organized, directed and orderly like those of the whole civilized world and that they lived and developed thus show that they do not know how, in the midst of our so advanced life, there can live and blossom so much often beautiful and splendid vegetation. These are islands as it were, where the ancient world and less civilized man certainly, but in some ways more grandiose and beautiful than us – the man of times gone by – is still seen and appears yet with his traits and various passions. This is the way that the families of miners are made - gypsies of work, wandering tribes of warriors against the earth, they live for civilisation without them hearing but a far-off echo of its voice and without them benefiting but remotely from its fruits.

But we must make a distinction. Not all miners are like this and we need to distinguish between some castes of miners and others. There are miners who go down the mines and who generally have lasting, stable jobs and if they so wish, can stay for a long time and even their whole lives with the same company and who form a kind of corporation wholly similar to those of workers in other industries.

For them, life is easier since they know they are guaranteed a continuous job and every day that passes brings its pay. The traces of ancient man die slowly in them despite there still being an occasional glimmer and the stable home enables them to occupy themselves lovingly to the hearth and take on the semblance of modernity. But for the tunnel miner and for all those workers in general who provide their labour in constructing railways, the unfolding of life is highly different. The tempestuous wind of need takes them from job to job, from country to country, lifting them, spinning them in space and dropping them summarily from one place to another in the globe with varying fortunes.

They labour for civilisation as long as there is drought, resistance and brutality to be conquered; when the sweetness of the fruit is ready to be picked the job is finished and the miners leave the completed job, now a source of life, moving on to elsewhere to other hard wars wielding their pickaxe to broaden yet again the confines of the civilised world that they will not know and will never enjoy.

This restless nomadic life, this instability, this lack of a fixed abode and home affects all their actions and guides every act of their lives and has consequences on their families, the structure of which takes on the same features of instability and restlessness. Like the proverbial rolling stone that gathers no moss, thus the tunnel miner gathers no lasting, unbreakable affection and thus we see illicit couples which break with the same ease with which they were formed. The children born of such unions more often stay with their mother who takes them into another union and it is a tacit understanding that one maintains a mother with the children she brings along. Thus are formed extraordinary family mixtures whose members have the most unexpected family relationships and it is not unusual for pseudo wives to be regularly changed at fixed times.

The characteristically ingenuous reply of a beautiful dark, filthy little urchin seated outside at the door of a hovel busy devouring a plate of soup to my question as to whether he was the son of a certain Pietro X: "No", replied the lad with engaging simplicity. "My father is now called Giovanni". Pietro isn't my father any more – he's the father of Tonino", and grasping the spoon in his fist indicated another urchin rolling on the ground in front of another hut nearby.

A part from these unstable unions which are certainly not the rule, there are also legitimate ones. But, as Calmette and Breton have pointed out, the miner's wife is seldom a good housewife because never having a fixed abode prevents house pride ever having the time to develop, and so the will to keep the home orderly is lost. But a mother is always a mother and her love for her children is always very much alive, and they are the sole comfort and great joy that she receives. The woman's main occupation is to walk the streets with her youngest children in her arm or at her breast with the others trailing her skirts, gossiping with her friends or in the food shops, speaking badly of their neighbours or going out to meet her husband coming back from work.

Clandestine forays into the next person's field are frequent and in many inns together with board and lodgings, the man also takes his ration of favours from his wife, his daughter or from the servant girl of the master.

On this, a handsome man told me he had discovered a fast and failsafe remedy against the so-called "buzzard", the state of adynamia and torpor that breathing the fumes of the tunnel bring on when they are full of the noxious gases produced when the dynamite burns instead of exploding, and he told me about the following episode. One night a miner pecked by the "buzzard" was taken out of the tunnel and carried home at an unusual time. Lying in bed with his tender wife he was drifting between semi-consciousness and sleep as happens in cases like this when a slight noise was heard by the door as it opened slowly and a dark figure appeared. The consort then very softly said: "Go away, he's here!...". That whisper to proving the infidelity of the wife was enough to cure him immediately of all symptoms of the "buzzard". In a twinkling he was on his feet and grasping a stout stick made towards the door but to no avail save to see a dark shadow take hasty flight and melt into the darkness of the night. Full of anger, he therefore turned his displeasure on his unfaithful consort administering a goodly dose of blows on her back and shoulders and discovered how the magic power of dishonour was a cure for the "buzzard".

I make mention of these cases in passing but one can ponder how strange life can be in a world so different from ours. Imagine what the family of the Simplon miner must have been like where the most unstable and almost savage element I mention was perhaps the most common that had ever been experienced in a single village and around a single source of work. The encounters, recognitions, changes, and the infinite variety of instances spawned and fostered an endless comedy, or rather an endless series of comic instances, often happy and full of carefree joy, not infrequently repugnant and sometimes, unfortunately terrible and tragic, but always strange, unforeseen and highly different. And it is this unusualness and abnormality of the life of the miners that makes their heroic spirit of sacrifice greater, more marvellous and, I dare say, more incomprehensible. This heroic sense of sacrifice and duty that blossoms alongside the greatest vulgarity arouses admiration for the sublime acts performed by people who have to struggle constantly against everything which is stable and sacred in the civilised world. Acknowledgment of the debt we owe miners and our love for them should grow in proportion to the idea we can get of their greatness of heart which often unconsciously overflows with initiatives of great generosity while every instant of their lives is conspiring to develop their less noble instincts. How many sacrifices made almost unnoticed, how many unrecognised acts of heroism how many moving scenes we could narrate! I, who lived their lives for many years, who searched the very depths of their soul, who constantly witnessed their pain and their joy, who received on my face the breath of their conscience; I want to tell of this poverty, I want to shout these heroic acts out loud! The first, greatest and most frightening of the former is their intellectual poverty which comes of the ignorance in which they live.

The unstable and wandering existence that they conduct from their early years leaves them no time nor chance to attend school and get educated, and so in them the sad tree of illiteracy grows and flourishes. I remember when the last census was conducted having to fill in the forms for those in my hospital, 22 patients, who were there that day, all males aged from 8 to 50 and only three were able to reply affirmatively that they could read and write. This enormous percentage in a group of men that chance had brought together, gives the right idea of the frightening level of illiteracy among mining labourers. This ignorance, which they feel and measure to its whole extent in hate against those in government who neither provide for them nor consider them, is the principal cause of their unhappiness and the reef against which all their efforts and attempts at social improvement are dashed. At the Simplon, however, a highly beneficial intervention by H. E. Mons. Pulciano, then bishop of Novara immediately recognised where the fetid sore of these workers lay and with the help of the company stepped in to do what neither government nor municipality had done namely to set up model schools then followed by the Opera Evangelica which provided hundreds and hundreds of miners' children with an easy means of education and of acquiring some skills which will be a great treasure in their lives. This lucky group should bless now and for evermore those who gave them the means of rising from the infected morass of ignorance by setting up and maintaining schools and also to him who, with much love and self denial, directed them and whom premature and tragic death took away from us, namely the priest A. Vandoni, the true type and embodiment of the hero so dear to Ada Negri for the unhappy peoples of Vesuvius and Calabria. This scant idea is the last salute to the obscure priest who, with admirable constancy and love, bore the sacrifice of each day, fatigue without rest to bring to the unkempt children of the poor miners the priceless benefit of civilisation and education and the word of peace and love to where others from the civilized world had come from time to time bringing only ideas of hatred and vengeance. I say this because people so different from us, those who really love them, should understand how important it is to gather them in to the heart of civilisation hour by hour with the patient work of years, and understand also how risky it is to suddenly throw doctrines in their midst which they cannot fully understand nor can they accept save according to their nature which leans more towards rapid action than to patient organisation.

In addition to intellectual poverty we have seen stories of physical poverty parade before our eyes, in which cursed syphilis and alcohol had left their tremendous mark, not to mention the damage caused by work itself – the traumas, injuries and deaths. A mason who falls from a scaffolding a mechanic overcome by his machinery are assuredly tearful and terrible occurrences but how much more frightening is death when it appears in the dark of the bowels of the earth and if what Foscolo sings is true

… *gli occhi dell'uom cercan morendo* – the eyes of the man in death seek out
il sole, e tutti l'ultimo sospiro – the sun, and with their last breath do
mandano i petti alla fuggente luce, – turn their breast to the fading light

what an enormous and impenetrable diaphragm blocks the eye of the dying man from the rays of the sun, the face of his mother, his spouse, his children who, at the tunnel's mouth and knowing his tragic fate, fix their eye and try to penetrate the murk with their desolate glance to reach the victim! And the train arrives and exits silently, his companions descend in silence and amidst the heartrending sobs of the family the stretcher is raised by strong arms and rested on the shoulders of these vigorous, naked torsos worthy of being a model for the genius of Rodin; then slowly do they proceed forward.

But much more terrible for the disastrous economic consequences on the family is death by illness which brooks no claims, no monetary indemnity as happens for death by injury. When the working head of a family dies, the pillar supporting the whole building collapses, the keystone is broken and everything crumbles and dissolves. Far from all the centres where charity is an institution, in unknown lands with no support and no acquaintances, the survivors can hope for nothing from the municipality, very little from public charity and the miner's family is dispersed like the leaves that the mindless wind blows away.

But at the Simplon, the favourable conditions of hygiene in which the company placed the worker, seeking by every means to keep him there, mortality among miners never exceeded the normal average and the survivors were always given generous moral and financial help by the company.

I close these few lines with a wish – a wish for the great family of workers on tunnels and for the fatherland, namely that companies like these come forth and multiply and together with profit bring forth the philanthropic spirit that drove the illustrious components of the Società per il Traforo del Sempione – Brandt, Brandau, Sulzer and Locher, who, together with economic and physical well-being, also thought of the moral uplifting of the labourer not merely perceiving him as a passive, blind tool of work but an effective, intelligent co-operator with their company.

La Medicina del Lavoro Med Lav 2006; *97*, 2: 125-131

OSH and globalisation, challenges for today

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Key words
Health services; risk at work; global burden

Summary
Globalisation is a phenomenon that concerns all countries in the world at every level: economic, of course, but also political and cultural. It is hard to see any alternative to the dominant market economy model, which is asserting itself as the only way towards wealth and value creation. And within this model, it is free enterprise, generating jobs and boosting consumption, that is the unequivocal model of development for the world's economies. How can we then address the question of occupational safety and health (OSH) within the context of globalisation? How can we ensure that worker protection is not relegated to the status of a secondary concern? Safety and health inequalities between countries are such that it seems difficult to state without being hypocritical that OSH is already a value in the globalised world. The number of occupational accidents and diseases remains at a disturbingly high level, especially in developing countries. The sectors most affected are traditionally heavy industry, agriculture, mining and construction. In these sectors, there is so much economically and financially at stake that the obligation to protect workers' health is often viewed as a constraint, at odds with the requirement of immediate profitability. I sincerely believe that the prevention of occupational risks really has a different meaning depending on whether you work in an SMU or a large corporation. And, of course, depending on whether you live in a country with a high level of social protection, or one where social insurance is considered a luxury only for the richest. And the globalisation of trade is tending to further increase this gap. We have therefore elected to state that occupational safety and health "cannot be taken for granted" in a globalised world and that there are challenges facing all those, whether officials in institutions or managers of a business, who believe that working in a decent environment is a non negotiable demand.

Riassunto
«Prevenzione e globalizzazione, le sfide di oggi». *La globalizzazione è un fenomeno che riguarda tutti i Paesi del mondo ad ogni livello: economico, naturalmente, ma anche politico e culturale. E' difficile vedere una alternativa al modello dominante di economia di mercato, che si sta affermando come l'unica strada verso la creazione di benessere e di guadagno. E nell'ambito di questo modello, c'è la libera impresa, che genera occupazione e consumo, che è il modello inequivocabile dello sviluppo per l'economia mondiale. Come possiamo allora impostare la questione della sicurezza e della salute occupazionali nel contesto della globalizzazione? Come possiamo assicurarci che la protezione del lavoratore non sia relegata a livello di preoccupazione secondaria? Le disuguaglianze tra i vari paesi nell'affrontare la sicurezza e la salute sul posto di lavoro sono tali che sembra difficile dichiarare senza essere ipocriti che queste siano già un valore del mondo globalizzato. Il numero di infortuni e di malattie dovute al lavoro resta su*

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livelli così elevati da allarmare, specialmente nei Paesi in via di sviluppo. I settori che ne sono tradizionalmente affetti sono l'industria pesante, l'agricoltura, l'estrazione mineraria e l'edilizia. In questi settori, c'è così tanto in gioco dal punto di vista economico e finanziario che l'obbligo di proteggere la salute dei lavoratori è spesso considerata come una costrizione, in contrasto con gli obiettivi di profitto immediato. Io credo sinceramente che la prevenzione dei rischi occupazionali abbia realmente un diverso significato a seconda che si lavori in una piccola-media impresa o in una grande impresa. E, naturalmente, a seconda che si viva in un Paese con un alto livello di protezione sociale, oppure in un Paese dove l' assicurazione sociale è considerata un lusso riservato ai più ricchi. E la globalizzazione del commercio tende ad aumentare ulteriormente questo divario. Pertanto bisogna affermare che la sicurezza e la salute sul lavoro "non possono essere date per scontate" in un mondo globalizzato e che ci sono sfide che attendono tutti quelli, siano essi pubblici funzionari o managers, che credono che lavorare in un ambiente decente sia una richiesta non negoziabile.

The phenomenon of globalisation concerns all countries in the world at every level – economic, naturally, but also political and cultural. There appears to be no alternative to the dominant market economy model that has asserted itself as the only means of wealth and value creation. And within this model, it is free enterprise, creating jobs and encouraging consumption, which constitutes the unequivocal model for the growth of global economies.

Following a brief overview of the OSH situation, I will set out what appears to me as the main challenges facing occupational safety and health, namely the economic approach to this question, the impact of globalisation on our OSH systems and the change in the very notion of what is meant by "work".

A GENERAL OVERVIEW OF THE CURRENT STATUS OF OSH

Inequality between countries

How should we be addressing the issue of occupational safety and health in the context of globalisation? How can we ensure that worker protection is not relegated to a concern of secondary importance? The inequalities with respect to occupational safety and health between countries are such that it seems difficult to say without hypocrisy that OSH is **already** a value in a globalised world.

Occupational accidents and diseases

The issue of occupational safety and health is therefore of acute importance today. Is it necessary to remind ourselves that workers around the world are subjected to conditions endangering their safety, their health and sometimes even their lives?

In developing countries the number of occupational accidents and diseases remains at a disturbingly high level. The sectors most commonly concerned are heavy industry, farming, mining and construction.

In Europe on the other hand the number of occupational accidents is declining in overall terms, but it is the number of recognised occupational diseases that is on the increase, in some cases massively.

The situation in this area therefore varies enormously depending on the level of economic, social and political development of the country concerned.

The changing nature of risks

In addition there is a more general, across-the-board change in the nature of occupational risks. Emerging risks, such as psycho-social or organisational factors, are tending to become major risks in more advanced countries.

But there still exist, especially in less developed countries, the traditional risks linked to industrial, mining or agricultural activity.

Moreover, occupational accidents or diseases have multiple causes: multifactor approaches to occupational safety and health are the big challenge for OSH bodies today. It is known for instance that musculoskeletal disorders affect western and less developed countries equally. There is talk of an MSD epidemic, and the truth of the matter is that there is no miracle remedy, or ready-made solution that can prevent these diseases.

OSH and social security

Health and safety measures to prevent occupational risks are already an integral part of a comprehensive social security policy, acknowledging that worker protection is an unchallengeable principle. What would be fair and equitable in this respect would be to achieve the same level of protection for all workers, whatever their job, in whatever country in the world.

But let us not be naïve, working conditions in fact generate one of the greatest forms of inequality and injustice. And even if this is a problem usually associated with developing countries, there are still a good number of developed or middle-income countries with coverage and safety problems. It is even debatable whether social protection is advancing or retreating in these countries.

I sincerely believe that occupational safety and health has a different meaning depending on whether you live in a country with a high level of social protection, or one that considers that social insurance is a luxury only for the rich. And the globalisation of trade is tending to accentuate this contrast.

When you look at the size of a company, the issue is formulated in different terms. Most major corporations show themselves internationally in their most virtuous light – from Asia to the United States, they say, the same standards of occupational safety and health apply. Principles such as sustainable development and corporate social responsibility are currently highly fashionable, because they link profitable business to an acceptable level of protection for workers. But is this in fact anything other than a clever marketing strategy?

Producing more, at lower cost, and just in time, often means cutting corners on the quality of working conditions. How then can it be stated that OSH is a value, when the only indicators of a "healthy" business are those found in its profit & loss statement?

OSH AND ECONOMIC POLICY

OSH and regulations

The question of occupational safety and health has in recent years taken a very technical and economic turn, in that the issue is being debated almost entirely in terms of cost-effectiveness.

Occupational safety and health continues to be presented as being in opposition to profit. It is true that national labour regulations have imposed occupational safety and health obligations on businesses and to a certain extent constitute a restriction on free enterprise. There is a now famous saying in France that freedom stops where the labour code begins. The fact is that these laws and regulations are not seen as fostering competitiveness, but as a purely legal requirement.

Even more importantly, there are many who consider that compliance with regulations is the same as implementing occupational safety and health. There was a survey in France last year which showed that for business managers being OSH-conscious meant applying regulations and nothing more. The fear of accidents or inadequate practices which can turn into health scandals, the fear of being involved in the sort of court cases occurring increasingly around the world (I am thinking for example of asbestos) – all of this creates an atmosphere in which everyone is constantly talking about occupational safety and health. But what it really means is simply complying with strictly minimum legal requirements.

The cost of occupational safety and health

One of the most profound changes that globalisation has imposed upon the traditional conception of occupational safety and health is that the original ideals of OSH systems, such as social justice and public health, are gradually giving way to an economic perception of occupational safety and health. The way in which these concepts were applied traditionally was based on the principle that "health is priceless"; and it is this principle that the globalisation of trade is now challenging.

The "ISSA Initiative" conference, held in Vancouver in September 2002, gave a pertinent summary of these aspects: *"As a consequence, member organizations continued to be concerned about the imbalance in the ongoing debate about social security. It seemed to remain purely a discussion of economic costs, without any discussion of the economic and social benefits derived from good social security schemes"*.

The challenge that lies before us today in my view is partly linked to this approach – how will it be possible to enforce worker safety and protection measures in countries that are less advanced in OSH terms if the only argument being used is the cost of such measures and the risk of loss of competitiveness that their introduction entails? We see here the two sides of globalisation – both progress through the increased trade movements that it allows, and the risk, for developing countries, of forming a zone with less-demanding OSH requirements, where practices outlawed in developed countries are authorised.

The economic and financial stakes in a globalised world are so high that the obligation to protect workers' health is too often considered in our own countries as a constraint, and at odds with the need for immediate profitability.

But this is in my view a completely wrong-headed approach to the problem. It is rather up to us as OSH specialists to argue in terms of the costs of occupational safety and health in order to show that improving OSH systems makes good business sense, not only for our societies as a whole, but also for businesses themselves. It is even more vital to demand not just safety in the companies where we work, but also that this safety be competitive and not endanger the organisation's ability to compete both at home and abroad.

The fact is that total economic losses due to occupational disease and injury are huge and constitute an additional burden hampering economic development. Occupational safety and health is not just a question of ethics, it is also a factor in business profitability. Indeed there are recent studies showing that occupational accidents and diseases cost national economies between 1.5% and 4% of gross domestic product.

Safer workplaces and healthier workers are essential elements of the European Social Model and contribute to improving European competitiveness and productivity.

NIMBY

The danger is one that is unfortunately only too well known: the NIMBY (Not in my backyard) phenomenon, otherwise termed delocation or exporting risk. Delocation is one of the main consequences of globalisation and in the area of occupational safety and health it raises the question of how to adapt national systems to international challenges. For developing countries exporting risk is a tempting and perverse way of complying with OSH regulations. One cynical means of solving the problems for an organisation consists in setting up its production facilities in countries that are less developed in terms of occupational safety and health. And these are in fact the same countries in which work is not – yet, hopefully – perceived in OSH terms. The level of socio-economic development and working conditions are such that workers are subjected to the pressure of "work at any cost", and at any risk.

However seeking to create a level playing field should not involve the transfer of risk or dangerous practices but rather the transfer of occupational safety and health requirements at the same time as the work itself is transferred. At the very least efforts should be made to avoid increasing inequalities, and, without a doubt, even doubtless to try to reduce them.

The European chemicals industry points with satisfaction to a historically low accident level; it can be congratulated, but we should also not forget that most of its "high-risk" activities have been exported to India or China, as shown by the trials and tribulations of a famous French aircraft carrier…

OSH AND GLOBALISATION

We have therefore elected to state that occupational safety and health "cannot be taken for granted" in a globalised world and that there are challenges facing all those, whether officials in institutions or managers of a business, who believe that working in a decent environment is a non negotiable demand.

At the same time however we can observe a convergence of technologies in which scientific and technical know-how, training and skills are becoming more and more transferable.

This means that an exclusively national approach to production systems is less and less relevant. In the same way, our OSH systems cannot make do with the restrictions of a national framework and must take the globalisation parameter on board, even perhaps in the way they are designed.

The interdependence of economies, the huge growth in international trade and the increased competition this brings with it are all reasons that explain what sociologists refer to as the "loss of bearings", and which affects both workers and the organisations they find themselves in.

New patterns of work

One of the main effects of this phenomenon can be found in the notion of flexibility. The traditional system of occupational safety and health was based on the direct and lasting bond between the worker and the organisation.

In France for example, but also in the rest of Europe, the law has held the company manager solely responsible for his workers' safety and health.

With the trend towards globalisation and increased competition however, organisations have tended to adopt very flexible systems of labour and people management, using temporary, contract staff, which is by nature unstable.

In such a context, the link created between the worker and the organisation is contrary to the balanced and lasting relationship needed to develop an occupational safety and health policy.

Social demand

At the same time the demand in our western societies for occupational health and safety has both increased and widened.

Increased, in that occupational accident and disease risk acceptability rates have developed in inverse proportion to their actual frequency. It has become socially intolerable to die as a result of one's job – doubtless the paradoxical effect of the constant decline in the number of accidents – or to fall ill because of it.

Widened, also, inasmuch as the social demand for occupational safety and health does not only relate to people who are workers, but also to the environment, as if globalisation has created the fear, whether real or imagined, that business and industry are irreversibly damaging the more visible balance of nature.

The notion of "sustainable development" is the reflection of this social demand attempting to form itself into an international system.

The impact of globalisation and its technical and scientific repercussions on the world of work is such that it represents nothing less than a redefinition of the very notion of work.

The new approach to work

In addition to "classic" occupational safety and health issues such as the risks related to manual handling, falls, road traffic accidents and asbestos-related diseases, new problems are constantly emerging, either because of the speed of scientific and technological development, or because of changes in society itself, and, in particular, changes in the social acceptance of occupational risk.

The continuous emergence of new risks coupled with increasingly rapid obsolescence of technologies and processes make it necessary to enhance our ability to monitor and anticipate so as to be able to prevent these risks before workers fall victim to them.

This clearly implies a profound change in the very notion of work itself, its significance and value within our societies.

For workers themselves, work is becoming increasingly intellectual and abstract (e.g. through automation and remote operation of tools and machinery). It is true that the spread of new information and communication technologies, which have driven as much as they have emerged alongside globalisation, has meant that some tasks are less strenuous than they were (handling and carrying loads, for example). It has also led to the creation of new skills, mainly in terms of information management. But it has also meant that workers are more isolated than before, and that the organisation of work has been redefined – it is not unusual for those who take the decisions not to be in the production facility itself, but several thousand miles away, which makes a considerable difference to the way in which workers and even management perceive the purpose of the job they are doing.

In the same manner, the ever greater use of outsourcing, which seeks to entrust to specialists those tasks which are not part of the organisation's "core business", introduces a form of competition among workers, who, though they work at the same location, belong to different companies, and do not have the same status or form of organisation.

These new patterns of work and this organisational change lead to a new approach to OSH techniques and to emerging problems. Issues such as stress, psychological stress load and musculoskeletal disorders are now on the research agenda of every OSH body. The man-machine relationship at work, which for decades was the focus of our research activity, is gradually being overshadowed by the relationship between people, or between people and the organisation.

Work/employment/profession

We must realise that occupational safety and health is the main challenge in a globalised world. What does that actually imply? That working is not exactly the same thing as having a job or being employed. The fact is that a worrying semantic shift tending to make the two synonymous is currently observable. In France for example, we already no longer have a ministry of labour or work, but a ministry of employment.

Having a job means being an anonymous and interchangeable part in the great global economic and financial construct. In times of unemployment the top priority of all policies is to facilitate job creation and help young people have access to jobs.

Working however is somewhat more than just that, involving a more complex human investment, consisting of a set of skills, routines and practices, continuous learning and permanent negotiation between what the organised production system has prescribed and the operator's independence. Working is in some way about working out the little arrangements that provide the leeway that distinguishes the operator from the machine. Put in different terms, working is not just about having a job, but also practising a profession.

And this is why the question of preservation of health, from the point of view of work and not from the point of view of employment, is not just a question of profitability…

What is globalised OSH?

I said at the beginning of this presentation that one of the challenges of globalisation was to ensure that occupational safety and health was not treated as the poor relation of corporate policies. The time has now come to add that "globalised occupational safety and health" must itself confront a new challenge: its future lies no doubt not so much in safety and health as in "occupational well-being".

On the whole, working has never been safer in our western societies. But at the same time, risk has become intolerable. More specifically, its "scope of relevance" has shifted – zero risk at the workplace, risk-taking accepted in the private domain, and intrusion of environmental or public health issues into that of occupational safety and health…

There are various questions being asked today which all concern the extension of the notion of "risk" in our society. For some years now we have seen how the debate about occupational risks has become one involving not just those most directly affected (workers, company managers, experts, government), but one in which civil society insists on shaping the definition of risk itself. This inevitably leads to increasing confusion between occupational risk in the strict sense and the other kinds of risk that society is exposed to.

Recent industrial or ecological disasters, such as the shipwreck of the Erica on the coast of Brittany and Vendée, the explosion of the AZF plant in Toulouse, human contamination by BSE, the risk of avian flu and the problems with asbestos, have placed new issues in the centre of social and political debate, all of which have a link to occupational safety and health, but which tend to broaden the scope of that field. The question we have to face today is: how are we to define our role as specialists of occupational safety and health, without overstepping the limits of our competencies, whilst at the same time giving due consideration to the interdependence of risks?

OSH and civil society

Civil society's increasing participation in the debate on risk acceptance forces us to reconsider what areas our knowledge should encompass and the scope of its relevance. Monitoring, whistle-blowing, precautionary principle and risk acceptability are all new concepts that we must learn to make an integral part of the way we work.

All of this indicates that changing social behaviour, sometimes even private behaviour, has a genuine impact on occupational safety and health. This is one of the reasons why OSH now finds itself at the intersection of fields such as public health and environmental protection.

The world has clearly become so complex that neither the citizen, the politician, the scientist nor the expert alone can understand or explain it. It is the notion of progress that emerged defeated at the end of the 20th century. No one now believes that technology leads to progress or is a prerequisite for it. Indeed, there has been a brutal backlash against technology which is blamed for most of our contemporary fears:

– high-tech foods (a few decades ago all the talk would have been of advances in food supply, both quantitative and qualitative) = fear of toxic foods (GMOs);

– development of communication technologies = fear of harmful radiation from mobile phones, for example.

At the same time there is a growing feeling of nostalgia and concern for the loss of nature – technology has supplanted it to such an extent that the term "techno-nature" seems appropriate. Heidegger saw in technology what he called a *pro-vocation* of nature, i.e. not serene confidence in the power of nature, but maximum use of it at minimum cost.

Against this background both politicians and scientists are virtually at a loss as to how to satisfy the social demand, since it is by definition contradictory: it desires technology, for the way it makes our lives easier, but not the risks inherent in its development.

"This will to be master becomes ever more insistent the more technology threatens to escape man's control". (Heidegger)

Conclusion

The challenges of occupational safety and health in a globalised world are obviously many and complex. I will not go back over everything I have just explained at some length. I will finish with a few thoughts. We are currently observing a chain reaction transformation of the economy, our societies, the notion of work and risk. It is hard for us to carry on with business as usual in our traditional OSH activities. But it would be a clever man indeed who had a clear vision of the kind of occupational safety and health that needs to be invented.

La Medicina del Lavoro Med Lav 2006; *97*, 2: 132-136

The changing nature of work: workplace stress and strategies to deal with it

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Key words
Stress; job insecurety; prevention

Summary
Workplace stress is costing the developed and developing world roughly between 5-10% of Gross National Product per annum in sickness absence, premature retirement due to ill health and lost productive value in terms of services and products. In addition, it is costing the health services of countries an additional burden in terms of treatment and incapacity benefits. A three prong approach to stress management and prevention is provided, exploring primary interventions (risk assessment), secondary interventions (training and development) and tertiary interventions (stress counselling and support).

Riassunto
«*Il cambiamento del tipo di lavoro: lo stress occupazionale e le strategie per affrontarlo*». *Lo stress presente nei luoghi di lavoro sta costando ai paesi industrializzati ed a quelli in via sviluppo approssimativamente tra il 5 ed il 10 % del prodotto interno lordo annuale a causa delle assenze per malattia, pensionamenti prematuri dovuti a problemi di salute e produttività persa in termini di servizi e produzione. Inoltre lo stress sta richiedendo ai servizi socio-sanitari una spesa supplementare in termini di assistenza medica e di benefici per invalidità. Viene proposto un triplice approccio alla gestione dello stress e alla sua prevenzione mediante interventi di primo livello (valutazione dei rischi), secondo livello (formazione e sviluppo), e di terzo livello (councelling e supporto psicologico per la gestione dello stress).*

The enterprise culture of the 1980s and the 'flexible workforce' of the 1990s helped to transform economies in Western Europe and North America. But, as we were to discover by the end of these decades, there was a substantial personal cost for many individual employees. This cost was captured by a single word – stress. Indeed, stress has found a firm a place in our vocabulary as fast foods, texting and blackberrys. We use the term casually to describe a wide range of aches and pains resulting from our hectic pace of work and domestic life. "I feel really stressed" someone says to describe a vague yet often acute sense of disquiet. "She's under a lot of stress", we say when trying to understand a colleague's irritability or forgetfulness. "It's a high-stress job", someone says, awarding an odd

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sort of prestige to his or her occupation. But to those whose ability to cope with day-to-day matters is at crisis point, the concept of stress is no longer a casual one; for them, stress can be a four-letter word – pain (3, 4).

The cost of stress

These excessive pressures in the workplace have been very costly to business. For example, the collective cost of stress to US organisations has been estimated at approximately $150 billion a year. In the UK, stress costs the economy an estimated 5-10 per cent of GNP per annum. In 2004, the Chartered Institute of Personnel and Development in the UK (the professional association of HR professionals) found that workplace stress accounted for the largest amount of long term sickness absence in the UK economy than from any other cause. If some of the other stress-related categories are added (poor workplace morale, impact of long hours, personal problems) it is the most significant bottom line cost to UK plc. The same costs have been found as well across many other European countries, particularly in countries undergoing major economic structural change (8, 7).

Since the industrial revolution, every decade has had its unique defining characteristics. Innovation and challenging the established norms of society epitomised the 60s; industrial strife and conflict between employer and employee the 70s; the 'enterprise culture', with its strategic alliances, privatisations and the like, the 80s; and the short-term contract culture, with its outsourcing and downsizing and long working hours culture, the 90s and early 2000s.

We are seeing the Americanisation of Europe spreading throughout the continent. This trend toward what is euphemistically called the 'flexible' workforce', originated in the UK. Britain led the way in Europe towards privatising the public sector in the 80s. Its workforce was substantially downsized during the recession of the late 80s and early 90s. Outsourcing many of its corporate functions, it left the recession behind in the early 90s, faster than its European counterparts. However, this scenario of 'leaner' organisations, intrinsic job insecurity and a culture of longer working hours are beginning to have an adverse effect on employee attitudes and behaviour.

A major Quality of Working Life survey (11) of a cohort of 5000 British managers found that these changes – downsizing, outsourcing, delaying and the like – led to substantially increased job insecurity, lowered morale and, most important of all, the erosion of motivation and loyalty. These changes were perceived to have led to an increase in profitability and productivity, but decision-making was slower and the organisation was shown to have lost the right mix of human resource skills and experience in the process.

More worrying, in respect of this trend, was the major increase in working hours and the impact of this on the health and well being of managers and their families. The survey found that 81 per cent of executives worked more than 40-hour weeks, 32 per cent more than 50 hours and 10 per cent more that 60 hours a week. Also, a substantial minority frequently worked at weekends. This trend has remained even over the last 5 years, with the latest Quality of Working Life survey (12) showing a sustained lack of employee well-being even (and maybe partly as a result of) continued economic growth.

What is so disturbing about this trend towards a long-hours culture is the managers' perception of the damage it is inflicting on them and their families. The survey showed that 71 per cent of the executives reported that these long hours damaged their health; 86 per cent said that they adversely affected their relationship with their children; 79 per cent that they damaged their relationship with their partner and 68 per cent that long hours reduced their productivity.

Another manifestation is the increasing level of job insecurity. Historically in Europe, very few white-collar, managerial and professional workers have experienced high levels of job insecurity. Even blue-collar workers who were laid off were frequently re-employed when times got better. The question that we have to ask is 'can human beings cope with permanent job insecurity?'

In the past the security and continuity of organisational structures also provided training, development and careers. This substantial decline in perceived job security was coupled with a large decline in employee satisfaction in terms of employment security (6).

The big questions about the developments are: is the trend toward short-term contracts, long hours and intrinsically job-insecure workplaces the way forward for us? How will this affect the health and well-being of employees? Can organisations continue to demand commitment from employees they don't commit to? What will this long hours culture do to the two-earner family, which is now the majority family in the UK? In comparative terms, the UK economy is doing remarkably well, but the levels of job insecurity and dissatisfaction are high and growing. Developing and maintaining a 'feel good' factor at work, and in the UK economy generally, is not just about the bottom line factor – profitability. In a civilised society the feel good factor should include quality of life issues as well, like hours of work, family time, manageable workloads, control over one's career and some sense of job security (1).

A STRATEGY FOR MANAGING STRESS IN A CHANGING WORKFORCE

How should organisations manage the pressures currently experienced by their employees in a changing workplace culture? Cartwright & Cooper (1997) (2) suggests a three-pronged strategy for stress management in organisations. For the prevention and management of stress at work, the following three approaches could provide a comprehensive strategic framework: primary (e.g. stress reduction), secondary (e.g. stress management) and tertiary prevention (e.g. employee assistance programmes/workplace counselling).

Primary prevention is concerned with taking action to modify or eliminate sources of stress inherent in the work environment, so reducing their negative impact on the individual. The focus of primary interventions is in adapting the environment to 'fit' the individual.

Possible strategies to reduce workplace stress factors include:

– redesigning the task;
– redesigning the working environment;
– establishing flexible work schedules;
– encouraging participative management;
– including the employee in career development;
– analysing work roles and establishing goals;
– providing social support and response;
– building cohesive teams;
– establishing fair employment policies;
– sharing rewards.

Primary intervention strategies are often a vehicle for culture change. The type of action required by an organisation will vary according to the kind of stress factors operating. Any intervention, therefore, needs to be guided by prior diagnosis or a stress audit, or risk assessment (using something like ASSET, an organizational stress screening tool; (5), to identify the specific factors responsible for employee stress.

Secondary prevention is concerned with the prompt detection and management of experienced stress. This can be done by increasing awareness and improving the stress management skills of the individual through training and educative activities. Individual factors can alter or modify the way employees, exposed to workplace stress, perceive and react to their environment. Each individual has his or her own personal stress threshold, which is why some people thrive in a certain setting and others suffer.

Awareness activities and skills training programmes, designed to improve relations techniques, cognitive coping skills and work/lifestyle modification skills (e.g. time management courses or assertiveness training), have an important part to play in extending the individual's physical and psychological resources. The role of secondary prevention is, however, one of damage limitation. Often the consequences, rather than the sources, of stress, which may be inherent in the organisation's structure or culture, are being dealt with. They are concerned with improving the 'adaptability' of the individual to the environment. Consequently, this type of intervention is often described as 'the band aid' approach. The implicit assumption is that the organisation will not change but continue to be stressful, therefore, the individual has to develop and strengthen his or her resistance to that stress.

Tertiary prevention is concerned with the treatment, rehabilitation and recovery process of individuals who have suffered, or are suffering, from serious ill health as a result of stress (9).

Intervention at the tertiary level typically involves provision of counselling services for employee problems in the work or personal domain. Such services are provided either by in-house counsellors or outside agencies, which provide counselling, information and/or referral to appropriate treatment and support services. There is evidence to suggest that counselling is effective in improving the psychological well being of employees and has considerable cost benefits.

Counselling can be particularly effective in helping employees deal with workplace stress that cannot be changed. It can also help non-work related stress (e.g. bereavement, marital breakdown etc.) which tends to spill over into work life.

The future

The pressures on all of us are likely to get worse. Stress is primarily caused by the fundamentals of change, lack of control and high workload. Increasing cross-national mergers, greater international competition and joint ventures between organisations across national boundaries, will lead inevitably to a variety of corporate 're-s': re-organisations, re-locations of personnel, re-designs of jobs and re-allocations of roles and responsibilities.

Change has been the byword of the first part of this millennium, with its job insecurities, corporate culture clashes and significantly different styles of managerial leadership – in other words, massive organisational change and inevitable stress. In addition, change still brings with it an increased workload as companies try to create 'fighting machines' to compete in international economic arenas. This will mean fewer people performing more work in more job-insecure environments.

Finally, as we move away from our own internal markets and enter larger economic systems, individual organisations will have less control over business life. Rules and regulations are beginning to be imposed in terms of labour laws; health and safety at work; methods of production, distribution and remuneration and so on. These are all laudable issues of concern in their own right, but, nevertheless, these workplace constraints will inhibit individual control and autonomy.

Without being too gloomy, it is safe to say that we have, at the start of this millennium, all the ingredients of corporate stress: an ever-increasing workload with a decreasing workforce in a climate of rapid change and with control over the mans of production increasingly being exercised by bigger bureaucracies.

It appears, therefore, that stress is here to stay and cannot be dismissed as simply a bygone remnant of the entrepreneurial 1980s. The challenge for senior management and occupational health in the future is to understand a basic truth about human behaviour that developing and maintaining a 'feel good' factor at work and in our economy generally is not just about 'bottom line' factors (eg. higher salaries or increased profitability). It is, or should be, in a civilized society, about quality of life issues as well, such as hours of work, family time, manageable workloads, control over one's career and some sense of job security. As the social anthropologist Studs (10) suggested "Work is about a search for daily meaning as well as daily bread, for recognition as well as cash, for astonishment rather than torpor, in short, for a sort of life rather than a Monday through Friday sort of dying".

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Med Lav 2006; *97*, 2: 137-142

Aging and globalization

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KEY WORDS
Aging; globalization; worker health

For those of us focused on the interaction of work and the aging process it is important to examine this concern in a global economic context. Current demographic predictions suggest that the global population growth rate has been and will continue to slow due to a decline in total fertility rates while, at the same time the global population will continue to age due to world-wide improvements in health that result in a rising life expectancy (figure 1). On the surface it would appear, therefore, that all nations are facing or will soon face the common problem of an increase in the dependency ratio (proportion of working age population to total population). The most direct response to these trends might be to embark on efforts to have older workers remain at work later into life than would have resulted were the 20th century social programs that support earlier retirement fully implemented. For instance, changes in government regulations in the United States have already extended the age of eligibility for retirement pensions. In Finland some attention has been devoted to improving the work environment to reduce adverse impacts on older workers who do remain actively employed.

It is important, however, to keep in mind that the rate of growth and timing of populations aging varies widely among countries. In general terms we can expect the workforce to continue rapidly aging across the richer industrialized countries, a result of the post-World War II "baby boom" and subsequent "baby bust" that followed. Over the next decade we will be entering the period for these nations when that large baby boom population begins to retire. The resultant impact will be a rising dependency ratio in the developed world (figure 2). By contrast, for the developing world, the relative size of the working age population can be expected to increase, a consequence of reduced infant mortality and generally better nutrition and sanitation, but little change in the dependency ratio due to increased aging of the population. Of course, even these changes vary widely within the developing world.

It would be a mistake, however, to see these trends only through the lens of the aging workforce in the industrialized world. We must examine how these changes will impact the world's older population in a period of increasing globalization. The phenomenon of globalization is not new. Rather, as

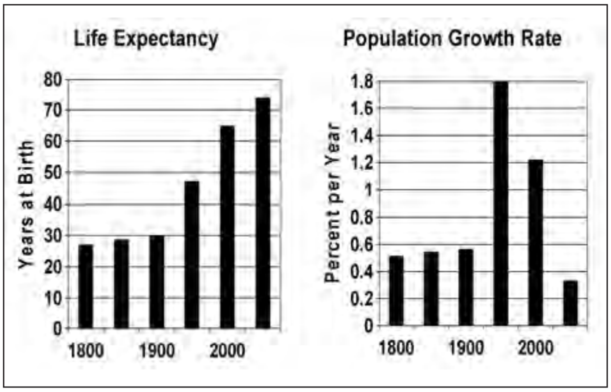

Figure 1 - World demographic transition from 1800 through 2050 (projected) (adapted from reference 4)

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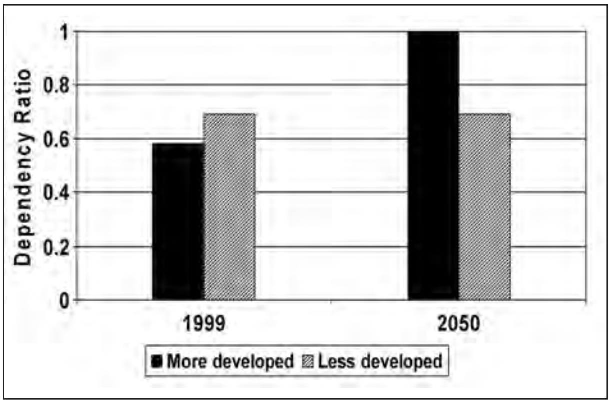

Figure 2 - Dependency ratio by development category - dependency ratio is defined here as: (<15 year olds + >60 year olds) ÷ 15-60 year olds (adapted from reference 7)

Sen notes, "[Globalization] is largely an intensification of the processes of interaction involving travel, trade, migration and dissemination of knowledge that have shaped the progress of the world over millennia" (6). It has, however, attracted special attention since the late 1990's with the increasing world-wide integration of markets for goods, services and capital along with a variety of changes that were perceived to occur at about the same time, such as an increased role for large corporations in the world economy and increased intervention into domestic policies and affairs by international institutions such as the International Monetary Fund, the World Trade Organization and the World Bank.

Globalization in the current era promised to include improvements for all society through privatization, de-regulation, "flexible" labor markets, and "free" trade. In recent years there has been a vigorous debate about whether or not these promises are or will come to fruition. Again, Sen provides a thoughtful perspective:

"[T]here is extensive evidence that the global economy has actually brought prosperity to many different areas of the globe. The productive and economic contributions of global integration can scarcely be denied. But we also have to recognize the enormous inequalities that exist across the globe and often within each country. Doubts about global economic relations come from different ends of the globe, and they are in this sense "global doubts" - not just an assortment of local opposition. We have to examine the manifest inequalities and disparities that give these global doubts the political salience they undoubtedly have. What is needed is not a rejection of the positive role of the market mechanism in generating income and wealth, but the important recognition that the market mechanism has to work in a world of many institutions. We need the power and protection of these institutions, provided by democratic practice, civil and human rights, a free and open media, facilities for basic education and health care, economic safety nets, and, of course, provisions for women's freedom and rights - a neglected area which is only now beginning to receive the attention it deserves" (6).

Balancing the generation of income and wealth with the power and protection of social institutions and effective government is a challenging task. The United Nations has adopted Millenium Development Goals to renew its 60-year-old pledge to free future generations from the scourge of war, to protect fundamental human rights and "to promote social progress and better standards of life in larger freedom". These were adopted in recognition of the continuing need to balance the positive economic impacts of globalization with greater equity, social justice and respect for human rights. The Human Development Report for 2005 established a baseline and the task is large. At present one in five persons in the world lives on less than 1 US Dollar a day and another one in four live on between 1 and 2 US Dollars per day (9). This is the global underclass, more than 40% of the world's population.

Adequate opportunities for safe and healthy work will play a critical role in addressing world poverty. However, when examining the workforce, the ILO estimates this almost 50 per cent of the world's workers (and almost 60 per cent of the developing world's workers) are not earning enough to lift themselves and their families above the US$2 a day poverty line (2). These facts are all the more important because a low level of income is often accompanied by little or no access to adequate health care, education, proper sanitation and/or housing.

This employment shortfall is reflected by glaring inequities that still must be addressed, particularly among the young who will inherit our world. Over 10.5 million children under the age of five die annually from preventable diseases and 480 million are moderately to severely underweight (8). Inadequate nutrition in a number of developing countries, of course, is occurring in the presence of an epidemic of obesity that is spreading throughout the developed world. In regard to general living conditions, over 40% of the world's population is living without basic sanitation and over 20% without access to improved water sources (8). These unacceptable conditions are mirrored in the poor educational attainment of those in developing countries where almost 25% are illiterate and 1.3 billion children leave school before the fifth grade (8).

What, then, might we expect to be the impact of globalization in the context of the demographic changes now occurring? From the perspective of the industrialized world at least five interacting responses are in play: replacement migration, substitution of equipment for labor, management through international trade and outsourcing, allowing older workers to continue in the workforce and adaptation of the workplace for older workers.

For some time migration from the developing to the industrialized world has been evident. In the United States, in fact, the demographic pyramid suggests that there has been sufficient replacement migration to ameliorate the impact of the baby bust. Immigrant families and their descendants have partially filled the spaces in the age pyramid that were anticipated as a consequence of the baby bust. Economists worry, however, that this trend may not be a long term solution as the generally lower educational attainment of immigrants may result in a less well educated work force and a slowing of productivity gains. Furthermore, the current controversy in the US over immigration policy shows the conflict between employer interests in access to abundant low-wage workers and native workers' concerns about adequate employment opportunities.

An alternative to importing labor from developing countries is the substitution of equipment for labor, i.e., technology and innovation enables a relatively small labor supply to support a larger number of dependents. Note, however, that industrialized economies are increasingly dominated by the service sector and many components of this sector cannot be addressed by substituting equipment for labor.

With respect to trade and outsourcing, many of the industrialized economies are already relying on the import of goods and services taking advantage of the lower cost of production in the developing world. This approach is a temporary solution at best because the more that jobs are exported the less purchasing power there is in the population that continues to reside in the industrialized world.

These developments have occurred as policy makers explore ways in which to allow or promote older workers to continue in the workforce. Many 65 year olds can continue working and increasingly find it necessary to continue to work as the societal supports weaken and policy imperatives reduce the possibilities for fully-funded retirements. If older workers are to continue in the workforce, then it is essential that workplaces be redesigned to allow older workers who remain in good health to continue working (10). Some examples of these changes include: flexible working hours, telecommuting, investment in ergonomics, and promotion of learning and retraining opportunities to adjust to the evolving technologies of the modern workplace.

Now we should examine the impacts of globalization through the lens of the developing world. Globalization seeks higher productivity at a lower cost and this has generally driven manufacturing to the developing world. But associated with these trends has been manufacturing of goods in much poorer working environments despite the promises of protection from some international trade agreements. The informal sector comprises a much larger percent of the workforce in developing nations and here the risks associated with work are the highest. The evidence continues to demonstrate that these trends are associated with a negative impact on health outcomes and increased health inequity for large segment of workers.

There is a hidden cost of these global demographic trends that directly affects aging workers in the developing world. Immigration from developing to developed nations is almost exclusively seen among young working age men and women. What this leaves behind is a population increasingly bifurcated – the very young and the very old. In countries where the work demands are increasing because of trade-related manufacturing, the workforce includes an unexpected increased proportion of child labor and older workers because both groups exist in families no longer supported by the young who have emigrated to the developed regions.

These trends also need to be located within a comprehensive view of work (1). Unlike the circumstances in the industrialized world, traditional societies engage all members in the activities that support and maintain the community. Work is an organic part of the life of the community and inherent in all aspects of daily living, such as child rearing, cooking, and other family activities. Work, rather than limited to a specified time period per day or week, is continuous as necessary for survival and consolidation of the community. Occupational safety and health (OSH) hazards are present for all these workers but is easily overlooked or ignored by those who have official responsibility for worker health because the concept of "work" is not applied to these activities. We can expect that globalization will result in ever new structures of "employment" in these traditional societies which will further exacerbate the division between "work" and other family and societal activities.

In summary the economic forces linked to globalization invoke more flexible labor contracts which threaten OSH with impacts on employment and unemployment, less regulation of working conditions and fewer resources provided for OSH services and preventive activities in workplaces. These impacts are reflected in exposure to recognized hazards in developing areas that would not be accepted in the developed world: lack of effective warnings to those exposed, poor notifications to employees of medical conditions discovered by health care workers, inadequate compensation of injured workers, exposure to technologies which have been replaced by safer alternatives in industrialized economies, and more.

From an economic perspective the forces of globalization have concentrated on competition between nations and corporations to provide the most cost-efficient production of goods and services. From an occupational health and safety perspective, even in the absence of formal studies of pre-post globalization OSH conditions there is ample reason for concern. The economic forces of globalization have, in most instances, moved counter to efforts to protect the workforce by relaxing wage controls, union protections, and workplace standards. There is increasing global division of labor, with exports of "dirty and hazardous" work to developing countries.

For example, one prominent characteristic of globalization efforts in the developed world has been the development of export processing zones. Whatever the advantages of these zones may be in economic terms, in human terms they are commonly associated with long working hours, deficient protection against known hazards (to keep production costs as low as possible) and poor social support systems (1). Furthermore, many developed nations have weak OSH enforcement (even if legislation is up to date) in the many companies operating throughout the country. Attention to the more vulnerable in the population, for example, women and child workers, is given the lowest priority, if considered at all.

In order to avoid repeating the same sad experience of the occupational diseases that have been documented in developed countries, available knowledge about safer and cleaner technologies needs to be applied in developing countries especially as the pace of technological change continues to accelerate. Despite the world-wide increase in mechanization of agriculture at least 60% of workers in the world are engaged in agriculture (3) where health hazards include vector-borne diseases, injuries, and increasingly, pesticides poisoning. The primary and extraction industries have also experienced rapid growth and these (e.g., mining and forestry) are workplaces with high risks for occupational injuries and diseases (3).

Less familiar to those responsible for OSH in developing economies are the problems associated with increasingly sophisticated technologies in new industries that bring with them a host of new potential hazards. Acute and fatal injuries associated with new and unfamiliar technologies are likely to continue to be a dominant concern but exposure to physical and chemical agents and an increasing work pace will also characterize these new manufacturing industries. WHO's Global Strategy on Occupational Health for All notes: "A number of studies show that in the most unfavourable conditions 50-100% of the workers in some hazardous industries may be exposed to levels of chemical, physical or biological factors that exceed the occupational exposure limits applied in the industrialized countries" (11). An emerging trend, even in the developing nations is the growth of service industries, with hazards resulting in musculoskeletal disorders from repetitive and forceful movements and stress-related diseases.

Overall it is not global integration of economies and cultures in itself that is a health threat, but the way that globalization is carried out. Those of us who have devoted careers to improving the health and safety of workers throughout the world must take the lead in demanding that the new economic system is conditioned on having proper OSH and social support systems form a cornerstone of development. In this respect, the improved global information and communications systems create new opportunities for occupational health advocacy that can help bring about such programs.

Jeffrey Sachs has proposed four key concerns that need to be addressed in order to fulfil this obligation (5).

1) Apply the successful post-World War II model and cancel the debts of the highly indebted poor countries as part of the financing package to permit the Millenium Development Goals to be achieved.

2) Revise global trade policy to make possible a substantial increase in export of goods from the developing world and thus obtain the foreign exchange needed to import capital goods from the rich countries. But trade alone will be insufficient and an effective balance of trade will still need to be supplemented by aid to fund the critical public investments needed to support developing societies.

3) Greatly enhance the science for development that brings necessary intellectual capital to the problems faced by the developing world – disease control and prevention is the most obvious of these but others include tropical agricultural developments, practical energy systems, water management and creating the scientific advancements that will permit sustaining ecosystems around the world (this latter should, for selfish reasons alone, be a priority for developed nations).

4) Environmental stewardship to include living up to the UN Climate Change conventions, financial support to respond to climate changes as these occur (e.g., response to drought and famine in Africa), and investment in climate science for the benefit of all.

To achieve these goals will require a sustained effort from international agencies, trade unions and consumer organizations and particularly we occupational health professionals who will need to demand that OSH performance in countries and enterprises be preserved as a fundamental component of the changes associated with globalization. Adequate public-sector and union capacity for setting standards and enforcement should be ensured, as well as international cooperation on norms of safe work; the liabilities of manufacturers, employers, and exporters; and work-safety rights. And always, we will need to be attentive to the need to focus attention on those currently marginalized from the opportunities of globalization.

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Acknowledgements: *Supriya Lahiri provided the foundation for the discussion of the demographic shift associated with aging and Charles Levenstein provided invaluable assistance in review of the manuscript*

La Medicina del Lavoro

Med Lav 2006; *97*, 2: 143-147

Monday - June, 12 2006 - Semi Plenary

Towards a longer and better working life: a challenge of work force ageing

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Key words

Ageing; life expectancy; working life

Summary

The aim of this overview is to describe the background of work force ageing and its consequences in the society, to introduce concepts for the solutions, to emphasize the actions needed, to point out the new challenges for occupational health, to review the targets of work life improvements, and to highlight the new innovations needed. Work life must be lengthened for the sake of society. Early retirement and low employment rates of 55-64-years old employees make the dependency ratios an increasingly heavy burden. New innovations and concepts like promotion of work ability and age management training have been effective tools for the increase of employment rates and decrease of age discrimination in Finland. The increase of the prevalence and incidence rates of work-related symptoms and diseases during ageing is a serious challenge for occupational health experts. The better adjustments of the working life with the individual health is a crucial element for a longer career. The European working life has not improved markedly for workers over 45 years between 1996 and 2000. Therefore, evidence based concepts should be widely and effectively implemented and new innovations created. A better co-operation between macro-, meso and micro levels is necessary, social partners should create mutual programmes in work places and a new deal is needed between the generations. Life course approach combines the needs and possibilities of different generations. Age management takes into consideration the different strengths of the diverse work force.

Riassunto

«Verso una vita professionale più lunga e migliore: una sfida per la forza lavoro che invecchia». *Questa relazione si propone di illustrare il contesto in cui avviene il processo di invecchiamento della popolazione lavorativa e le relative conseguenze per la società, presentare idee per l'identificazione di soluzioni, enfatizzare le azioni necessarie da intraprendere, porre in risalto le nuove sfide che la medicina del lavoro deve affrontare, riesaminare gli obiettivi da raggiungere per migliorare la vita lavorativa e evidenziare le innovazioni necessarie da introdurre. E' ormai necessario per il benessere della società che la vita lavorativa sia allungata. Sia il pensionamento anticipato che i bassi tassi di occupazione nella fascia di età tra i 55 e i 64 anni rendono i rapporti di dipendenza un problema di portata sempre maggiore. In Finlandia, l'introduzione di innovazioni e di nuove idee come la promozione della capacità di lavoro e i programmi di training per l'age management si sono rivelati strumenti efficaci per aumentare i tassi di occupazione e ridurre la discriminazione dei lavoratori più anziani. L'aumento dei tassi di prevalenza e incidenza dei sintomi e delle malattie lavoro-correlati legati all'invecchiamento costituisce una sfida complessa per gli esperti di medicina del lavoro. Ottenere una migliore congruenza fra vita lavorativa e salute individuale è un elemento cruciale per consentire una carriera lavorativa più lunga. Fra il 1996 e il 2000, la vita lavorativa per i lavoratori euro-*

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pei sopra i 45 anni non ha conosciuto sostanziali miglioramenti. Per questo motivo, concetti fondati sull'evidenza dovrebbero essere introdotti in maniera efficace e su larga scala e ulteriori innovazioni prodotte. E' necessaria inoltre una migliore cooperazione fra i livelli micro, meso e macro, mentre i partner sociali dovrebbero sviluppare programmi condivisi all'interno dei luoghi di lavoro. Occorre inoltre un rinnovato accordo tra le generazioni. L'approccio basato sul corso di vita combina le esigenze e le possibilità offerte dalle diverse generazioni di lavoratori. L'age management è in grado di mettere in risalto i diversi punti di forza di una popolazione lavorativa differenziata.

Higher life expectancies and lower birth rates

One of the greatest achievement during the last 100 years has been the improvement of human life expectancy (LE). During the preceding 40 years, it has increased by 8 years for both men and women in the European Union. LE at birth in the EU25 countries was 75 years for men and 81 years for women in 2003. At the age of 60 years, men had approximately 19 and women 24 years left to live. The LE at the time of birth was slightly better in the EU than in the US, but decidedly lower than in Japan (3).

At the same time, however, the total fertility rates have declined. In 1965, the total fertility rate of the EU15 countries was 2.7. By 1995, it had dropped to 1.5, after which it remained somewhat stable until 2001. This trend indicates that population has not been regenerated for almost 10 years (1, 4).

High life expectancies and low birth rates together affect on the demographics of the work force, too. The proportion of 50+ work force will be almost double the size of the 25- work force in the EU in the year 2025. About one third of the work force will be older than 50 years within few decades in Europe (5).

Living longer but working shorter: a great problem for the societies

A market paradox exist between a longer life and shorter working life. The extra healthy years will be spent more for the retirement than for work life. One objective of the EU is to increase the employment rate of 55-64-years old population to 50% before 2010. In 2003, this rate was 41.7% in the EU15 countries (3). Thus there was still a gap of 8.3 percentage points between the reality and the goal set. The differences between the countries were substantial - six countries had reached the target by 2003 and six other countries need an improvement amounting to over 20 percentage points.

Societies are concretely affected by the low employment rates. When people are retiring too early, dependency ratios are becoming an increasingly heavy burden, and costs of retirement and health care are growing. Ageing also challenges the sufficiency and quality of social and health care services, including the occupational health services. Work life must be lengthened for the sake of society (1, 7, 11).

National solutions and concepts

The EU countries have carried out a large variety of policy measures to encourage later exit and employment of older workers. Three types of measures can be identified: pension reforms, reduction of early exit pathways, and incentives for working longer (13). All EU15 countries show several measures since 1996 but the improvements in employment rates have been rather limited. In some countries, like in Finland and The Netherlands, the employment rates have increased over 13%-units between 1997-2003.

The success in Finland were at least partly based on the three new concepts, which has been implemented during the Finnish National Programme on Ageing Workers 1998-2002 (9). Employability of older workers were based on combining the promotion of work ability at the workplace level with the policy measures of the ministries. In this way, an integration of actions needed at the individual, enterprise and society levels was possible. The promotion of work ability (PWA) includes measures directed on individual resources and on work (2, 7, 8). The major challenge was the changes needed in the quality and organisation of the work. Therefore an Age Management Concept was created. Age Management training was offered for managers, supervisors and foremen of the companies by the Finnish Institute of Occupational Health together with other Management Training Institutions. The target of the seminars was to change the attitudes towards ageing by giving facts about ageing. The collaboration between the ministries, promotion of work ability and age management training was the base for a successful national programme. These innovations are in use in the new national programmes in Finland, too.

What should be urgently done?

For the solution of the ageing challenge at least three actions can be identified: attitudes toward ageing should be changed, the knowledge level of managers and supervisors in age matters must be improved, and a better, age-adjusted working life should be created.

One of the key question is, how to change the attitudes towards ageing in more or less globalised working life? Legislation against age discrimination is a basic need but it is not enough powerful in real life of companies. Indirect ways to discriminate are common, and can be seen between the employer and employees as well as within the personnel. One solution is to provide positive and negative facts about ageing and to increase the awareness level of all stakeholders. All age groups and generations have their own strengths which should be acknowledged and utilized.

The knowledge about the strengths of ageing is a key base for age-adjusted work places. Also good examples and best practices of age strategies of companies highlight that ageing is more a challenge than a problem for the companies. Age management or awareness training is a useful and efficient tool for employers, employees and other stakeholders (6).

Older workers as a new challenge for occupational health

The dimensions of human resources are health and functional capacities, competence, as well as values and attitudes. All the dimensions of human resources change with age and the most concrete ones are those related to health (14). A survey in the EU15 countries in year 2000 showed that about 40% of men and women over 45-years of age reported that work affects on their musculoskeletal and psychosocial symptoms (6, 12). Also 40% reported about the work-induced stress symptoms. The sickness absence rates, at least 3 days per year, were induced by the work among 33% of men and 38% of women over 45-years in the EU. However, country differences in all health matters were large within the EU 15 countries. Based on the survey, work-related health problems are very common among men and women over 45-years in the EU.

Although the prevention of work-related symptoms and diseases has always a high priority, another challenge faces the ageing workers, too. How to manage at work with chronic symptoms or diseases? What can occupational health experts do to avoid early exit of those suffering from health problems? It is obvious that only the treatment of the diseases is not powerful enough. The new challenge is to find the adjustments needed at work due to the deterioration of the health. If 40% of the musculoskeletal and psychosocial health problems are work-related, the work needs treatment too, not only the worker. The knowledge and experiences of occupational health doctors and nurses should be widely used for the adjustments needed at work. The OHS´s play an important rule in making a longer and better working life a reality. It is necessary also, that the recommendations and solutions for adjusted working life for older workers must be evidence-based.

The EU survey indicated also, that about 60-70% of workers over 45-years believed that, on the base of their health, they are able to work in their present job at the age of 60 years. This results gives some hope for the EU-employment target for older workers. However, one third of the work force did not believe on their possibilities, which might lead to early exits (12). Some logistic regression analysis showed that the probability to work at 60 increase with age, and is higher among men than women. The probability was highest in administrative and managerial jobs, lowest among those with lower education level, physical load and time pressure (10).

Quality dimensions of work are crucial for a longer and better work life

Criteria for good working life include several dimensions: physical and psychosocial work environment, physical, mental and social work demands, organisational features of work, autonomy and empowerment at work, working time arrangements, as well as management and leadership. The EU-survey data indicated that the European working life did not change much between 1996 and 2000 among the workers over 45 years (6). Physical work environment remained in the same level but exposure to noise increased among men. Physical load at work did not decrease but bad working postures increased among the ageing men. In mental load of the work the use of computers and complex working tasks increased but the learning of new things at work decreased. Autonomy at work, measured by the possibilities to regulate own work, did not change. Working times remained almost the same, only long work weeks decreased among the ageing men. Age discrimination was unchanged. Clear improvements were seen in supervisory work: it improved both among the ageing men and women during 1996-2000 in the EU15 countries (6).

New innovations needed

Can we afford in getting older? Societies impose great pressure on the generations of baby boomers. While it is true that they have a crucial role in guaranteeing well-being in the future, it is important to realize that a longer career in work life can also be promoted by making it easier for younger generations to enter work life and preventing unemployment and gaps in employment among the middle-aged groups.

New innovation is needed in improving the co-operation between the macro-level (government, ministries), meso-level (occupational health and safety, rehabilitation and training institutions) and micro-level (workplaces, employer and employee) actors. Social partners at work site level should implement together the evidence based models like Promotion of Work Ability and Age Management Training. New deals are necessary between the generations. Approach to extend the working life should be the life course: extra years needed in working life can be achieved from critical transfer periods during the entire working life. Working life should be also age-integrated: learning, working and leisure are the combined elements for everybody from the entry (20-25 years) to the departure from working life (63-68 years).

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Social protection sustainability, prolongation of working life and greater participation of women in the labour market

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Key words

Women; ageing; pension system

Summary

One of the greatest problems of European societies is the financial sustainability of social protection systems in Europe. Together with Japan, Europe has the highest levels of ageing population in the world. This concern explains the reiterated insistence of the European Commission and the OECD regarding the reforms that governments should undertake. In this paper, reference is made to two of these reforms: prolonging of working life and a greater participation of women in the labour market.

Riassunto

«Sostenibilità della protezione sociale, prolungamento della vita lavorativa e maggiore inserimento delle donne nel mercato del lavoro ». *Uno dei più grandi problemi delle società europee è rappresentato dal sostegno finanziario dei sistemi di protezione sociale in Europa. Con il Giappone, il continente europeo ha i più alti livelli di popolazione anziana nel mondo. Questo problema spiega l'insistenza ripetuta della Commissione europea e della OECD sulle misure di protezione che i governi dovrebbero mettere in atto. Lo studio prende in esame due di queste riforme: il prolungamento della vita lavorativa e il maggiore inserimento delle donne nel mercato del lavoro.*

The issue of this paper is rooted in the dramatic crisis currently affecting the social protection systems in Europe. The globalisation produced by the economy and communication technologies, together with the fierce competition from rapidly developing countries and the important processes of delocalisation are all factors which are weighing down on the competitiveness of European growth and questioning the soaring costs of social safeguards.

In addition, European countries, along with Japan, have the highest levels of ageing population in the world. The *baby boom* generation will be reaching retirement age in the near future and the low levels of fertility – 1.46% in 2002 and in EU-25 – neither manage to counterbalance its effects nor offer an adequate population structure with appropriate age brackets. The OECD estimates that the labour force supply in EUmember countries could grow around 5% over the period 2000-2025,

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before undergoing a downturn of 9% during the period 2025-2050. The adhesion of the new member states from Central Europe has not improved the demographic outlook, as these countries register an ageing trend which is even more pronounced than in the EU-15: in the case of these new member states, the active population could even shrink to 30%.

This ageing process – as shown in the figures 1 and 2 – will lead to a significant increase in health costs, despite – and, actually, because of – increased technological development. The OECD highlights that health service use of a person over the age of 60 is between 4 and 5 times greater than a person under 60. If no serious reforms are undertaken, an annual increase in health expenditure of between 0.4 and 0.7% is expected for the period 2000-2020.

The greatest problem of European societies is the financial sustainability of the pension systems, which is by no means guaranteed in the majority of the European member states. The mere demographic factor will cause, on average, an increase in pension expenditure of 5 percentage points of GDP between 2000 and 2050. The European pension systems, which were established in a completely different demographic context, lack equity and proportion and require a substantial structural reform in most Member states. Examples are the reforms carried out in Sweden and Italy which reflect this situation, albeit in Italy a very lengthy transition period is foreseen, in an attempt to avoid political conflicts.

Overall, total expenditure of social protection[1] in 2002 was on average 70% of the Public Administration budget for the EU-15 countries (figure 3), thus jeopardizing public spending capacity. If drastic corrective measures are not taken, this percentage could reach as much as 80-82% of Public Administration spending in 2050. So, how would it be possible to implement research, innovation, infrastructures, environmental protection, inter-territorial solidarity, etc.?

The concern for financial sustainability of European social protection explains the reiterated insistence of the European Commission and the OECD regarding the reforms that governments

[1] According to the ESA – European System of National Accounts – social protection expenditure includes: health, invalidity, old age and survivor's pensions, unemployment, family and infants, education, housing and social exclusion

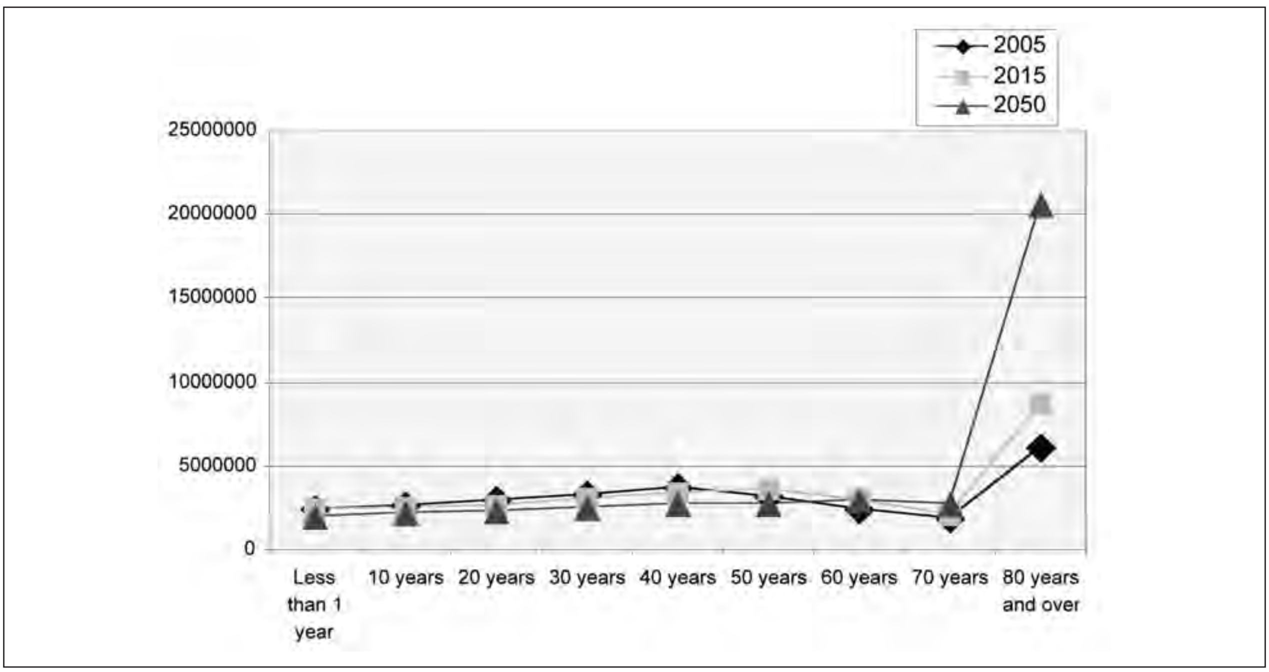

Figure 1 - Population projections for the EU-25, males. Source: Eurostat and authors' personal compilation

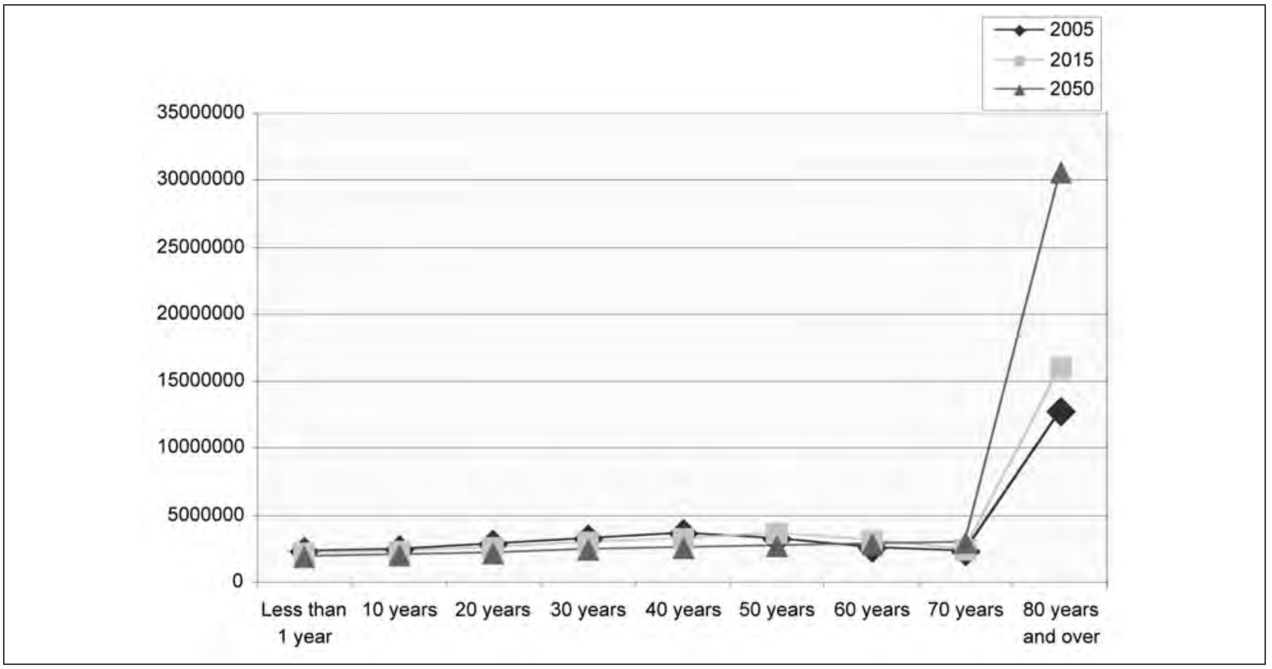

Figure 2 - Population projections for the EU-25, females. Source: Eurostat and authors' personal compilation

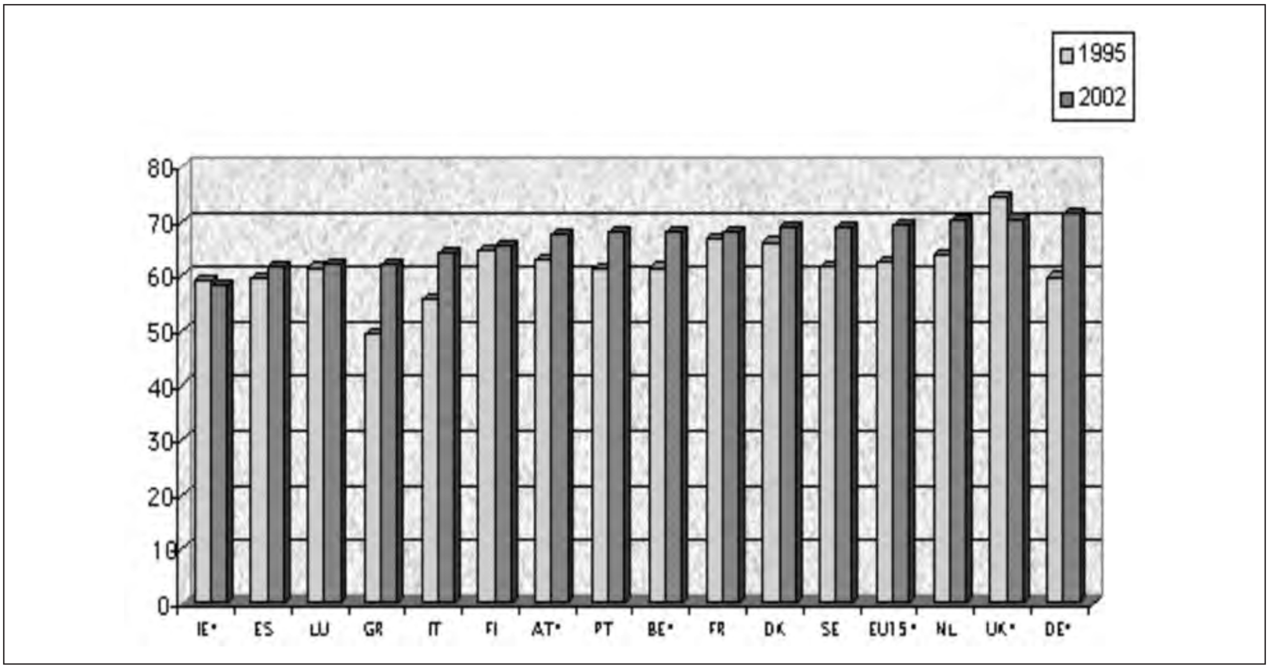

Figure 3 - Social protection expenditure, ESA, as % of government expenditure, EU-15. Source: Eurostat and authors' personal compilation

should undertake: decentralisation; introduction of public-private partnerships; change in the health and retirement systems, elimination of the counter-incentives to employment (early retirement, sick leave entitlement, unemployment and invalidity benefits); greater insertion of women in the labour market; prolonging of working life. Hereafter, reference will be made solely to the latter two aspects will be considered, as they constitute the main issue of this paper.

Prolongation of working life

In the European summit in Barcelona, heads of state set the following employment objectives for 2010: employment levels at 60% for women and 50% for older workers (aged between 55 and 64). Tables 1 and 2 show the present employment rates according to sex, age and level of education. These tables are of great interest as they show that in nearly all countries and age groups, higher education levels mean higher employment rates. The trend is the same for both men and women. Female employment rates are higher for the age group 24-49 years and do not differ greatly from the those of males in the higher education strata. There are no significant differences between old and new member states. It is important to point out the participation in work of males over 60 in Estonia, Ireland, Cyprus, Latvia and Great Britain, where employment rates are higher than 50%. Moreover, for male workers over the age of 65, Cyprus, Ireland, Lithuania and Estonia have employment rates over 12.5%. As regards women, there is an important slump in employment for the age bracket 60-64 years. The

Table 1 - *Employment rates by age groups and highest level of education attained, males, in %. First quarter 2005*

	25-49 years				50-59 years				60-64 years				65 years and over			
	total	isced 0-2	isced 3-4	isced 5-6	total	isced 0-2	isced 3-4	isced 5-6	total	isced 0-2	isced 3-4	isced 5-6	total	isced 0-2	isced 3-4	isced 5-6
be	86.9	76.9	88.8	93.5	67.2	56.2	70.4	81.8	23.6	16.1	26.8	37.9	3.7	2.2	4.2	10.4
cz	89.8	54.3	91.3	95.1	81.6	57.4	81.5	94.7	32.6	12.3	30.1	61.3	5.6	1.2	4.7	16.7
dk	87.3	75.5	88.8	91.4	82.3	70.3	83.2	88.1	46.8	30.8	42.1	67.1	8.9	4.3	11.1	14.3
de	83.5	67.4	82.4	92.9	76.2	60.2	73.9	87.1	35.4	22.9	31.0	48.7	5.4	4.0	4.2	9.1
ee	81.6	65.8	80.7	91.1	69.7	-	68.5	82.5	50.7	-	55.0	76.7	12.7	-	-	-
gr	89.6	88.1	89.9	91.2	78.1	76.1	76.9	85.6	44.4	44.2	38.0	55.7	6.6	6.0	6.4	11.9
es	86.5	83.9	87.6	89.7	77.5	74.7	77.7	86.0	45.6	43.5	45.7	54.6	3.1	2.0	4.2	11.8
fr	86.8	78.7	89.8	89.7	72.1	65.5	73.1	84.2	13.6	8.5	12.7	32.9	1.6	1.2	2.0	3.8
ie	89.0	80.9	92.5	93.6	77.4	71.3	82.5	89.9	56.3	53.4	61.0	64.5	13.6	13.1	14.1	15.9
it	86.5	84.4	88.3	87.5	69.1	60.8	75.8	93.0	27.8	22.3	32.3	59.9	5.6	4.0	7.9	24.2
cy	91.9	86.9	93.1	93.9	86.8	87.1	83.5	90.0	56.9	62.3	52.2	46.3	18.4	17.3	22.6	18.3
lv	82.0	72.6	82.3	89.9	73.3	67.6	72.2	85.3	42.2	27.6	42.9	73.1	13.5	16.0	23.1	-
lt	82.4	58.6	82.7	91.8	71.0	51.1	72.0	84.7	51.2	40.1	49.4	74.2	6.2	-	-	-
hu	81.8	57.7	84.7	94.6	63.0	41.2	63.9	86.4	20.8	8.3	23.7	49.0	2.6	-	4.7	16.3
mt	91.8	89.4	95.5	96.0	74.3	72.6	85.1	80.4	30.1	30.6	44.7	20.0	3.2	1.7	8.8	14.1
nl	90.2	84.2	90.7	93.9	80.8	75.6	79.8	87.0	31.8	24.9	29.9	43.0	7.6	5.2	6.2	13.6
at	88.2	73.5	89.1	93.3	71.5	60.4	70.4	85.1	20.3	15.0	17.7	33.2	4.3	3.9	3.5	7.8
pl	77.3	55.4	77.4	91.9	52.7	38.0	52.7	78.0	23.4	21.1	17.4	53.3	9.1	8.7	7.3	15.4
pt	87.5	86.8	87.2	92.8	75.0	74.2	70.5	86.3	48.0	48.4	-	52.1	24.0	24.4	-	-
si	88.0	77.3	88.3	96.0	67.7	56.7	67.8	83.6	21.6	28.5	12.7	42.5	9.7	13.2	7.8	8.8
sk	80.7	26.5	83.4	92.9	71.1	41.2	72.6	89.7	18.6	-	19.2	34.2	2.2	-	-	10.7
fi	83.8	70.9	82.6	92.4	70.7	62.1	68.5	83.7	34.0	27.1	35.4	44.4	4.4	3.3	5.9	7.1
se	84.0	74.2	85.7	87.1	81.5	76.3	81.4	87.9	62.2	55.3	61.7	77.6	6.3	10.3	13.1	14.2
uk	88.5	64.9	89.5	94.5	79.5	61.8	82.1	85.5	54.6	43.6	58.7	58.0	8.7	100.0	100.0	100.0

Notes: isced 0-2: Pre-primary, primary and lower secondary education, levels 0-2, International Standard Classification of Education 1997 (ISCED)

Isced 3-4: Upper secondary and post-secondary non-tertiary education, levels 3-4

Isced 5-6: Tertiary education levels 5-6

Source: Source: Eurostat and authors' personal compilation

Table 2 - *Employment rates by age groups and highest level of education attained, females, in %. First quarter 2005*

	25-49 years				50-59 years				60-64 years				65 years and over			
	total	isced 0-2	isced 3-4	isced 5-6	total	isced 0-2	isced 3-4	isced 5-6	total	isced 0-2	isced 3-4	isced 5-6	total	isced 0-2	isced 3-4	isced 5-6
be	73.2	50.1	74.1	89.0	43.1	28.3	53.1	61.7	8.2	6.5	10.6	10.7	1.0	0.6	2.7	-
cz	72.2	48.2	73.4	81.8	61.6	42.1	64.6	84.7	12.3	4.9	13.3	33.0	2.2	1.0	2.9	10.3
dk	79.9	58.3	81.4	85.6	76.9	53.9	77.8	89.8	28.2	15.5	31.6	40.0	3.1	-	5.1	8.7
de	71.2	52.3	72.3	82.4	63.0	47.9	64.4	78.9	20.2	15.9	19.0	34.4	2.4	1.9	2.8	4.0
ee	76.8	54.3	73.4	83.8	73.1	-	71.9	81.7	39.2	-	40.2	-	6.6	-	-	-
gr	59.9	46.5	58.3	79.2	37.1	33.0	35.7	63.8	19.3	19.9	11.6	34.2	1.8	1.8	-	-
es	62.3	47.7	65.7	77.8	40.8	32.1	49.8	77.5	18.1	15.0	28.2	39.4	1.1	0.9	4.3	5.0
fr	73.0	59.5	75.2	81.9	61.4	54.1	65.1	74.3	12.4	11.4	11.7	19.1	0.8	0.7	1.2	2.2
ie	68.6	46.4	69.0	84.0	50.7	36.5	59.0	77.3	25.6	18.7	31.8	44.9	3.2	2.4	-	-
it	59.5	43.0	67.3	78.4	39.3	26.5	56.8	81.0	9.8	6.4	21.1	28.8	1.1	0.9	2.4	6.2
cy	73.8	58.8	72.9	85.4	49.9	38.5	56.5	81.1	18.7	21.1	-	-	4.8	4.6	-	-
lv	75.0	40.8	74.7	87.3	65.7	45.1	63.8	86.9	27.2	23.4	25.6	37.7	3.7	-	-	26.4
lt	80.1	53.9	77.3	89.5	63.6	47.0	61.6	79.1	21.3	-	28.6	36.7	2.4	-	-	-
hu	67.0	43.8	69.6	81.7	54.1	37.1	57.5	83.5	9.8	3.1	14.9	29.2	1.0	0.7	3.7	8.9
mt	40.0	28.0	70.3	81.0	20.1	15.2	54.7	70.3	0.7	0.8	-	-	-	-	-	-
nl	76.4	60.0	77.9	87.9	56.8	43.6	61.5	76.3	17.7	12.5	20.6	29.8	1.9	0.9	3.7	4.8
at	77.5	63.5	78.9	87.0	52.3	42.0	53.8	76.2	7.6	5.3	8.2	17.5	1.1	0.8	1.5	-
pl	65.3	41.0	62.2	86.7	36.9	25.8	35.3	66.8	12.1	10.5	9.7	26.9	3.1	2.9	2.5	7.5
pt	76.3	71.5	79.9	90.4	57.8	55.5	60.7	77.9	35.7	36.1	-	-	12.8	13.1	-	-
si	83.6	72.0	82.4	93.4	48.4	37.9	47.6	72.2	8.3	10.7	5.4	-	4.9	6.1	2.7	-
sk	69.2	30.5	71.3	84.1	48.0	25.7	51.4	77.6	5.9	-	5.1	25.1	0.9	-	-	-
fi	78.7	63.0	76.0	84.9	73.6	61.5	74.2	85.7	28.6	21.5	30.1	40.5	1.3	0.8	-	-
se	79.8	60.0	79.7	86.5	79.1	65.4	77.4	91.8	54.7	46.3	52.5	70.5	2.6	4.2	5.4	11.1
uk	74.9	43.9	74.7	87.3	67.6	48.6	72.1	80.3	30.6	100.0	100.0	100.0	4.2	100.0	100.0	100.0

Notes and Source: see Table 1

highest employment rates in women occur in Sweden (with a rate of 54.7%), Estonia, Portugal and Great Britain with rates which are above 30%. For the age bracket 65 or over, only Portugal has figures of some relevance (12.8%).

Empirical research predicts that, on the whole, the future workforce will be better trained than the current one. The widespread use of information and communication technologies requires a higher level of qualifications and more intensive training throughout the whole working life. In many cases, more than adhering to a standard production plan, it is essential to be able to respond to changing outlooks and unforeseen needs. For their part, companies are interested in providing training for their employees if they believe their continued presence meets work requirements. Nevertheless, older workers are frequently discriminated against because of a presumed lower productivity which in general is not documented. *"The productive potential of the older people does not appear to be substantially impaired by ageing per se (…) A substantial decline in trainability is unlikely to occur for most workers who have continued to acquire new job skills through the course of their careers"* (3).

Indeed, more lifelong training within the business context cannot be improvised due, for example, to its relevant costs. Nevertheless, if a company realizes that investment in training of older employees is profitable in the long run, it will be obviously more inclined to provide such training.

The econometric evidence on substitution patterns for workers of different ages suggests that they are good substitutes in production. *"To the extent this finding is reliable, it suggests that modest declines in the relative earnings of older workers would be suffi-*

cient to secure their employment in the future. Any such changes in the wage structure would also provide an incentive for employers to adjust recruitment and training practices so as to take fuller advantage of the potential contribution of older workers. However, this research provides little guidance about how efficiently the human resource practices of firms will respond to the market signals created by work-force ageing, or whether public policies can facilitate those adjustments" (2). Nevertheless, on the whole, the flow of workers that enter and exit the labour market do not usually occupy the same job posts nor do they coincide with the same production areas. Early retirement schemes have been very common in the industrial sector and in large companies, whereas the newcomers into the labour market have found employment in SMEs and in the service sector. Normally these sectors do not compete with each other.

The OECD highlights much research revealing that there are no significant differences in the achievements results of young and older workers. Moreover, the variations within the same age group are greater than the diversity between different age groups. "Good health" in older workers' notably lowers levels of invalidity – whatever the age involved. This is also a consequence of the increasing percentage of workers involved in the service sector. Notwithstanding, the critical relationship between age and productivity of the worker should be subject to continuous scrutiny.

The International Labour Office (ILO) states: *"It is commonly believed that, for companies, older workers are more expensive than younger workers, because of higher remuneration, fringe benefits and social contributions. While it is true that wages and fringe benefits often rise with age, there is no reason to believe that performance and accumulated know-how of older workers does not compensate for the higher cost (…) Increases in life expectancy have been accompanied by significant health improvement at older ages. The shift of employment away from manual occupations has also diminished the significance of age related health problems for job performance. Age has been reported to account for a small percentage or the variance in workers cognitive, perceptual and psychomotor abilities, when experience, education and type of occupation were controlled for. It has also been argued that older workers compensate for declines in various information processing and physical abilities by means of experience and mental and physical load-reducing strategies"* (1).

Over the past last few years, attention has been increasingly paid to the drawbacks of early retirement: Government has become aware of the enormous financial cost of such a decision, companies have lost their more experienced and capable staff, moreover, the workers themselves have realised that there are benefits to be obtained from a gradual transition to retirement. In fact, companies from different member states, having granted early retirement to their older managers, seek to maintain some sort of relationship with them – i.e. by way of consultancy contracts – to take the advantage of their experience, which can be transferred to younger generations.

Another important factor to be taken into account when considering the hypothesis of maintaining older workers in their job positions are the conditions of the job itself, from the point of view of both labour organisation and physical environment. In developed countries, labour conditions have changed much over the last few decades: physical and chemical risks have markedly declined, as production with low technological content have been moved to developing countries, where salaries and environmental controls are lower. In developed countries, more than 70% of the population works in offices. More flexible and reduced working hours might compensate for lower productivity, meeting the needs of both employers and employees.

One of the problems hindering higher rates of work participation are the counter-incentives to employment. In fact, older workers can easily take advantage of early retirement schemes, invalidity and unemployment benefits. Moreover, they also have high levels of substitution. The debate surrounding the prolongation of working life is, at present, one of the burning issues in many European countries. There is a need for a global approach that embraces the policies of both public administration and private companies. Public policies include three types of intervention: 1) reform of social protection, especially of pensions; 2) revision of invalidity and unemployment benefits and early retirement arrangements; 3) encouragement of employment in the last stage of professional career, before and after retirement.

As for companies, different measures are being adopted in order to encourage older workers to keep on working: the abolition of age discrimination legislation, adjusting salaries to productivity, greater flexibility of working hours, etc. It is noteworthy that when senior citizens continue working, more than half of them consider themselves satisfied, and only 8% dissatisfied. Dissatisfaction levels at work tend to be greater among younger workers; this may be due to the fact that the older workers are more adapted to their job duties.

TOWARDS AN INCREASED PARTICIPATION OF WOMEN IN THE LABOUR MARKET

The issue responds to the need a their greater participation rate of women in the labour market (in order to contribute also to the cost of social protection). Moreover, it responds to the need for higher birth-rate levels, higher family incomes, improved education for children and labour equality between men and women. Equal opportunities policies are a matter of Member states. For example, in Sweden and in the other Scandinavian countries there is a well-established social protection system which encourages women to work. Holland favours part-time work for women (and occasionally for men). France has implemented a strong policy of family aid. Ireland focuses on eliminating the obstacles preventing women from entering the labour force. It is noteworthy that these countries have the highest birth rates: 1.96 Ireland, 1.88 France, and 1.7 Holland, similar to the Nordic countries.

In Sweden, for example, combining work with family life is made possible by a social protection scheme which grants: paternity/maternity leave of 480 days, with 390 days paid at 80% of the salary; significant family benefits until their offspring reach the age of 16; a two-hour reduction of the working day (and corresponding reduction in salary) for parents with children under the age of eight.

Actually, Swedish men and women had the highest labour force participation rates of the EU-25 in 2004, with only a slight difference between sexes, as shown in figures 4 and 5. In 2000, 86% of women with children in pre-school age and 94% of women with children in school age, worked outside the home. Women with children under eight years old often work part-time; this is recognised by law until the child is eight years old. Moreover, there is a great amount of flexibility in timetables; *"flex-itime"* enables the employees to choose to work in the morning or in the evening; in addition, by agreement with the employer, they can predetermine the number of hours worked over the week.

Holland uses a model which focuses on part-time work. In 2004, 74.4% of Dutch women worked part-time outside the home (figure 6) with a distribution homogeneous among age groups. A survey carried out in 1994-95 (4) showed that in reply to the question "Does a child at pre-school age suffer if his/her mother works?" 44% of the Dutch population responded responded "yes". In the case of children in pre-school age, 40% of the

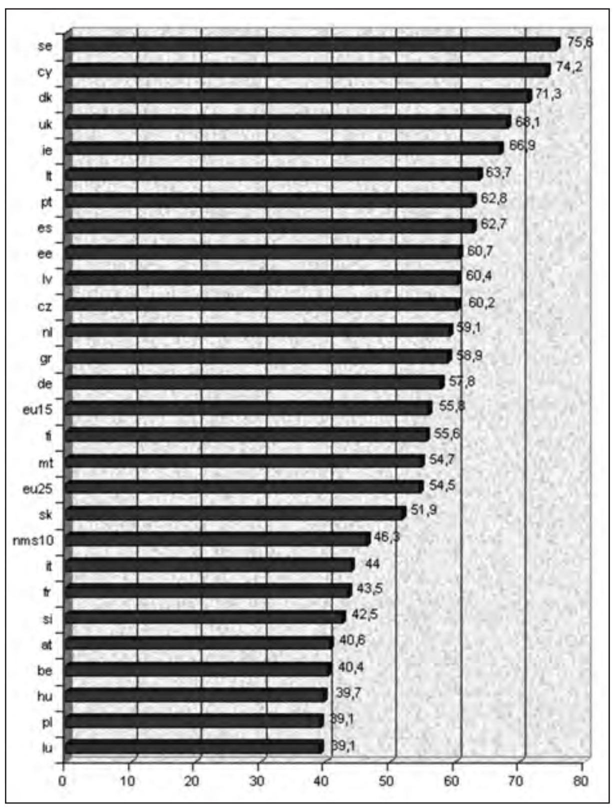

Figure 4 - Activity rates (%) in the EU-25, males, 2004. Source: Eurostat and authors' personal compilation

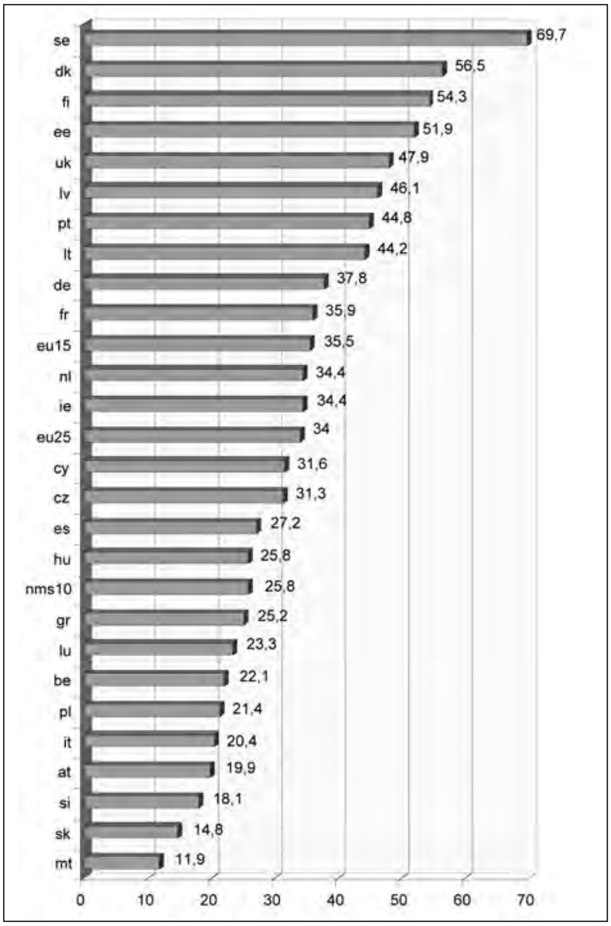

Figure 5 - Activity rates (%) in the EU-25, females, 2004. Source: Eurostat and authors' personal compilation

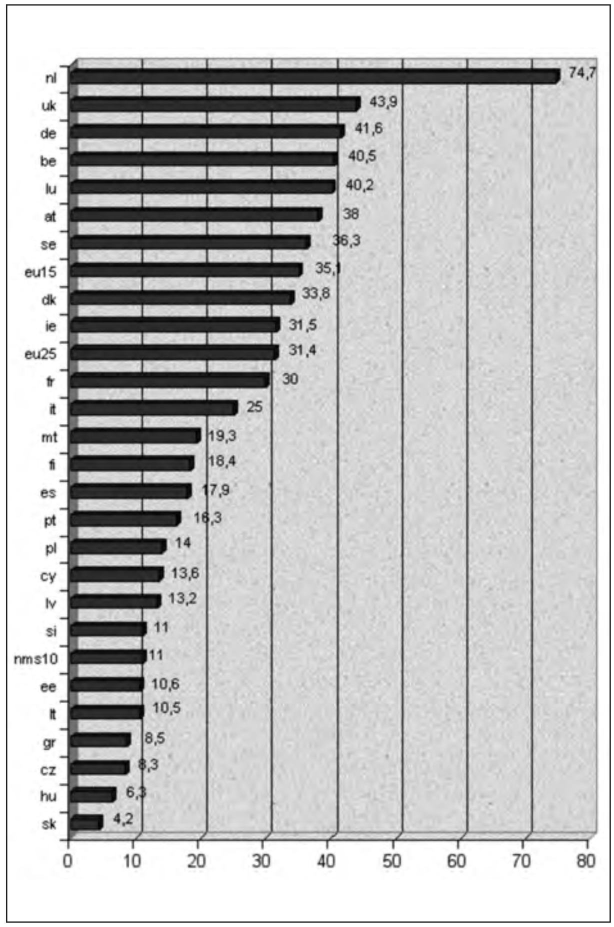

Figure 6 - Part-time employment rate as % of the total employment, females EU-25,2004. Source: Eurostat and authors' personal compilation

population were in favour of part-time work for women; 40% considers that mothers should remain at home and only 20% approved of women working full-time. Thus, the focus is placed on encouraging a close relationship between mothers and their children. 80% of working couples in which both husband and wife work uses the formula: "a salary and a half". Moreover, it seems that Dutch women, once they had opted for working part-time when their children were younger have continued to do so afterwards on a permanent basis. This explains why part-time work has received such an important backing from legislation.

It is clear that European governments are becoming increasingly aware of the need to protect the family as well as of the necessity of encouraging women's entrance into the labour force. Nevertheless, there is still a lot to do. An upheaval in the meaning of work and its organization, deeper reflections on family issues and gender differences, together with the use of financial instruments as a way of protecting a common asset, will be vital.

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Med Lav 2006; *97*, 2: 156-157

Occupational inequalities in health: do occupational risks matter?

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Key words
Socioeconomic status; occupazional hazards; epidemiology

Summary

In all developed countries mortality, morbidity and disability show a decreasing social gradient of risk from the less to the more advantaged occupations. The health profile of an occupation is influenced directly by the exposure to occupational hazards in the specific workplace and indirectly by the disadvantaged social position to which the occupation belongs, that may severely limit the access to goods, services, opportunities, support, information, abilities that promote health. Alternatively, illness or its predictors may influence the occupational trajectory of a person, ending in a social segregation of unhealthy workers. How much relevant is each of these explanations of occupational health inequalities? Few longitudinal studies have tried to disentangle such different mechanisms of occupational health inequalities at the same time. In a Danish sample of 5000 workers two thirds of the social class gradient with regard to worsening of self-rated health over time could be explained by differences in work environment factors (ergonomic factors and repetitive work in particular) (Borg & Kristensen, 2000). On the contrary, in the Turin Longitudinal Study, occupational exposures were able to explain the male occupational class differences in mortality only to a moderate extent, probably due to misclassification of exposure (measured by a JEM), together with the fact that mortality is a less sensitive outcome for many occupational risk factors (Mamo et al., 2005). This paper will examine and discuss the relative importance of occupational and non- occupational risk factors in explaining social class inequalities for different health outcomes, in the light of both indirect evidence coming from the determinants of health inequalities and direct evidence coming from a review of adequate studies.

Riassunto

«Differenze nella salute tra le professioni: hanno importanza i rischi professionali?». *In tutti i paesi sviluppati mortalità, morbilità e disabilità mostrano un gradiente sociale di rischio decrescente dai lavori meno a quelli più avvantaggiati. Il profilo di salute di una professione è influenzato direttamente dall'esposizione a rischi professionali presenti in uno specifico luogo di lavoro e indirettamente dalla posizione sociale svantaggiata a cui il lavoro è legato, che può seriamente limitare l'accesso a beni, servizi, opportunità, sostegni, informazioni, abilità che promuovono la salute. D'altra parte la malattia o i suoi indicatori predittivi possono influenzare il percorso professionale di una persona, sfociando nella segregazione sociale dei lavoratori non sani. Quale peso hanno ciascuna di queste spiegazioni nelle differenze di salute tra le professioni? Pochi studi longitudinali hanno provato a districare meccanismi così differenti di ineguaglianza nella salute tra le professioni presenti contemporaneamente. In un campione di 5000 lavoratori danesi due terzi del gradiente di classe sociale relativo al peggioramento nel tempo dello stato di*

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salute percepito può essere spiegato da differenze in fattori legati all'ambiente di lavoro (fattori ergonomici e lavori ripetitivi in particolare) (Borg 2000). Mentre nello studio longitudinale di Torino le esposizioni professionali erano in grado di spiegare le differenze di mortalità nella classe professionale maschile solo per una frazione modesta, probabilmente per un errore di classificazione dell'esposizione (misurata con JEM) e per la mortalità, indicatore meno sensibile per molti fattori di rischio occupazionali (Mamo 2005). Questo articolo esaminerà e discuterà l'importanza relativa di fattori di rischio professionali e non, nello spiegare le differenze di classe sociale che esitano in differenti effetti sulla salute alla luce di entrambe le evidenze: indirette provenienti da strutture esplicative dei determinanti delle differenze nella salute e dirette provenienti da una revisione di studi adeguati.

La Medicina del Lavoro

Med Lav 2006; *97*, 2: 158-159

Psychological well-being and work attitudes across a range of employment status categories

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Key words

Employment status; well being

Social and economic changes over recent decades, have produced types of employment that differ from traditional work arrangements in which it was generally expected that work was done on a full-time basis and that it would continue indefinitely. As a result, employment status is no longer restricted to those in and out of work but is spread over a continuum of work arrangements including unemployment, underemployment, part-time, and full-time employment. Unfortunately, little is known about the psychological and health effects of these increasingly common forms of non-standard employment, as the psychological literature on work has tended to concentrate on investigating employment and unemployment. However, it has now become evident that employment, as well as unemployment, may lead to negative outcomes in terms of physical and mental health. This study aimed to shed light on possible causal links between different types of employment status and psychological well-being, physical health, and work-attitudes, as well as potential moderating and mediating variables. This was achieved by conducting a four-year longitudinal investigation that followed school-leavers into the workforce. The use of a sample of young people meant that baseline data could be gathered before participants entered the workforce. It also allowed for an evaluation of those most at risk of poor work outcomes, as young people appear to be at a particular disadvantage. The sample comprised 1289 adolescents (mean age of 15 years at baseline) drawn from single sex and co-educational schools in rural and metropolitan regions of South Australia. Participants completed questionnaires on an annual basis over four years (T1, T2, T3, T4). On the basis of their work status at T4, participants were divided into four employment status groups (employed, unemployed, underemployed, full-time students) for comparison. Analyses included an examination of how employment category affects psychological well-being and work attitudes; the predictors of employment status; and factors moderating how well individuals cope with inadequate employment. These findings provide key information about how non-standard employment can affect the individual, how to identify those at most risk of inadequate employment, and which factors protect against the negative outcomes of work status.

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La Medicina del Lavoro Med Lav 2006; *97*, 2: 160-164

Emerging aspects of psychosocial risks: violence and harassment at work

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Key words

Mobbing; physical violence, post traumatic stress disorder

Summary

In the last twenty years, psychosocial risks have become crucial in Occupational Health. Particularly, there is an increasing interest about psychological and physical violence at the workplaces. Psychological violence (mobbing or workplace bullying) is described as a situation in which the person has been the victim of negative acts directed to the person and work, with offences, discriminations and isolation. Physical violence at work, still underestimated in many parts of the world, is becoming a topical subject both for its frequency and its pathogenic potential and consist of violence among workers (internal violence) and between workers and external persons (external violence). Examples of external violence are bank robberies, which are prevalent in many European countries, particulary in Italy. The costs of psychological and physical workplace violence are very high at all levels; individual, for the implication of violence for health and quality of life as well as organizational, for the increase of absenteeism, turnover and health care demands and claims. The Medical Centre for Occupational Stress and Harassment (CDL) of the "Clinica del Lavoro Luigi Devoto" was set up in 1996 with a day-hospital service for the diagnosis, rehabilitation and prevention of work related psychological diseases. From its opening, about 5000 patients have been examined.

Riassunto

«Aspetti emergenti dei rischi psicosociali: violenza e offesa al posto di lavoro». *Nell'ultimo ventennio i rischi psicosociali sono diventati argomento di cruciale importanza per la Medicina del Lavoro; in particolare, hanno assunto crescente rilievo i fenomeni della violenza psicologica e fisica nei luoghi di lavoro. Nell'ambito della violenza psicologica, si colloca il fenomeno mobbing (altrimenti denominato bullying at work, psychological harassment etc.), comunemente descritto come una situazione in cui una persona riceve, in modo frequente e persistente, attacchi contro la propria persona e il proprio lavoro, in termini per esempio di offese, discriminazioni, demansionamento, fino al totale isolamento sociale. Ancora poco esplorato in Italia ma di crescente attualità per la sua frequenza e il potenziale patogeno è il tema della violenza fisica sui luoghi di lavoro: violenza interna (che si verifica tra i dipendenti) ed esterna (perpetrata da figure esterne contro i dipendenti). Un esempio di quest'ultima sono le rapine in banca, fenomeno frequente in molti paesi europei e particolarmente in Italia. I costi della violenza fisica e psicologica, sono molto elevati e riguardano l'individuo, per le ripercussioni sulla salute e la qualità*

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della vita, le organizzazioni, in termini per esempio di assenteismo, turnover e calo della produttività e la società in generale, per l'aumento delle richieste di cura e assistenza. Il Centro per il Disadattamento Lavorativo (CDL) della Clinica del Lavoro di Milano, ha attivato nel 1996 un servizio di day-hospital dedicato alla diagnosi, cura e prevenzione delle patologie occupazionali stress-correlate; presso il CDL, dotato di uno staff multidisciplinare che si avvale di metodologie specifiche, sono stati esaminati circa 5.000 pazienti.

In the last two decades, the attention paid by Occupational Health to psychosocial risks at work has increased with a special focus on psychological and physical violence.

Psychological violence

Many terms have been used to describe psychological violence at work such as harassment, bullying or mobbing, each of them highlighting a particular aspect or deriving from a specific research current. Bullying at work or mobbing refer to a phenomenon for which an internationally accepted definition has not been provided yet but that has been described with a general consensus by researchers, organizations and national authorities as a situation where a person is frequently and persistently offended, harassed, intimidated, socially excluded and isolated. A definition given by influential researchers in the field says that "*Bullying at work means harassing, offending, socially excluding someone or negatively affecting someone's work tasks. In order for the label bullying (or mobbing) to be applied to a particular activity, interaction or process it has to occur repeatedly and regularly (e.g. weekly) and over a period of time (e.g. about six months). Bullying is an escalating process in the course of which the person confronted ends up in an inferior position and becomes the target of systematic negative social acts. A conflict cannot be called bullying if the incident is an isolated event or if two parties of approximately equal "strenght" are in conflict*" (3).

Bullying at work is becoming an increasingly significant issue worldwide and many Institutions are dealing with these topics. According to a survey carried out by the *European Foundation for the Improvement of Living and Working Conditions* (9) in the EU 9% of workers reported having been subjected to intimidation in the previous 12 months. The *European Agency for Safety and Health at Work* reports that bullying and harassment are potential health risks often leading to stress-related illness. The *International Labour Office* (ILO) (1), states that workplace violence, physical or psychological, has gone global, crossing borders, work settings and occupational groups. The *European Parliament* (5) emanated a resolution on harassment in the workplace stating that bullying is a serious problem that urgently needs greater attention and more countermeasures.

According to Einarsen et al. (3) bullying is a complex and multi-causal phenomenon that cannot be explained by one single factor, but rather by an interaction of different factors, which regards individuals, dyadic and group relationships, work organization and society. On the individual level, personality of the victim and of the perpetrator have to be considered; for example the victim can have few coping skills or be oversensitive; at the same time the perpetrator can be aggressive and persecutive. On the dyadic level the specific and unique relationship and escalation of conflict between two persons in a particular context has to be highlighted; according to these authors, this is very important to understand the imbalance of power between the parties, which is central to the definition of bullying. For what concerns the level of the social group, the "scapegoat" phenomenon is frequent in bullying when aggressiveness is directed towards the weakest member that can be considered an "outsider" for his/her own features, even being too honest. On the organizational level bullying can be part of the managerial style or can be legitimated by a competitive culture which allow unfair behaviours in order to reach individual goals.

With a wider view society, national, historical, legal and socio-economic culture, can play a part in the determinants of workplace bullying.

Physical violence

Also physical violence in the workplace both for its frequency and its pathogenic potential. In many parts of the world, alarming data on the magnitude of violence at work are reported by the main institutes committed on this topic, such as the National Institute for Occupational Safety and Health (NIOSH), the International Labour Office (ILO) and the European Agency of Health and Safety at Work (OSHA). According to the study of the US Bureau of Justice Statistics (BJS), from 1993 to 1999, about 1.7 million persons have been victims of an aggression at the workplace in the USA. In the same period, 800 persons have been killed at the workplace (www.cdc.gov/niosh/injury/traumaviolence.html). A recent study carried out in South Africa, showed that about 80% of the persons interviewed had been victims of an aggression at the workplace. In France, the number of victims among the personnel of the public transportation system reached a peak of 2000 in 1998 (1).

Particularly interesting is the distinction present in the European literature between "internal violence" and "external violence", that is between threats and physical aggressions at the workplaces by employees and by external subjects.

Data from the European Foundation for Improvement of Living and Working Condition show that 1.9% of women and 1.2% of men have been victims of physical violence at work perpetrated by colleagues and co-workers. They also show that 4.5% of women and 3.5% of men have been victims of "external violence" at work. "External violence" increases in the occupational sectors involving contact with costumers and clients: 13% in the health social sector, 8% in the public administration, 7% in the public transport sector and education (9).

In this context, the armed-robbery is included as one of the most frequent acts of violence at work, perpetrated in banks, post offices and retail shops (4). The magnitude of this phenomenon is particularly high in Italy, which is the European country with the highest incidence of bank robberies. Yearly, 1 in 13 Italian bank offices are robbed, compared to the European average that is 1 in 30 (8).

Victims of physical violence, as all victims of any other traumatic life event, are at risk to develop post-traumatic symptoms. These symptoms, if not promptly recognised, can last and the person can develop also serious psychiatric diseases, such as for example Post-traumatic Stress Disorder (PTSD).

The costs of workplace violence

Needless to say, there is a price to pay for workplace violence.

The costs of workplace violence are very high. A report commissioned by ILO (7) states that *"as with stress, exposure to any form of violence at work has negative implications for individuals, organizations and society as a whole"*. The individual can suffer from physical and mental impairment; organization bears costs related to sickness absenteeism, increased turnover and reduced productivity; the costs for society are increased pressure on social services and welfare.

Caution should be adopted when calculating the costs of workplace violence; much of the data available are of rather poor quality and difficult to generalize.

For what concerns individual costs, the loss of wages and additional expenditure, primarily in the form of health care and medical treatment, should be taken into account.

Workplace violence can cause many physical, psychopathologic, psychosomatic and behavioural disorders. In addition to possible physical damages due to the physical contacs, health effects generally comprise a number of psychopatologic (anxiety reactions, depressive mood, insomnia, recurrent nighmares etc…), psychosomatic (arterial hypertension, coronary heart disease, stomach ulcers, headache etc…) and behavioral symptoms (auto and hetero-aggressive reactions, eating disorders, increased alcohol and drug intake, increased smoking, sexual dysfunctions and social isolation).

Depression and anxiety are commonly diagnosed disorders, but other diagnoses are most frequently established, namely Post Traumatic Stress Disorder (PTSD).

In some countries, the diagnosis of Adjustment Disorder is advanced as a consequence of workplace bullying. For instance, according to our experience, AD accounts for 68% of the cases of the workplace bullying-related diagnoses.

This difference in the formulation of the diagnosis is due to how the stressor criterion A1 for PTSD is considered. If this criterion is strictly interpreted the diagnosis of PTSD cannot be posed.

Quantifying these costs is nearly impossible because the compensation systems and the medical expenses are different in the different countries.

There are more studies regarding organizationals costs. The causes of the organizational costs are listed hereafter (7):

– Sickness absence
– Premature retirement
– Replacement costs in connection with labour turnover (recruitment, training and development costs)
– Grievance and litigation/compensation costs
– Damage to equipment and production resulting from accidents and mistakes
– Reduced performance/productivity (lack of added value to product and service)
– Loss of public goodwill and reputation.

These costs are particularly relevant if one considers that staff account for approximately 50- 80% of organisational costs (2).

Workplace bullying outcomes have repercussions on all the organizational structure; the work atmosphere deteriorates and show conflicts, while turnover and distress increase (10). Increasing absenteeism, reduction of quantity and quality of production output, loss of professionalism, reduction of the profit are other outcomes of workplace bullying.

The costs of violence to society include health care/medical treatment for the victims of violence, loss of output and sickness absence, and premature retirement. These factors have warying weight in the different countries.

Medical activities at "Clinica del Lavoro Luigi Devoto"

In Italy the issue of psychological harassment at work began to raise the interest of public opinion and of scientific community only after 1995. Heinz Leymann, a few years earlier, was invited to give a seminar at the Post Graduate School of Occupational Medicine of the University of Milan, but the cultural climate was not yet ready to be confronted with this phenomenon.

In 1996 it was decided to activate the first Italian Medical Centre at the Milan University with a day hospital service in the "Clinica del Lavoro Luigi Devoto". This centre, named Medical Centre for Occupational Stress and Harassment (CDL), was aimed at carrying out diagnostic work as well as preventive/rehabilitation interventions on patients suspected of having developed psychophysical diseases connected with the workplace situation.

CDL is a public hospital centre with a staff of occupational physicians, psychologists, psychotherapists and technicians. From its inception, about 5.000 persons coming from the entire national territory were examined. The increase in hospital admissions, in terms of number of persons, has been constant throughout the years rising from 194 in 1997 to 674 in 2005. CDL still represents a public medical reference centre for harassment-related disorders in Italy, although other centres have been set up more recently. CDL carries out mainly clinical activity and the patients are generally taken to the day hospital if the psychophysical impairment has reached a certain degree of severity. At CDL, an ad hoc protocol for harassment-related disorder is adopted. It comprises a general medical examination with collection of the occupational history, a psychological interview and a battery of psychological tests. The aim is to obtain a profile of the social-emotional balance, the personality, and behavioural disorders. An important objective is the establishment, whenever possible, of the compatibility between the clinical picture and harassment.

With regard to the victims of physical violence, a specific diagnostic protocol was created in 2003 for workers victims of robbery-related assaults. It consists of a medical examination, a battery of psychological tests and the PTSD section of the Structured Clinical Interview for DSM IV (SCID IV) (6) to assess post-traumatic reactions and Post-traumatic Stress Disorder following the robberies.

Future challenges

Despite the general attention paid to these topics, a shared definition of bullying at work has not been provided yet and there is a lack of shared methodologies to evaluate the phenomenon of physical and psychological violence and to collect comparable data in different Countries. This would be very useful and necessary to identify workers groups and occupational sectors at a high risk of exposure to violence at work. Special attention should be paid to women, also according to Community strategy on health and safety at work which includes "gender mainstreaming" (that is the specific attention to the role of gender) in its priorities. Also workers with disabilities should be particularly considered and problems related to ageing should be highlighted.

Specific organization of work and management practice should be studied as the context where violence can occur and increase or even be facilitated.

Improving knowledge of the problem is necessary to develop specific and detailed prevention programs, such as informative and formative packages as well as specific guidelines to manage the issue.

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Med Lav 2006; *97*, 2: 165-166

The longer term health impact of war service

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Key words

Veterans; gulf war; PTSD

Post-deployment health effects in returning war veterans have been well described since at least the time of the American Civil War (6). The post-deployment effects in veterans who served in the 1990-91 Persian Gulf War have been extensively studied. One of the main findings from this body of research conducted in several different countries is that self-reported symptom reporting across all body systems is elevated (9, 13), but there has been no increase in mortality nor in other objective adverse physical health indicators. Several factor analyses of symptom reporting data have failed to find patterns consistent with a unique Gulf War Syndrome, as similar factor patterns have been found in the comparison groups (8). The other major finding in Gulf War veterans is that they have elevated rates of several psychological disorders, including depression, posttraumatic stress disorder, other anxiety disorders and alcohol use disorders (12) and that there is a strong dose response relationship between these effects and Gulf War combat exposure (7).

The cause of increased symptom reporting in Gulf War veterans remains controversial. A recent review has concluded that this is likely to be due to many factors, including being in a war zone, fear of chemical and biological weapons and media emphasis on a mysterious Gulf War Syndrome (14) Other researchers have suggested that Gulf War Illness is a type of encephalopathy or other nervous system effect caused by exposure to neurotoxins during the Gulf War, but apart from some evidence for an increase in amyotrophic lateral sclerosis (ALS) in USA Gulf War veterans (4), the evidence for adverse neurological effects is weak (10).

Now that more than 15 years have passed since the Gulf War, it is unlikely that more light will be shed on Gulf War exposures and their relationship with increased symptom reporting in Gulf War veterans (14). It has been proposed that the future research effort should focus on the longer term impact of health effects in Gulf War veterans and better ways to manage it. There is some evidence that post-deployment effects can last for many decades. Our group's research on Australian Korean War Veterans 50 years after the end of hostilities has shown that they reported poorer quality of life, were five or six times more likely than the comparison group to have PTSD and depression and three times more likely to have a history of problem drinking (11). Within the Korean War veteran group, poorer psychological health was strongly associated with combat severity, lower rank, service in the Army, being wounded in action, younger age at deployment, and fewer years of service experience prior to the Korean War. Therefore, post-deployment effects, including adverse lifestyle patterns, can be long-lasting in war veterans and can adversely impact on their long term quality of life and health.

Some recent data on USA veterans returning from the current Iraq War or from Afghanistan

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have shown that, despite what has been learned about post-deployment effects in veterans of the 1991 Gulf War, mental health problems are still common, being reported by almost 20% of the Iraq or Afghanistan veterans (3). This study also showed that 35% of Iraq Veterans accessed mental health services in the year after returning home. Post-deployment psychological screening was also shown to be of limited utility in predicting mental health problems, as less than 10% of those veterans who received mental health treatment were referred through the screening program. We have recently shown that the onset of a psychiatric illness during military service leads to about a 20% increased likelihood of separation from the Defence Force and that most of this occurs in the first year (1). Therefore, these studies suggest that deployment to a war zone is continuing to have a deleterious impact on maintaining defence force numbers and combat readiness.

Many questions remain about the nature, causes, long term outcomes, screening methods and ways to manage post-deployment syndromes. As most of the Gulf War health research was undertaken many years after the 1991 war, there is a need for improved health surveillance in this type of occupational group to provide more timely health data (5). There is also a need to improve the research methodology used in previous studies, especially in relation to exposure assessment (2).

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La Medicina del Lavoro Med Lav 2006; *97*, 2: 167-174

Monday - June, 12 2006 - Semi Plenary

Evaluation of scientific evidence in law, adjudication and policy: when occupational health takes the witness chair

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Key words
Forensic medicine; occupational health; litigation

Summary
Health and medical knowledge are essential to the resolution of disputes in law and administrative applications (such as workers' compensation) and provide essential input into public policy decisions. There are no socially agreed-upon rules for the application of this knowledge except in the law. On a practical level, the legal system lacks the capacity to evaluate the validity of knowledge as evidence and therefore relies heavily on expert opinion. Over the last 30 years, an approach called "critical appraisal" and "evidence-based medicine" addressed a similar problem in medical practice and established norms for the acceptance of evidence in clinical medicine. A similar evidence-based framework may be possible for applying knowledge of health and medicine to dispute resolution in the law. One critical issue is how to apply scientific evidence when the standard is "more likely than not" rather than scientific certainty. Another is how the generalizations drawn from epidemiology and population-based sciences are interpreted and individualized, as they must be, for the case at hand. A related issue is how risk is interpreted for an individual after the fact, when conventional probability treats risk before the fact and conventional biostatistics applies primarily to a population. This emerging approach is called "evidence-based medical dispute resolution".

Riassunto
«Valutazione dell'evidenza scientifica in campo legale, giudiziario e politico: quando la medicina del lavoro occupa il posto del testimone». *Le conoscenze mediche e sanitarie sono essenziali nella risoluzione delle dispute in materia legale ed amministrativa (come il risarcimento dei lavoratori) e forniscono un dato fondamentale nelle decisioni di politica pubblica. Non ci sono regole socialmente riconosciute per l'applicazione di tali conoscenze, eccetto che nel sistema giudiziario. In pratica, il sistema legale difetta di capacità di valutare la validità di tali conoscenze come evidenze oggettive e pertanto si deve avvalere in modo consistente dell'opinione di esperti. Negli ultimi trenta anni, un approccio chiamato "valutazione critica" e "medicina basata sulle evidenze" si è rivolto a un problema analogo nella pratica medica e ha fornito un modello perché si tenesse conto delle evidenze nella clinica medica. Un modello simile basato sulle evidenze può essere costruito perché le conoscenze mediche e sanitarie siano utilizzate nella soluzione delle dispute in campo legale. Un punto critico è come considerare l'evidenza scientifica quando lo standard è "di probabilità" piuttosto che scientificamente provato. Un altro è in che modo interpretare e classificare i dati risultanti dagli studi epidemiologici e dalle scienze che studiano le popolazioni. Altrettanto importante è come intepretare il rischio per un individuo dopo che è avvenuto il danno, quando usualmente la probabilità è valutata sul rischio a priori e gli studi statistici si applicano a popolazioni. Questo nuovo approccio è chiamato "risoluzione di dispute mediche basate sulle evidenze".*

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Experts play a critical role in the resolution of some of society's most taxing problems of equity and justice. Providing sound advice in legal disputes and administrative judgements is one of the most important services professionals in any field can offer society.

Much expert witness testimony is disputed and controversial. Experts are frequently accused of crossing ethical lines and offering up "junk science." However, the courts depend on expert witnesses to help them interpret the facts of the case; it cannot function without them.

In many parts of the world, occupational health professionals, especially physicians, are often involved in litigation as expert witnesses. Even more often, occupational health professionals are involved in adjudication systems derived from personal injury law, which substitute the judgements of a panel or judge or tribunal for that of a trial. These are called "alternative dispute resolution" systems. The most important such system, certainly in North America, is the workers' compensation system. The principles are similar to personal injury law, with many modifications.

This talk uses examples from the legal systems in the United States of America and Canada because they are familiar to the author. However, the principles involved in this discussion are not limited to any one system of jurisprudence, although individual laws, precedents and procedures may vary widely.

The social functions of litigation

It is not surprising that people in complicated, pluralistic, often transient societies use litigation to resolve conflicts, and often resort to lawsuits instead of negotiation. Societies that are more traditional, homogeneous and under less pressure to change often have other ways to settle differences, such as the intervention of elders, religious figures, family members or strong government and business figures; private adjudication procedures; and public consensus, often driven by religion. However, in a pluralistic society where no one community dominates, the generally respected institutions for resolving disputes within one community cannot apply to the others or to the majority. Different communities do not necessarily agree about norms and acceptable behavior. Some external means of dispute resolution is required. The legal system is where such norms are worked out (8, 12, 14).

The part of the law that deals with personal injury, in which one person or entity has caused harm to another, is called "tort law" in the American and Canadian (and other Commonwealth) systems. The personal injury itself may be a physical injury, an economic loss, a failure to fulfill a duty owed or some other privation. This injury is called a "tort" in English. The original, French word from which tort derives is the same as that for the word "torture" and the word "tortuous." Many people think that this is highly appropriate, because tort law has become difficult, painful, and convoluted, especially in the United States.

Tort liability also serves a constructive social function, however. When one person has suffered an injury at the hands of another, that person can bring a legal action. Through anticipation and fear of an adverse judgement, it deters people from actions that are likely to infringe on the rights or interests of others. It does so without being an absolute barrier, so that some "gray areas" may be explored and risks can be taken, within a narrow range of acceptable liability. If an injury can be proven, through action or negligence on the part of the responsible party, and if it can be shown that tangible damages resulted, the person who brought the lawsuit (called the plaintiff) can recover damages from the person being sued (the defendant). This comes at a high cost and inconvenience to both parties, which does however have the effect of discouraging suits that have no basis. Because the costs for are born by the litigants individually, there is a rough justice: whoever the court decided was wrong is burdened with considerable expense.

The problem with the social role of tort liability is that it is very cheap to bring a lawsuit, expensive to see one through to the end; the awards can be very large (although huge awards are often reduced later on appeal) and are not always proportional to the degree of injury. Litigants contribute to a social resolution of these problems in the process of resolving their own case and bear both the cost for this socially useful function and, in some cases, the risk of catastrophic judgements. The cost of this system is essentially underwritten by the losers in the actions and by the public, which maintains the system. The costs may be large and unpredictable and by the nature of litigation an action precipitated by one party may result in disastrous expenses on the other party, sometimes not justified.

In recent years, class action suits in North America have raised litigation to new levels of intensity and magnitude. The picture is not pretty: it is messy, brutal, often unfair and sometimes attracts junk science and fraud. These lawsuits have caused economic disruption, saturated the courts and have often been arbitrary in their awards. However, legal actions taken against asbestos manufacturers, the tobacco industry and gun manufacturers have also conferred a major social benefit by compensating the injured and by deterring further abuses. At a time when the prevailing political sentiment is against regulation, this litigation may serve as the last backstop to ensure that public health gains are not lost.

Knowledge applied to resolving disputes

The legal system as a whole could benefit if there were more explicit norms for expert witnesses (8). The norms of interpretation and analysis expected of an expert witness reflect the normal standards of the profession and are consistent with the same standards of practice and ethics.

Expert knowledge, and especially health and medical knowledge, are essential to the resolution of many disputes in law (such as tort litigation) and administrative adjudication (such as workers' compensation). The medical or occupational health expert provides essential input into public policy decisions. How to use this knowledge is not always clear. Scientists know how to evaluate evidence in science following the "95% certainty" principle for statistical significance. However, civil law (and most systems of adjudication) has a different standard for disputes between parties: the balance of probabilities, or "weight of evidence", which translates to >50% certainty. When the medical or occupational health expert ventures into the courtroom, therefore, it is like a game with very different rules (8, 12, 14) By comparison, the standard of certainty for criminal cases, when the accused will be deprived of rights, is "beyond reasonable doubt," a standard even more stringent than 95% certainty.

Some expert witnesses stick to the familiar rules of science and are therefore, by definition, too conservative in their opinion. Others may feel liberated by the looser standard of civil litigation and free to make up theories and opinions that are extrapolated far beyond solid evidence. Litigation has been a spawning ground for so-called "junk science" (4, 8, 16), which has threatened the credibility of experts in general and has probably discouraged many knowledgeable investigators and practitioners from sharing their knowledge when it has been needed. An example of this is suspect testimony in the wave of litigation over "toxic mold" in the United States today, where experts have testified to unlikely health effects associated with levels of exposure to mold in indoor air, mostly in homes, far beyond what is supported by the available evidence.

The adversarial structure of the American and Commonwealth legal systems encourages extreme interpretations. The foundation of a trial in the American or Commonwealth (e.g. Canadian) system of law is advocacy on behalf of two opposing sides that have a duty only to present their own best case, the adversary system cannot be changed. It would be inimical to the legal system if, for example, plaintiff and defense experts, or claimants and adjudicators, let their experts meet in conference to decide among themselves what science is correct. (Something like this has been attempted, however, by judges who have set up expert panels to advise them in class action lawsuits (18)).

Still, there are standards of practice for ethical expert practitioners in "witnesscraft"(8) just as there are in medical practice (1). One wonders if it would be possible to achieve a generally accepted norm, or consensus, on what constitutes good practice in expert testimony. There are no broad, socially agreed-upon rules for the application of medical, occupational health, public health, and for that matter any scientific knowledge except in the rules of evidence and decisions of the law. (3, 10) This is particularly evident in tort litigation, when liability for causing injury is under consideration and often rests on theories of disease etiology and the circumstances surrounding exposure to a hazard.

The application of medical knowledge in tort litigation has had successes and failures:

– Litigation over the legacy of asbestos exposure remains highly controversial: arguments over criteria for recognizing asbestos-related diseases are at the heart of the controversy, despite decades of high-quality research. At the time of this writing, efforts are being made in the United States Congress to set up an adjudication system. One particularly controversial issue has been the formulation of fair criteria for accepting claims.

– Litigation over silicone breast implants dried up after it was finally decided that the scientific evidence did not support claims of injury (6, 19).

– Litigation over the safety of mefloquine (an antimalarial drug) has been slow to evolve as scientific evidence accumulates: this is characteristic of a new issue, or "first case".

– Litigation over the safety of Bendectin (an antiemetic used in pregnancy) forced the drug off the market despite its proven efficacy and good safety record (2, 20).

The common factor in these sets of cases has to do with opinions regarding causation (17), where these issues are particularly evident.

A similar problem once existed for the clinical practice of medicine. Over the last 30 years, an approach called critical appraisal has established norms for the acceptance of evidence in clinical practice that are now almost universally accepted. Critical appraisal is a systematic approach to evaluating the evidence based on clinical epidemiology; evidence-based medicine is the practice of medicine justified by valid studies correctly interpreted. (Canada played a major role its history.) Critical appraisal of the medical literature and the reliance upon evidence-based principles by managed care organizations and utilization review organizations led to the adoption of evidence-based medicine in clinical practice today. The concept of evidence-based medicine was not written into in legislation or enforced as governmental or judicial policy. It advanced over many years through education and consensus because it made sense to all participants. Evidence-based medicine did not end controversy in medical practice but it confined the scope to the scientific issues and rooted controversy in evidence rather than unsubstantiated opinion (8).

Is it possible to develop a similar framework for applying the knowledge of health and medicine similar to expert services in law? Over the last few years, the author and a small group of scientists and lawyers have tried to develop such a framework, which has been called "evidence-based medical dispute resolution" (7-9).

Evidence-based medical dispute resolution, conceptually, is a systematic approach to evaluating scientific evidence in a particular context, that of law, adjudication and public policy. The idea behind the approach is to adapt methods of evidence-based medicine and "critical appraisal" that are now well accepted in health care to assist a court (or, as in workers' compensation, an adjudicating body) to weigh evidence in disputes involving health risks. However, there are practical problems: this is not just a matter of treating evidence for court in the same way as one would decide on the best option for treatment. The "practice" of medical expert witnesses is not standardized or governed by a consistent set of principles. Each expert witness is essentially autonomous. An expert witness cannot easily compare opinions with or learn from a community of other experts who have a consistent view of how to approach a problem or interpretation.

It should be possible, however, to develop a similar framework for the evaluation of scientific evidence in legal settings. It will not be possible – or even desirable - to distill a set of firm rules or protocols for dealing with scientific evidence in legal settings. However, if the broad outlines of reasonable care can be agreed upon, experts will have advanced much further and can concentrate on the facts of the individual case.

EVIDENCE-BASED MEDICAL DISPUTE RESOLUTION

There are no broadly agreed-upon rules for the application of this knowledge except those recognized by the law. Although physicians are subordinate to the requirements of the legal system when they serve as expert witnesses, the law recognizes professional standards and the norms of medicine and, increasingly, epidemiology. In the United States, the culture of scientific investigation and the legal privileges given expert witness are reflected in legal precedent (cases that have already been decided by higher courts) and in the Federal Rules of Evidence.

There is no formula or easy set of rules that can be derived for the universal application of this approach to scientific evidence. Rather, there are difficult questions to be asked:

– Can a consensus be achieved among legal and medical professionals on how disputes related to health and medical management should be "framed" (in legal vocabulary) and the essential health and medical issues defined?

– Can both a medical understanding of complexity and a legal ability to parse the issues each be taught to the other profession, so that there is mutual understanding concerning the essentials?

– Can the tools of critical appraisal (clinical epidemiology, meta-analysis and critical evaluation) be applied to the body of evidence admitted in a legal dispute?

– Can the tools of critical appraisal be adapted to apply to the rules of civil law and administrative practice?

This framework could be as simple in design, as robust, and as adaptable as the idea of evidence-based medical practice. The rise of evidence-based medicine shows that it is possible for a consensus to emerge, despite the prerogatives of highly independent practitioners. The counterpart in the application of medical knowledge to law may achieve a similar consensus if it meets the need of legal systems, satisfies the demand of society for fairness, and makes sense to all participants.

What would "evidence-based medical dispute resolution" consist of? A rational approach to evaluating evidence in the health sciences requires both a capacity to generalize, usually on the basis of a population, and a capacity to individualize to the specific case. If the mechanism is known, the explanation enhances the credibility and therefore the persuasiveness of the conclusion. This approach should be useful in the development of a specific case and in guiding the development of the administrative systems in which it is used. Therefore, such an approach should contain these elements (8).

– Epidemiology and the interpretation of population data

– Individualization of the evidence to the specific case, using methods of clinical medicine, toxicology and (in the future) genetics

– Statistical treatment that does not necessarily rely on conventional assumptions designed for scientific studies

– An understanding of science that takes into account the social nature of the scientific enterprise, as shown in contemporary studies in the history and philosophy of science

– Adaptability to a variety of applications, including public policy, statutory adjudication systems, and tort litigation

The role of epidemiology

One of the most powerful tools in modern tort litigation and adjudication for occupational and environmental hazards has been epidemiology. The epidemiologist is now the essential expert for the resolution of issues involving health outcomes following exposure to hazards. However, epidemiology is not enough.

Epidemiology is fundamentally a science of generalizations. The basic approach of epidemiology to estimating risk is to measure the experience of a population of individuals with the expectation that, all other things being equal, the overall risk for the group will be a valid estimate for most members of the group. Epidemiology has become increasingly valued in health-related cases precisely because it is a powerful tool for generalization (5, 8, 20).

However, epidemiology has limitations precisely because it is a science of generalizations. That is its great strength but also its great weakness. When applied to class actions, generalizations make sense because one is considering patterns in a large population. However, most litigation involves individual plaintiffs and the individual circumstances of the case must be separately considered. (This is also true in most adjudication systems, such as workers' compensation.) Thus, epidemiology can inform the expert witness with a description of what happens most of the time or what is most probable, but the interpretation still must be brought to the level of the individual case. This may mean demonstrating that the plaintiff or claimant is similar to a group at demonstrably high risk or that he or she is different and therefore belongs to a subgroup or has unique characteristics and so their risk is not adequately described by summary statistics. This is where a well-prepared, knowledgeable medical expert can play a critical role.

For the epidemiological science to be brought down to the specific case, it must be understood and then interpreted with knowledge of the circumstances of the specific case. The medical expert comes into play in going from the broad generalization, which is called "general causation" in American law, to an opinion on causation in the particular case, which is called "special causation." This requires an expert who understands the epidemiology but also understands the individual. Occupational health and safety professionals, including occupational physicians and nurses, spend their entire careers doing just this!

Another critical issue is how to apply scientific evidence when the standard is "more likely than not" rather than scientific certainty. In other words, what would epidemiology and biomedical sciences be like if the standard for conclusions (not necessarily individual experiments) were 50% rather than 95% certainty? What would be the role of the doctrine of "falsification" (the notion that a theory cannot be proven, only disproven) if the standard for accepting a theory were only the weight of evidence rather than a single fact that the theory cannot explain? In effect, this is the issue that confronts the expert in developing a theory of what happened in, or "framing", the individual case.

The role of the expert

Expert testimony is an old and venerable function of health professionals. The law, in general, respects the opinion of physicians and other expert witnesses, including experts in occupational health. In past years, the informed judgment of health professionals, without reference to the evidence, carried greater weight than it does today. However, junk science and the spectacle of "dueling experts," who seem to fight without grounds for their positions, have provoked a backlash.

In the United States, one court decision has clarified the standard for applying scientific information to dispute resolution. The decision in Daubert v. Merrell Dow Pharmaceuticals, Inc. 113 S. Ct. 2786 (1993) [this is an American legal citation] attempted to set a new and higher standard for federal courts in reviewing scientific evidence. The effect of this decision was that judges presiding over technically complicated cases have assumed a new "gatekeeping" function monitoring scientific evidence that they cannot be expected to have mastered. This federal court decision was later expanded upon and served as the model for many state decisions (8, 12-14). Since Daubert, courts have put much greater emphasis on defensible arguments based on empirical data and less emphasis on expert judgment. The ability to base testimony on evidence, and to fit the evidence together in an objective-appearing way, is far more important in today's courtroom. Opinion is not enough. A personal, subjective or idiosyncratic interpretation of the facts contributes little and may even undermine one's professional credibility. So, just how does the expert witness meet these elevated expectations (8, 13)? In the United States, as a result of Daubert, the emphasis is on deciding whether scientific evidence is sound and considerable power is given to the judge to decide whether an expert's interpretation can be admitted into the trial. This has led to strategies by lawyers designed to keep out scientific evidence before a jury hears it or before a judge presiding over a case is allowed to consider it in the trial. In Canada, by contrast, the emphasis is on how much weight to give the evidence after it is admitted, not on keeping it out.

The need to demonstrate a balance of probabilities on the basis of evidence creates two primary responsibilities for the medical advisor in adjudication or the expert witness in court: to provide a clear rationale behind the opinion and to articulate it in a manner that is useful to the adjudicating body. The expert witness has always been expected to express a sound opinion in a comprehensible fashion. Now, the expert is also expected to provide solid grounds and a coherent chain of logic for the opinion expressed and to place it in a context that assists the adjudicator in arriving at an informed decision. The expert is expected to reflect either a professional consensus or a well-accepted minority opinion with considerable backing in the scientific community.

The key is to find a theory of the case that makes sense, does not depend on just a single fact, can stand up to more than one interpretation of events and does not depend on too many assumptions. This is not easy. An apparently rational but complicated theory of a case may easily require so many contingent steps, each with a low probability, that the final odds that the theory resembles what happened are much less than even. (8, 11)

Finding a theory that makes sense is also not enough. The theory of the case must also be communicated clearly and simply. In court even a reasonable theory developed to fit the particulars of a highly unusual case may appear idiosyncratic, even bizarre, when distorted by the "other side."

There is nothing unethical about holding one opinion with respect to the legal interpretation of a set of findings and another with respect to the scientific interpretation. One may legitimately consider a matter to be very likely but not scientifically proven (such as asbestos as a cause of colon cancer).

Often, the scientific evidence for an association is strong but not conclusive. In such cases, it is entirely reasonable and responsible for an expert witness to maintain on the witness stand that there is or is not an association, on the basis of an interpretation of "the weight of evidence", but to maintain in a scientific forum that the association is not proven because it has not been proven beyond a reasonable doubt. What counts in the end in terms of resolving legal disputes is the weight of what evidence exists, not how strong the body of evidence is in its entirety.

Conclusion

In coming years, perhaps a broad consensus will emerge among health professionals and lawyers on the most reasonable approach to interpreting scientific evidence in health-related disputes. One may even hope for a consensus on the "rules" of evaluating scientific evidence that may resemble the "rules" of evidence-based medicine. Such a consensus should be subject to continual review and inspection, as is science itself, but if achieved, it will provide a living and working framework that will bring us closer to objectivity in weighing the evidence in disputed cases.

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La Medicina del Lavoro Med Lav 2006; *97*, 2: 175-181

Prioritizing future resources for epidemiologic research on old and newly emerging occupational hazards

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KEY WORDS
Epidemiology; emerging risk, occupational hazards

SUMMARY
Background: *Inevitably, occupational epidemiologists must decide when and how to shift research attention and resources from investigations of old, established health hazards to a focus on newly emerging potential risk factors. As yet unknown occupational health consequences of burgeoning worldwide technologies, such as the microelectronics industry, and increasing recognition of the importance of common, yet non-traditional occupationally-related health effects, such as musculoskeletal disorders in office workers, give strong impetus for embarking in new directions. However, there remains much to be learned from continued investigation of well-established occupational hazards, such as asbestos, benzene, and lead.* **Objectives:** *A rational strategy for planning future research will need to consider optimizing resources.* **Conclusions:** *The following suggestions are offered. 1) First and foremost, occupational risk factors are most directly, and arguably most validly, identified by studying workers in well-defined cohorts, ideally when exposures are adequately characterized. To this end, industry-based cohort studies should be given priority, at least for older hazards, over population-based case-control and surveillance designs. 2) Defined cohorts with extensive exposure and health outcome data should continue to be followed, as resources permit; 3) Launching cohort studies for potential new hazards should incorporate extensive exposure assessments at the outset, and should preferentially select inception cohorts of newly hired workers. Valid biomarkers of pre-clinical disease will be especially valuable in this regard. 4) Capitalizing on new technological advances in exposure assessment, clinical medicine, molecular genetics should be encouraged.*

RIASSUNTO
«*Ottimizzare le risorse future per la ricerca epidemiologica su vecchi e nuovi rischi professionali emergenti*».
Inevitabilmente, gli epidemiologi occupazionali devono decidere quando e come spostare l'attenzione della ricerca e le risorse dallo studio dei vecchi e noti rischi per la salute per concentrarsi su nuovi potenziali fattori di rischio emergenti. Le ancora sconosciute conseguenze sulla salute dei lavoratori del diffondersi delle tecnologie nel mondo, come l'industria della microelettronica, e il crescente risconoscimento dell'importanza di comuni, anche se non tradizionali, effetti sulla salute correlati al lavoro, come le patologie muscoloscheletriche nei lavoratori d'ufficio, danno una forte spinta per imbarcarsi verso nuove direzioni. Rimane comunque molto da imparare dal continuo studio di ben noti rischi professionali, come l'asbesto, il benzene e il piombo. Una strategia razionale per pianificare la ricerca futura dovrà considerare l'ottimizzazione delle risorse. Offriamo i seguenti suggerimenti: 1) per prima cosa i fattori

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di rischio professionali vengono più direttamente e sicuramente meglio identificati studiando i lavoratori in coorti ben definite, idealmente quando le esposizioni sono adeguatamente caratterizzate. A questo fine bisognerebbe dare la priorità a studi di coorte per tipologia di industria, almeno per i rischi più vecchi, studi di popolazione caso-controllo e progetti di sorveglianza; 2) coorti definite con esposizioni ben valutate e con risultati della sorveglianza sanitaria devono continuare a essere seguite nel tempo, se le risorse lo permettono; 3) nel dare inizio a studi di coorte per individuare nuovi potenziali rischi è necessario incorporare valutazioni estese dell'esposizione all'inizio e si dovrebbero scegliere preferenzialmente lavoratori neoassunti. Indicatori biologici di effetto preclinico sarebbero particolarmente importanti in questi casi; 4) Dovrebbero essere incoraggiati investimenti in tecnologie avanzate per la valutazione dell'esposizione, per la clinica e per la genetica molecolare.

INTRODUCTION

Historically, the greatest successes achieved in occupational epidemiology have been the identification of workplace health hazards and quantification of dose-response relations that have informed risk reduction interventions. These advances have been realized primarily in situations where overt toxicity is clearly manifested, and substantial health risks have been demonstrated. Benzene-related leukemia (5) and impaired fertility among workers exposed to the nematocide DBCP (16) are just two of many well-recognized examples. There are, of course, numerous other occupational exposures for which health consequences are either incompletely understood or unknown. An example would be exposures that result from recently developed technologies, such as the microelectronics industry. Moreover, the growing burden of occupational illness and injury from non-traditional sources, such as the office environment, indicates a need to expand occupational epidemiology into newer research directions.

In many respects, future research will be guided by individual investigators' particular interests and training, and by funding opportunities. As such, it may seem somewhat artificial to conceptualize a planned research agenda. Nonetheless, it is worthwhile to develop a general strategy for occupational epidemiology, as a discipline, because the scope of research will always be constrained by available resources and access to study populations. From this perspective, I will attempt to offer some suggested approaches that may, if implemented successfully, have promise for maximizing the yield of occupational epidemiology research during the next 10-20 years. These recommendations will focus chiefly on identifying the most suitable study populations and designs to investigate exposure/health outcome relations that are of greatest concern.

STUDY POPULATIONS, DESIGN OPTIONS, AND CAUSAL INFERENCE

Before any decisions can be reached concerning research prioritization of exposures and health outcomes, it is worthwhile for epidemiologists to consider how their choices of study population and design will ultimately influence causal conclusions. Few would dispute the assertion that the ultimate goal of occupational epidemiology, illness and injury prevention, requires clear understanding of the relations between workplace exposures and health consequences. Such understanding requires identification of potentially causative exposures and dose-response characterization. For outcomes, such as acute injuries, establishing causation is relatively straightforward - the immediate conditions preceding injuries can be assumed to be causal. Of course, modifying factors, such as combinations of co-occurring exposures, age, gender, and prior work experience, may be important, although not readily apparent risk modifiers that deserve in-depth study. In contrast, more complex health outcomes, such as cancer, respiratory diseases, chronic musculoskeletal disorders, and neurodegenerative diseases pose greater challenges to epidemiologists attempting to identify preventable causes.

In studies of the so-called “complex diseases”, which has been a sustained research focus among many occupational epidemiologists for decades, there are two general approaches. The first are cohort studies of risks among defined occupational populations with reasonably well-defined exposures, where multiple health outcomes may be investigated simultaneously. The alternative design is exemplified by population-based case-control studies of specific diseases in which occupational exposures are typically among numerous risk factors under consideration. The obvious distinction between these approaches is that cohort studies focus principally on the workplace and related exposures, whereas population-based case-control studies are focused primarily on specific diseases. Other design variants, such as cross-sectional morbidity surveys and case-crossover studies of acute outcomes, fit into the same general framework of an alternative focus on exposure or disease. The relative advantages and limitations of the various study designs are very familiar, and need not be reiterated here.

In order to identify risk factors and quantify dose-response associations for complex diseases, the most direct, and arguably the most valid, approach is to conduct cohort studies of worker groups whose exposures are widespread (in the workplace) and can be assessed with specificity and accuracy. This is not to suggest that the population-based case-control designs should be abandoned, but rather that they are of secondary value for establishing causation.

To illustrate, consider epidemiologic research on Parkinson’s disease (PD), which is truly a complex disease whose etiology remains very poorly explained. There are varying levels of support for causal contributions by metals, based on clinical case reports (e.g., manganism mimicking features of parkinsonism) (13) and epidemiologic findings (4). Toxicological research has also provided biological plausibility for some metals, especially iron and manganese, as PD risk factors (17). Most recent epidemiologic research relevant to these exposures and PD is limited to population-based control studies, and findings have been mixed. A particular shortcoming of these studies is the low population frequencies of occupational metal exposures. For example, welding as a primary occupation is relatively uncommon in the population-at-large, and as such, one would anticipate small attributable risks and statistically imprecise risk estimates, which indeed has been the case. One might conclude that welding or associated metals are not important PD risk factors, and by extension, that manganese and other welding exposures are similarly not of causal concern. Although on a population-wide basis, it may be true that welding exposures may be a minor determinant of PD, inferences regarding the potential hazards experienced by welders or, more broadly, the neurotoxic consequences of welding exposures, would not be defensible. What is needed is direct research among welders that accomplishes the goals of relating carefully assessed exposures with health outcomes. It should be appreciated that carefully measured exposure does not necessarily imply occupational hygiene measurements of metal and gaseous fume concentrations in the workplace, although such measurements can be very valuable for exposure assessment. Instead, a thorough determination of occupational history among welders would suffice in most instances. A recent study of US welders (8) demonstrated a high prevalence of parkinsonism that suggests dose-relatedness. Further studies of welders, especially research that can establish disease onset and preclinical disease states, rather than merely prevalence, will be particularly valuable.

Continued follow up of established cohorts

Inevitably, epidemiologists need to decide when enough has been learned about specific hazards such that further investigation might be an inefficient use of resources. For example, there is an enormous body of literature that clearly documents the risks for pulmonary fibrosis (asbestosis), lung cancer, and mesothelioma consequent to asbestos exposure. From that standpoint, a reasonable case could be made that risk assessments based on presumed exposures in the workplace and ambient environment, linked to risk estimates derived from previous cohort studies of occupational groups, should be preferable to either extended follow-up of existing cohorts or initiation of new cohort studies. This may indeed be a true assertion with respect to asbestosis, lung cancer, and mesothelioma. Nevertheless, there are good reasons for extended follow-up of previously established occupational cohorts. Continuing with the example of asbestos, the evidence for excess risks for diseases other than asbestosis, lung cancer, and mesothelioma, especially for gastrointestinal cancers, is remarkably sparse and in many respects inconclusive. The primary reason for the dearth of knowledge on asbestos-related risks for gastrointestinal cancers is that most cohort studies were focused on lung cancer and mesothelioma, whereas findings for other cancers were often not reported in adequate detail, and in some instances, dose-response estimation was not attempted. Recently reported findings for gastrointestinal cancers derived from updated cohort studies of crocidolite asbestos miners Wittenoom Gorge in Western Australia (9) and London asbestos factory workers (1) do provide site-specific dose-response estimation for gastrointestinal cancers. These newer findings, relevant to an "old" hazard will prove to be highly influential in characterizing the spectrum of health effects attributable to asbestos. Similar arguments might be made for further investigation of other well-studied occupational toxicants, such as benzene, lead, arsenic, and formaldehyde.

It is perhaps best to consider established cohorts whose exposures have been assessed extensively as "international treasures" that should not be abandoned. Obviously, extended follow-up of existing cohorts is not a cost-free endeavor. Thus, occupational epidemiologists will need to make convincing arguments that the gains in public health and scientific knowledge justify the costs.

INVESTIGATING NEW HAZARDS

In a world of ever-changing technology and economic globalization, newly emerging workplace exposures and potentially related adverse health effects will require epidemiologic evaluation. Likewise, new information from toxicological research may suggest the need for epidemiologic study of chemical and physical agents that might previously have been considered to be innocuous. Extensive research on the associations between occupational electromagnetic fields and breast cancer (3, 7) is one of many recent illustrative examples. Moreover, the types of exposed populations continue to undergo change in terms of demographic factors and geographic distributions. Ideally, occupational epidemiologists should be well poised to address emerging health concerns in a timely manner, which can be accomplished most readily for situations of acute toxic outcomes. More typically, however, epidemiology is not a rapid response science, but instead moves at a deliberate pace.

There are several important considerations that enter into decisions about which new exposure/disease associations warrant epidemiologic study. First and foremost is the likelihood of toxicity, which may be based on clinical case series or toxicological research. Other considerations are the widespread nature of exposure in the workplace (and ambient environment in some instances), access to suitable study populations, and the ability to perform reasonably accurate exposure assessments. This is by no means an exhaustive list of considerations, nor is it intended as a checklist that needs to be satisfied.

A relatively cost- and time-efficient approach to examining new associations is to screen existing databases, which can take the form of death certificate surveys of recorded occupations, or census linkage studies that relate cause-specific mortality or morbidity with population-wide census data on occupations. Very strong exposure/disease associations can be detected by these methods, but the obvious limitations are the absence of detailed exposure data and disease diagnostic verification. As a result, weak to moderate associations can easily be missed. The consequences of false negative research findings can be substantial when exposures of interest are widespread in the population.

Here again, I would argue that the most scientifically rigorous tests of new associations can be made among defined occupational cohorts where exposure assessment and disease outcome are accurately and validly measured. By way of illustration, consider a situation where new toxicological evidence indicates that a particular chemical is cardiotoxic. Among the initial research options would be population-wide mortality and morbidity surveys, such as census-linkage studies or cross-sectional studies of exposed workers. Both approaches might be informative in a general sense, but would likely suffer from inadequate exposure assessment and healthy worker effect biases. Alternatively, studies that follow exposed worker cohorts over time for changes in cardiovascular parameters (e.g., blood pressure, serum lipid profiles, electrocardiographic abnormalities) in relation to measured exposure changes can provide far more direct evidence of human toxicity. Relatively short-term follow-up (e.g., several years) can provide the framework for longer-term investigation of chronic effects, such as myocardial infarction and stroke. The optimal study populations for follow-up would be inception cohorts of newly hired, and hence newly exposed, workers. A good template for this approach is the 20-year prospective follow-up of respiratory system outcomes among Chinese cotton textile workers conducted by Christiani et al. (2, 14, 15). Findings from the first 5 years of follow-up indicated accelerated loss of lung function (2), and subsequent follow-up findings indicate the potential for chronic obstructive lung disease related to cotton dust and endotoxin exposure (14, 15).

Admittedly, repeated measures studies of exposures and health effects can pose formidable logistical challenges. Nonetheless, the gain in public health and scientific knowledge justify the costs.

CAPITALIZING ON TECHNOLOGICAL ADVANCES

The ability to measure exposures with increasing specificity and accuracy, especially at low concentrations, has been a major contribution by occupational hygienists to industry-based studies. In parallel, exposure assessment methods for community-based studies, mainly case-control designs, have been beneficial (11). Inasmuch as the quality of exposure assessment is a critical factor in the ultimate value of every occupational epidemiology study, it will be especially important for future research to take full advantage on technological advances in identifying and quantifying harmful agents. The quality of exposure assessment becomes particularly critical when relatively small health effects of interest are anticipated (i.e., relative risks close to the null). Among the emerging topics that will probably deserve epidemiologic attention are characterization of chemical mixtures of low-level contaminants and very small particles (e.g., nanoparticles) whose adverse health effects are increasingly being realized in air pollution research.

There has also been during the past two decades a remarkable revolution in molecular genetics, evidenced most prominently by the sequencing of the human genome. This has led to the now widespread availability of laboratory capabilities that enable characterization of genotypic profiles for numerous genes that may be pertinent to occupationally related diseases. Accordingly, epidemiologists have increasingly applied genetic methodology in an effort to identify disease susceptibility factors (6). The underlying notion is that one's genotype may modify the effects of a toxic exposure, either favorably or unfavorably. Identification of genetic effect modifiers, commonly referred to as gene/environment characterization, has the potential for identifying particularly susceptible subgroups in the population. An example of a gene/environment investigation in an occupational epidemiology study is the characterization of a specific gene variant that confers apparently elevated risks for berylliosis in exposed workers (10).

Despite the attractiveness, in terms of disease prevention potential, of applying genomic methods to identify subgroups of workers with greatest disease susceptibility to workplace hazards, some caution should be exerted before this approach becomes a widespread practice in occupational epidemiology. First, interpretation of genetic data, although relatively easily obtained, is often fraught with uncertainty. Human disease processes are inherently complex, and pathways involving toxicity from occupational exposures are likewise complex. As such, genetic variability may have low predictive power for risks in a population. Furthermore, susceptible subgroups identified genotypically are likely to be only small fractions of the total population, which implies that there will typically be a low overall population attributable risk for any gene/environment interaction. Considered in terms of resource allocation in future research, where there are competing demands for exposure assessment enhancements, better diagnostic classification, and genetic analyses, it would seem that genetic analyses should be accorded the lowest priority. As Vineis (12) has aptly noted, we should not undervalue the importance of the environment (including the workplace) in the gene/environment equation. Fortunately, DNA samples can be archived and assayed years after collection, which can minimize immediate costs, and avoid the distraction of conducting complicated genetic profile analyses at the expense of thorough exposure assessment and estimation of dose-response relations.

Conclusions

Prognostication of future research needs and priorities is inevitably an uncertain exercise. It is nearly impossible to predict with much accuracy which occupational health concerns will emerge as most pressing in the upcoming years or decades. Nonetheless, it is quite reasonable to attempt to predict and prioritize general research strategies that should have most promise for disease prevention. My recommendations can be summarized as follows:

– Characterization of the relations between occupational exposures and adverse health outcomes is most efficiently realized by workplace-based studies, rather than by population-based studies. As such, the cohort study approach should be given preferred status.

– Efforts should be made to continue epidemiologic follow-up of occupational cohorts exposed to well-established hazards (e.g., asbestos), with priority given to cohorts with the highest quality exposure assessment.

– Characterizing "new" occupational hazards can also be addressed most effectively by workplace-based studies. Longitudinal follow-up studies of newly hired workers is the optimal design, especially when early disease indicators can be measured. Population-wide surveillance analyses can also be valuable for detecting relatively strong associations that warrant more in-depth investigation in workplace-based studies.

– Occupational epidemiology should certainly capitalize on technological advances in exposure assessment, clinical medicine, and genetics. Among these, exposure assessment and diagnostic technologies should be given far greater resource allocation than genetics. Gene/environment research has promise that, fortunately, can be realized at later times when interpretations are clearer.

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Med Lav 2006; *97*, 2: 182-183

Work-related musculoskeletal disorders: is the burden equitably distributed?

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Key words
Musculoskeletal disorders; ergonomics; physical workload

Musculoskeletal disorders (MSDs) are widespread at least in every society where records are maintained and are caused by a wide range of risk factors, including working conditions. Like many other occupational hazards, MSD risk factors are more common in low-status, low-wage jobs. Additionally, the distribution of ergonomic stressors (both physical and psychosocial) differs between men and women. Recent trends in globalization, such as outsourcing of hazardous work from the economic center to the periphery, have also redistributed some highly strenuous jobs to areas of the world where labor costs are cheaper and MSD morbidity is more easily externalized to members of the workforce.

While some countries, especially in Europe, have promulgated labor regulations to reduce ergonomic exposures, others, such as the United States, have not taken such action or have actively resisted it. The political battle over ergonomics regulations has often been couched in scientific terms regarding the sufficiency of the evidence to justify political action. Some similar concerns have been raised in countries (e.g., Sweden) where ergonomics regulations have not led to the dramatic decreases in MSD absenteeism that were anticipated. Nonetheless, it is important not to confuse the need for more research with an absence of evidence that MSD risk is higher in jobs with high physical workload.

One way that the scientific argument has become obfuscated is through discussion of the failure to adjust for socioeconomic status and/or psychosocial exposures, which is true especially of studies conducted in previous decades. In the U.S., at least, these limitations have been argued to invalidate the findings of those studies regarding the contribution of physical workload - even though later, more robust research has continued to uphold those findings. These methodologic issues will be discussed with particular attention to the importance of distinguishing among factors that confound, serve as effect modifiers, or sit on the causal pathway. Illustrations from the empirical literature will be utilized in particular to elucidate the relationships among socioeconomic status, gender, physical and psychosocial exposures, and how those inter-relationships are structural consequences of work organization and macroeconomic factors. In the current political and economic climate, mis-representing or mis-interpreting these relationships can have not only scientific but also policy consequences. Epidemiologists and ergonomists have a responsibility not to exaggerate our uncertainty or allow the nuances of our discourse to be used against needed public health interventions.

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Med Lav 2006; *97*, 2: 184-188

Health risks of exposure to non-ionizing radiation – Myths or science-based evidence

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KEY WORDS
Non-ionizing radiation; UV radiation; EM fields

SUMMARY
Introduction: *The non-ionizing radiation (NIR) contains large range of wavelengths and frequencies from vacuum ultraviolet (UV) radiation to static electric and magnetic fields. Biological effects of electromagnetic (EM) radiation depend greatly on wavelength and other physical parameters.* **Optical radiation:** *The Sun is the most significant source of environmental UV exposure, so that outdoor workers are at risk of chronic over-exposure. Also exposure to short-wave visible light is associated with the aging and degeneration of the retina. Especially hazardous are laser beams focused to a small spot at the retina, resulting in permanent visual impairment.* **Electromagnetic fields:** *Exposure to EM fields induces body currents and energy absorption in tissues, depending on frequencies and coupling mechanisms. Thermal effects caused by temperature rise are basically understood, whereas the challenge is to understand the suspected non-thermal effects. Radiofrequency (RF) fields around frequencies of 900 MHz and 1800 MHz are of special interest because of the rapid advances in the telecommunication technology. The field levels of these sources are so low that temperature rise is unlikely to explain possible health effects. Other mechanisms of interaction have been proposed, but biological experiments have failed to confirm their existence.*

RIASSUNTO
«Rischi per la salute dovuti all'esposizione a radiazioni non ionizzanti: mito o evidenza scientifica?». *Le radiazioni non ionizzanti (NIR) contengono una vasta gamma di lunghezze d'onda e frequenze che vanno dalle radiazioni ultraviolette (UV) nel vuoto a campi statici, elettrici e magnetici. Gli effetti biologici delle radiazioni elettromagnetiche (EM) dipendono molto dalla lunghezza d'onda e da altri parametri fisici.* **Radiazioni ottiche**: *Il sole è la maggiore sorgente di esposizione ambientale ai raggi UV, cosicché i lavoratori all'aperto sono a rischio di sovraesposizione cronica. Anche l'esposizione alla luce visibile ad onda corta è associata all'invecchiamento e alla degenerazione della retina. In particolare i pericoli sono i raggi laser concentrati in una piccola zona sulla retina, che esitano in un danno permanente della visione.* **Campi elettromagnetici:** *L'esposizione a campi elettromagnetici determina correnti corporee ed assorbimento di energia nei tessuti la cui entità dipende dalle frequenze e dai meccanismi di accoppiamento. Gli effetti termici causati da aumenti di temperatura sono sostanzialmente noti, mentre la sfida è di capire i probabili effetti non termici. I campi delle radiofrequenze attorno a frequenze di 900 MHz e di 1800 MHz sono di particolare interesse per il rapido progresso della tecnologia nelle telecomunicazioni. I livelli dei campi di queste sorgenti sono così bassi che il rialzo della temperatura è poco probabile che possa spiegare i possibili effetti sulla salute. Sono stati proposti altri meccanismi di interazione, ma gli esperimenti biologici sono poco validi per confermare la loro esistenza.*

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Introduction

The non-ionizing radiation (NIR) spectrum contains a large range of wavelengths and frequencies from vacuum ultraviolet (UV) radiation to static electric and magnetic fields. Biological effects of NIR depend greatly on wavelength, frequency and other physical parameters, with a variety of consequences for exposed human beings. Various categories of NIR are separated, basically reflecting different biological interactions. Optical radiation consists of UV, visible and infrared (IR) radiation. The other parts of the NIR spectrum contain static electric and magnetic fields, extremely low frequency (ELF) and low frequency (LF) electromagnetic (EM) fields and radiofrequency (RF) radiation. Except for visible radiation, i.e. light, NIR is invisible to the human eye and not perceived by other senses at typical occupational exposure levels.

Health risks of optical radiation

Exposure to NIR has a variety of potential consequences for a human being. To begin with optical radiation, severely burned people, mostly young women, every summer need medical help after over-exposure to the Sun. Although the painful erythema ('sunburn') will fade gradually after a few days, recurrent over-exposures may still cause serious late effects. Chronic UV exposure has been indicated to be the primary factor in the induction of non-melanocytic skin cancers (NMSC). In addition, epidemiological studies on cutaneous melanoma suggest that UV erythema may be of particular importance in its initiation (9). Despite the high incidence, NMSC is usually diagnosed at an early stage and the mortality rate is relatively low compared with that of melanoma. The risk of developing skin cancer varies greatly with skin type, and persons who readily sunburn are also more prone to develop skin cancer. Skin cancer of fair-skinned individuals is increasing at an alarming rate (4-6% per year) around the world (4). In USA, for example, skin cancers are the most common type of cancer, with about 1.3 million new cases each year (2).

An unprotected eye exposed to direct UV radiation from the Sun or to reflected UV from snow may accumulate a sufficient dose to cause hazardous effects on the cornea, called photokeratitis. As with erythema of the skin, the symptoms are delayed for several hours. Within a few hours overexposure to UV radiation gradually gives rise to symptoms from a feeling of itchiness, 'sand in the eye' sensation, increased tearing, to severe pain and photophobia. The condition is referred to as 'snowblindness' or 'welders flash', depending on the source of exposure (12).

In addition to corneal injury, epidemiological data shows an increased risk of cortical cataract with UV exposure (1). In the unusual situation where the UV absorbing lens or lens implant are not present, retinal injury is also possible for wavelengths over 300 nm (9). The global prevalence of blinding cataracts exceeds 50 million, and the prevention and slowing of the progress of lenticular opacities should be an important objective in occupational health activities.

Though the intensity of the solar UV radiation depends on latitude, being the highest at the Equator, it is worthwhile to note some peculiarities concerning conditions in high geographical latitudes. In summer, the daily duration of sunlight is very long and the height of the Sun predominantly low, so that it is difficult to avoid looking at it. In winter, the main contributing factor to the UV exposure is the reflection from snow and ice. Under these conditions, safe UV exposure limits can be easily exceeded without eye protection (11). Hence, outdoor workers, such as fishermen, merchants at marketplaces, and road constructors are at risk of chronic over-exposure to solar UV radiation.

As for the adverse effects of visible radiation on the eye, there are numerous epidemiological studies indicating that chronic exposure to short-wave light, so called blue-light, is a contributing factor to aging and degeneration of the retina. Several studies have revealed that the shorter the wavelength, the more severe the ocular photochemical damage. Fortunately, the human eye is protected by the aversion reflex against hazardous light sources (11). Therefore, it is difficult to look at the sun when it is high and bright, hence being dangerous for the retina. The amount and the spectral distribution of the solar radiation changes with the height of the Sun, so that comfortable and safe viewing of it is possible only at angles of less than a few degrees - a moment after the sunrise or before the sunset.

Though the eyelids normally close at exposure to sudden bright light, this aversion response is too slow in some special situations. Especially hazardous are coherent laser beams that are focused to a small spot at the retina, resulting in permanent visual impairment (12).

These examples clearly indicate that health hazards of high exposure to optical region of NIR are science-based and incontestable. Therefore, workplace campaigns emphasizing importance of individual responsibility and necessity of personal protection should be part of occupational health education. However, it should be also noted that other adverse effects, e.g. increasing prevalence of multiple sclerosis and type 1 diabetes in higher latitudes, have been associated with low sun exposure and vitamin D deficiency (10).

Health risks of electromagnetic fields

Correspondingly to optical radiation, people in technically developed countries are surrounded by ELF and RF electromagnetic fields. Natural background EM fields are several orders lower than those emitted by human-made sources, so that most occupational exposure is caused by sources that emit EM fields either intentionally or as byproducts (13). Whole-body or localized exposure to EM fields induces body currents and energy absorption in tissues, depending on specific frequencies and coupling mechanisms (8). Thermal effects caused by local or whole-body temperature rise are obvious and basically understood, whereas the principal scientific challenge is to reveal and understand the suspected or hypothesized non-thermal effects. For instance, as a matter of a scientific mystery, some occupationally or non-occupationally exposed persons in various countries claim to experience unpleasant feelings during or after exposure to EM fields. Typical hypersensitive reactions and symptoms are described as headache, dizziness, fatigue and nausea. These sensations are not regarded pathological, but they may seriously affect the physical or mental wellbeing of such persons.

In 2002, International Agency for Risk of Cancer (IARC) classified ELF magnetic fields as a possible human carcinogen (Class 2B), based on the risk of leukaemia in children living near electric power transmission lines (5). Exposure to ELF magnetic fields has also been associated with several other end-points, such as increased risk of brain cancer, breast cancer, heart disease, and Alzheimer's disease, but these associations are speculative and not confirmed.

At present, RF fields around frequencies of 900 MHz and 1800 MHz are of special interest because of the rapid advances in the telecommunication technology. As a result of the global expansion of the use of hand-held cellular phones, RF exposure is becoming ubiquitous, and the focus of public interest has moved from power lines to mobile telephones and base station antennas. The levels of these emissions are so low that the mechanism of temperature rise is unlikely to explain the alleged adverse health effects. Non-thermal mechanisms of interaction have been proposed, but biological and human experiments have failed to confirm their existence (7).

WHO's International EMF Project

Several international bodies have realized the necessity of expanding interest in the RF radiation research in order to identify the gaps in scientific knowledge. For example, the World Health Organization (WHO) acknowledges that EM fields represent one of the fastest growing environmental factors, spreading anxiety and speculation also among working population. Ten years ago, the WHO launched an International EMF Project for providing independent scientific assessments of health effects from exposure to EM fields. The Project has encouraged setting of internationally accessible guidelines and standards for exposure limits and device emissions. It has also provided information on risk perception, risk communication and risk management of the EM fields (14).

The role of ICNIRP in health risk assessment

The principal scientific organization supporting the work by WHO is the International Commission on Non-Ionizing Radiation Protection (ICNIRP). The main activity of ICNIRP is to provide guidance on safe exposure and protection of workers and members of the public by issuing statements and recommendations. ICNIRP monitors continuously and periodically carries out critical reviews of the scientific literature concerned with the sources and possible biological and adverse health effects of NIR. ICNIRP performs critical scientific analysis by evaluating the relevance, scientific quality and credibility of each report (6).

The exposure limits developed by ICNIRP are intended to protect against diseases and other adverse health effects. Because risk assessment is focused to human health, ICNIRP prefers the data derived from human studies. The relationship between exposure and certain short-term biological effects can be evaluated from human laboratory studies, whereas data on long-term human effects can only be derived from epidemiological studies. However, the epidemiological studies are not considered sufficient to provide evidence of causal relationships without biological data from experimental studies.

In its exposure guidelines, ICNIRP defines occupational and public exposures in general terms. When applying the guidelines to specific situations, it is ICNIRP's opinion that authorities in each country should decide on whether occupational or general public guideline levels are to be applied, according to existing national rules or policies.

European Directive on workers' EM field exposure

In Europe, it has been considered necessary to introduce specific measures protecting workers from the risks associated with EM fields. Therefore, a new Directive given by the European Commission and Council was published in 2004 (3). Similar to ICNIRP's philosophy, this Directive refers to the health risks of workers due to known short-term adverse effects caused by the circulation of induced currents and by energy absorption as well as by contact currents. Hence, it does not address suggested long-term effects, including possible carcinogenic effects, stating that there is no conclusive scientific evidence establishing a causal relationship.

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Is occupational epidemiology necessary in poor countries?

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Occupational epidemiology has contributed to occupational health by ensuring recognition of the determinants of health and disease in relation to work, by establishing surveillance systems to target preventive programmes, by identifying priorities for intervention and evaluation, and by supporting the establishment of appropriate exposure limits. Nevertheless, the discipline is usually a minor (or absent) element of occupational health systems in poorer parts of the world. Although the indirect benefits of occupational epidemiology are reasonably well accepted, - for example as a competency in the production of confident, independent professionals – the direct benefits are less well recognized.

Some questions that may assist in evaluating the role of occupational epidemiology in poor countries are considered:

1. What topics have occupational epidemiological projects addressed in developing countries over the past 15 years? A review of the occupational health literature will be presented.

2. Is there evidence that occupational epidemiology can contribute to making workplace hazard control a significant public health issue? Two case studies will be used: (1) understanding the relations among silica exposure, PTB and HIV infection in southern Africa shows how knowing the modern epidemiology re-established silica control as a major concern in the region; and (2) studies of acute and chronic health consequences of pesticide use in Central American workers have placed the pesticide issue high on the regional public health agendas.

3. Are there examples of improvements in working life directly due to epidemiologic projects in poor countries? Sentinel studies will be reviewed.

A case can be made that judicious investment in occupational epidemiology will improve occupational health in developing countries, provided the agenda is not only driven by what is fashionable, or publishable, elsewhere. Studies looking simultaneously at toxic or infectious exposures and social-cultural determinants of workers' health may provide good insight into aetiology and realistic possibilities for interventions. North-South and South-South collaborating networks are, however, necessary to achieve occupational epidemiology with wide impact in developing countries.

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La Medicina del Lavoro Med Lav 2006; *97*, 2: 190-194

Epidemiology in risk management for chemicals

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Key words
Hazard; attributable risk; hazard identification; risk assessment

Summary
Risk management is the process by which choices are made between alternative actions or policies according to the likelihood of beneficial or adverse outcomes. It entails an assessment of the potential risks and benefits associated with each possible option, and the application of value judgements to decide which option should be chosen. In formal risk management for chemicals, a distinction is made between hazard (a potential adverse effect of the substance) and risk (the probability that that a hazard will be realised given the circumstances and extent of exposure to the substance). Where there is uncertainty about the existence of a hazard or about the level of risk associated with an exposure, this must also be taken into account. Of the various measures of risk, the two that are most relevant to risk management are the individual attributable risk and the population attributable risk. Assessment of risk entails the identification and characterisation of hazards, and estimation of the risks associated with the exposure circumstances that will follow from different policy options. Examples are given of the way in which epidemiology can contribute to this process, and also to checking that the outcomes of decisions in risk management accord with what was predicted by underpinning risk assessments. The strengths and limitations of epidemiology as a tool in risk management are discussed.

Riassunto
«L'epidemiologia nella gestione del rischio chimico». *La gestione del rischio è il processo con cui si prendono decisioni circa azioni e/o strategie considerando la probabilità di effetti benefici o avversi. Essa implica una valutazione dei potenziali rischi e benefici associati ad ogni possibile opzione e l'applicazione di un giudizio di valore per decidere quale opzione deve essere scelta. Nella gestione del rischio chimico si distinguono formalmente il "pericolo" (il potenziale effetto dannoso di una sostanza) e il "rischio" (la probabilità che un pericolo si realizzi date le circostanze e l'entità dell'esposizione alla sostanza). Quando c'è incertezza circa l'esistenza di un pericolo o circa il livello di rischio associato ad una data esposizione, tale incertezza deve essere adeguatamente considerata. Tra le varie misure di rischio, le due più importanti in ambito di gestione del rischio sono il rischio attribuibile individuale e il rischio attribuibile di popolazione. La valutazione del rischio implica l'individuazione e la caratterizzazione dei pericoli e la stima dei rischi associati con le circostanze di esposizione che risulterebbero dalle varie possibili misure di intervento. Vengono presentati esempi su come l'epidemiologia può contribuire a questo processo e anche aiutare a valutare se gli effetti delle decisioni prese in sede di gestione del rischio combaciano con quanto preventivato al momento delle valutazione del rischio. I vantaggi e i limiti del metodo epidemiologico come strumento nella gestione del rischio sono presi in considerazione e valutati.*

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Introduction

Risk management is the process by which choices are made between one or more alternative actions or policies according to the likelihood and importance of beneficial and adverse outcomes. It entails an assessment of the potential risks and benefits associated with each possible choice, and then the application of value judgements to decide which option should be chosen. The effort that is expended in risk management should be proportionate to the gains that can be achieved by optimising a decision. Thus, in everyday life, most decisions in risk management are made informally and with minimal if any thought. However, for more important decisions, and particularly those that can impact on multiple stakeholders, the approach is often more formal and systematic. This promotes more reliable assessment of risks, improves the consistency and fairness of decision-making, and makes it easier for people who are affected by the decision to understand the basis on which it has been made.

Epidemiology is one of the main scientific disciplines that underpins formal risk management for chemicals in the workplace and wider environment. This paper reviews the role of epidemiology in this context, and examines the strengths and limitations of its contribution.

Nomenclature

Like many specialist activities, formal risk management has its own technical vocabulary, in which words are used with a more precise meaning than in common parlance. In particular, a distinction is drawn between the terms, "hazard" and "risk". A hazard is a potential adverse effect of exposure to an agent. Risk is the probability that a hazard will be realised, taking into account the nature and circumstances of exposure. For example, pulmonary fibrosis is a hazard of exposure to chrystalline silica, and the risk of its occurrence will depend on the extent to which respirable particles of silica are inhaled. Handling chrystalline silica in a situation where it is not inhaled will not carry a risk of pulmonary fibrosis. Hazards can vary in severity from minor and reversible to seriously and chronically disabling, or even fatal. Risks from chemicals will usually depend importantly on the route and level of exposure.

It is helpful further to distinguish between "risk" and "uncertainty". Risk in an individual can be understood as corresponding to an excess rate of a hazardous outcome that would be observed in a population of exposed persons. For example, when we say that a specified exposure to benzene carries a 20% excess risk of leukaemia, we imply that in a large cohort of people with this level of exposure, there would be 20% more cases of leukaemia than might be expected in the absence of exposure to the chemical.

Uncertainty relates to conclusions that can be drawn at a population level, and arises from incompleteness of scientific understanding. It may apply to the assessment of both hazard and risk. Thus, there is currently uncertainty as to whether radiofrequency magnetic fields from mobile phones pose a hazard of brain cancer. If there is a hazard, then depending on their exposure, some individuals may be at increased risk. However, if there is no hazard then there will be no excess risk in anyone.

Uncertainty may in part be statistical and therefore semi-quantifiable. For example, doubts about the exact risk of chronic obstructive pulmonary disease from a given exposure to coal mine dust stem in part from the limited size of cohorts that have been studied epidemiologically, and this is reflected in confidence intervals for the parameters of exposure-response relationships. In general, however, the assessment of uncertainty is more subjective than that of risk, and does not lend itself as readily to simple `numerical quantification.

Theoretical framework

Risk management for chemicals usually requires a decision whether to restrict exposure to the substance under evaluation, and if so how. Restrictions may be achieved through outright prohibition, or through prescribed working practices, use of personal protective equipment, or limits on permitted exposures. Sometimes decisions are made on the basis of hazard rather than risk. For example, classification of a pesticide as a genotoxic carcinogen would normally preclude its approval for use in the European Union. This may reduce the cost of the decision-making process, but it can sometimes lead to anomalies in which higher risks are adopted in preference to lower risk alternatives.

When carried out formally, risk management for chemicals entails a series of stages (table 1). Unlike the other stages, decision-making (Stage 5), which involves the application of value judgements, is not a scientific activity. It should take account not only of the estimated risks and costs that are associated with each alternative option for control (lower costs, either financial or in lost opportunities, are equivalent to a benefit), but also the related uncertainties.

Table 1 - *Stages in risk management for chemicals*

Stage 1: Hazard identification
Potential adverse effects of a chemical or mixture of chemicals are identified.

Stage 2: Hazard characterisation
The determinants of adverse effects are specified more precisely. In particular, the probability of their occurrence is estimated according to the route, intensity and duration of exposure. Associated uncertainties are evaluated.

Stage 3: Exposure assessment
Exposures are estimated for different possible policy options (e.g. according to the stringency of regulatory controls that might be imposed on the chemical(s)).

Stage 4: Risk characterisation
Estimates of exposure are combined with the characterisation of hazard to derive estimates of risk for alternative policy options, again with an assessment of associated uncertainties.

Stage 5: Decisions on risk management
Estimates of risk for different policy options are set alongside estimates of their costs (both financial and in lost opportunities), and value judgements are applied in choosing between them.

Stage 6: Checks on outcome
Checks may be made to confirm that the outcome of the chosen policy is as expected. These may entail measurements of exposure, of biomarkers for exposure or early biological effect, or of disease rates.

The role of epidemiology

The three main scientific disciplines that contribute to risk management for chemicals are toxicology, occupational/environmental hygiene, and epidemiology. Toxicology can provide information about the absorption, distribution, metabolism and excretion of a compound; about its genotoxic potential in vitro and in vivo; about its effects in living animals at different stages of life; about its mechanisms of toxicity and possible determinants of individual sensitivity to its toxic effects; and about dose-response relationships in animals. Occupational/environmental hygiene can give information on the levels and patterns of exposure associated with alternative policy options, which can then combined with the characterisation of hazards to generate estimates of risk. Epidemiology can make inputs to several of the stages listed in table 1.

An example of the application of epidemiology in the identification of a new hazard was the discovery by Donald Acheson that dust from vegetable-tanned leather can cause sino-nasal cancer (1, 7). As part of an investigation following up an excess of nasal cancer in High Wycombe (which was shown to be caused by hardwood dust in the local furniture industry), he explored the geographical distribution of cases throughout the region covered by the Oxford cancer registry. This revealed a second cluster in Northamptonshire, and follow-up studies demonstrated that it arose from occupational exposure to leather dust in the manufacture of boots and shoes.

In the characterisation of hazards, epidemiology has been useful in defining which chemicals are responsible for increased rates of disease in occupational populations. For example, in his seminal cohort study of bladder cancer in the dyestuffs industry, Robert Case carefully classified men according to the classes of chemical with which they had worked (4). In this way, he was able to show that risk was particularly high in those exposed to 2-naphthylamine and benzidine, whereas there was no evidence of a hazard from exposure to aniline.

More recently, our own group has sought to define more precisely the agents that are responsible for a hazard of infectious pneumonia in welders. The demonstration of excess risk also in foundrymen pointed to a hazard from metal fume rather than welding gases (5) and a subsequent case-control study implicated ferrous fume specifically, although an effect also from non-ferrous metals could not be ruled out (9).

Epidemiology also provides valuable information on exposure-response relationships for chemical hazards. Examples include the risks of lung cancer from exposure to asbestos (2) and of coal workers' pneumoconiosis from exposure to coal mine dust (6).

The assessment of chemical exposures is primarily the role of hygienists, but epidemiological methods can be useful in establishing the determinants of personal exposure to chemicals. For example, in the TEAM study in the United States, analysis of correlates with benzene concentrations in exhaled breath indicated that residence near to petrochemical plants had little if any impact on exposure in comparison with smoking and activities related to driving (12). And research by the Institute of Occupational medicine in Edinburgh has indicated the important impact of spills and splashes when handling concentrate on the exposures of farmers to organophosphate sheep dips (3). This subsequently led to new regulatory requirements for wider necked containers for pesticides in the UK.

Where controls on a hazardous exposure are implemented as part of risk management, it is important to check that they are effective. This may be through monitoring of exposure levels, or of biomarkers of exposure and early biological effect, but it may extend to measurement of disease rates. For example, in the UK, following the demonstration of increased rates of bladder cancer in the rubber industry, the chemical responsible, 2-naphthylamine, was prohibited. Subsequent epidemiological research indicated that there was no excess of the tumour among workers recruited to the industry after the ban was implemented (10) confirming the adequacy of the control strategy. Similarly, the low rate of hospital admission in England for accidental pesticide poisoning supports the view that current regulatory controls on pesticides are effective in preventing serious acute poisoning (paper in preparation). On the other hand, the finding that the incidence of mesothelioma in Britain has continued to increase indicates that exposure limits in the 1970s were not sufficiently stringent or that they were not effectively implemented (8, 11).

STRENGTHS AND LIMITATIONS

The major strength of epidemiology as an aid to risk management is its direct focus on human health, and on the levels and circumstances of exposure that occur in real life. Thus, it avoids the scientific uncertainties that are inherent in extrapolations from experiments in vitro and in animals. It also enables investigation of health outcomes such as subtle effects on intelligence or behaviour that may not be easily addressed in animal studies. Against this, however, must be weighed several important limitations.

First, epidemiology can rarely provide evidence of increased risk from a chemical until attributable cases of disease have started to occur (an exception might be the demonstration of effects on preclinical markers of risk such as cytogenetic abnormalities).

In addition, the potential for error from bias, chance and confounding limits the confidence that can be placed in epidemiological results. This is particularly troublesome where there is a need to identify and control even small relative risks. For the purpose of risk management, what matters is the attributable (absolute excess) risk in individuals and in populations. However, particularly for more common diseases, an important attributable risk may correspond to only a small relative risk. In these circumstances it may be impossible to discriminate relevant effects with confidence by epidemiology.

Because of these limitations, when potential health risks from chemicals are being assessed, information from epidemiology should always be integrated with that from toxicology and occupational/environmental hygiene. Even so, there will inevitably be residual scientific uncertainty, and as a consequence, decisions in risk management will not always give the best possible outcome. However, careful planning and interpretation of scientific research can ensure that the optimal choices are made most often.

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Med Lav 2006; *97*, 2: 195-198

Refining the focus of construction injury durveillance

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KEY WORDS
Injuries; construction industry

SUMMARY

We conducted two studies of construction injury occurring at Denver International Airport (DIA), whose construction required 31 million work hours. Initially we conducted a retrospective cohort study that allowed estimation of injury and workers' compensation (WC) payment rates for strata such as size of employer and type of work; risk factors were also estimated. The second study examined written injury reports for 4,000 injuries at DIA. We modified Haddon's matrix to classify factors contributing to injury. We identified 108 factors within 4 broad categories: human, object, environment and organization. This approach provided information on rates at which each factor contributed to injury and the WC payment rates for each factor. A study shortcoming was that injury reports varied in completeness and quality. In a third ongoing study, to compensate for the shortcomings of injury reports, particularly to improve consistency and completeness of data, we designed a worker questionnaire completed immediately after injury, which included questions specific to hazards associated with each type of injury. Upon completion, the interviewer (a safety professional) uses the modified Haddon's matrix to note contributors to the injury and explain briefly the reasons for each notation. This requires the interviewer to consider a full set of possible factors and determine whether they contributed to injury. This process elicits richer data and places specific factors within the four higher-level categories. This process confer advantages on both contractors and researchers. Contractors can become immediately aware of contributing factors and ameliorate them quickly. The data can also be used in post hoc analysis of injury etiology. Moreover, the data are sufficiently flexible and complete that they can be coded into schemes describing sequences of events leading to injury, as well as those simply identifying factors contributing to injury. Haddon's matrix is invaluable in such analysis because it leads to a fuller understanding of the origins of the most proximate contributors to injury than would otherwise occur. Particularly for contractors and owners with significant safety infrastructures, this approach may be attractive, because it allows for more complete and quicker correction of specific hazards and, with systematic evaluation, recognition of more general safety concerns present on many construction sites.

RIASSUNTO

«Migliorare l' attenzione della sorveglianza degli infortuni in edilizia». *Abbiamo condotto due studi sugli infortuni in edilizia che hanno avuto luogo all' aeroporto internazionale di Denver (DIA), la cui costruzione ha richiesto 31 milioni di ore di lavoro. Inizialmente abbiamo condotto uno studio di coorte retrospettivo che ha permesso la stima dei tassi degli infortuni ed il livello di risarcimento dei lavoratori, per strati quali la dimensione dell'azienda e il tipo di lavoro; sono stati stimati anche i fattori di rischio. Il secondo studio ha esaminato le denunce scritte per 4000 infortuni durante la costruzione dell' aeroporto. Abbiamo modificato la matrice di Haddon per classificare i*

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fattori che hanno contribuito all'infortunio. Abbiamo indicato 108 fattori entro 4 ampie categorie: umana, oggettiva, ambientale, organizzativa. Tale approccio ha fornito informazioni sulla entità del contributo di ogni fattore all'infortunio e sui livelli di risarcimento per ogni fattore. Un limitazione dello studio stava nella completezza e qualità delle denunce di infortunio. In un terzo studio ancora in corso, per compensare le incompletezze delle denunce di infortunio, in particolare per migliorare la consistenza e la completezza dei dati, abbiamo messo a punto un questionario per i lavoratori da completare immediatamente dopo l'infortunio, che comprendeva domande specifiche sui rischi associati ad ogni tipo di infortunio. Dopo averlo completato, l'intervistatore (un professionista della sicurezza) usa la matrice di Haddon modificata per annotare le cause che hanno contribuito all'infortunio e spiegare brevemente le ragioni di ogni annotazione. Questo richiede che l'intervistatore prenda in considerazione una gamma completa di possibili fattori e determini se essi abbiano contribuito all'infortunio. Questo processo offre dati più ricchi e colloca fattori specifici nell'ambito delle quattro categorie di maggiore livello. Questo procedimento conferisce vantaggi sia alla parte committente che ai ricercatori. I committenti possono divenire immediatamente consapevoli dei fattori che contribuiscono all'infortunio e mettere in atto velocemente le modifiche per il miglioramento. I dati possono essere anche usati in analisi post hoc per studiare l'eziologia degli infortuni. Inoltre i dati sono abbastanza flessibili e completi da poter essere codificati in schemi che descrivano le sequenze di eventi che portano all'infortunio, oltre a quelli che semplicemente identificano i fattori che hanno contribuito all'infortunio. La matrice di Haddon è inestimabile in tali analisi perché porta a una comprensione più completa delle origini dei fattori contribuenti in maniera sostanziale all'infortunio. Particolarmente per i committenti e gli imprenditori con infrastrutture di sicurezza significative, tale approccio può essere attraente, perché permette una correzione più completa e più rapida dei rischi specifici e, con una valutazione sistematica, il riconoscimento di preoccupazioni più generali sulla sicurezza che sono presenti in molti cantieri edili.

Background

We conducted two studies of injuries occurring during the construction of the Denver International Airport (DIA), which involved 32,000 employees working 31 million hours. The City of Denver provided workers' compensation (WC) insurance to all workers and furnished injury and payroll records to us for analysis. Using these data, we conducted an initial retrospective cohort study focused on injury and WC payment rates (2). For the second study, the city provided us with written injury reports for all injured workers. These reports contained information on the circumstances surrounding the injuries and allowed us to analyze factors contributing to the airport injuries (4).

The initial DIA study was immensely valuable: centralized payroll (time at risk) and injury data had never before been available for research on such a large construction project. The data we were provided allowed us to estimate not only stable injury and WC payment rates by several strata, such as size of employer and type of work, but also to identify risk factors at the contract level and contractor practices affecting safety (3, 8, 9). We were able to document that construction work is more dangerous than previously thought and to identify areas for prevention at the company level and for different types of construction work. But this database lacked specific information about the factors that contributed to individual injuries, thereby limiting the usefulness of these findings for developing prevention programs aimed at ameliorating hazards particular to types of work and to the conditions under which work occurs.

The second study we undertook examined in detail the written records for each of the approximately 4000 injuries occurring during DIA construction. This allowed us to improve the specificity of our analysis to make it more useful to employers in developing targeted prevention measures. We modified a widely used framework (Haddon's matrix) to identify and classify all factors contributing to each injury. We identified a total of 108 factors falling into 4 major categories of contributors: human factors, objects, environmental factors, and organizational factors. We were able to calculate the rates at which each factor contributed to injury for each type of work as well as the WC payment rates attributable to each contributing factor (1). We were also able to analyze factors involved in individual categories of injury, such as falls and slips/trips, in detail (6, 7). Such information can be used by individual employers to improve their safety performance and develop prevention methods that focus on contributing factors common to their types of work. One shortcoming in this analysis was that injury reporting forms varied somewhat and asked for relatively limited data about the circumstances of the injury; moreover, they were completed by a wide variety of people, including safety officers, medical personnel, construction supervisors and the workers themselves. As a result, they varied in completeness and quality.

IMPROVING ON RETROSPECTIVE INJURY REPORTING

We are currently conducting a study of the construction of two large commercial buildings for which we have developed methods designed to compensate for the shortcomings we encountered in the data available to us for the DIA analysis of injury reports. To do this, in particular to improve the consistency and completeness of data collection, we designed an interviewer-administered questionnaire to be completed with the injured worker immediately after the injury occurred. The questionnaire asks for specific information about the date, time, and place of the injury, the stage of construction, the worker's trade and age, the task(s) the worker was performing and years of experience in performing that task. Specific questions were asked about the presence or absence of particular conditions or factors that are commonly involved in construction injury, e.g., tools, equipment, materials, other workers. Also, for each common injury mechanism (overexertion, falls, slips/trips, eye injury), questions specific to the hazards associated with that mechanism were asked. For instance, for falls from elevation, we asked what the worker fell from, the condition of the work surface, the condition of the surface onto which the worker fell, how the worker landed, how far (s)he fell, the worker's weight, actions that occurred just before the worker fell (e.g., surface collapse, trip), whether the worker was using tools or handling materials, whether equipment failed, and the condition of the worker's footwear. The worker was asked to describe all of the circumstances surrounding the injury event, and the interviewer used prompts to ensure that a complete description was obtained.

When the interview was complete, the interviewer, who, in this case, was an experienced safety professional, marked the Haddon's matrix factors he thought contributed to the injury, based on the worker's responses. For each factor noted, the interviewer provided a brief explanation of the reasons for including it. An important effect of using Haddon's Matrix in this way is that it requires the interviewer to consider a full set of factors in several major categories (human, object, environment, organization) and determine whether they contributed to the injury. This tends to elicit a richer set of data than would otherwise be recorded. Another consequence of using Haddon's matrix for recording and classifying contributing factors is that specific factors are placed within higher-level categories (e.g., time pressure could be placed within the 'organization' category), and we believe that this forces the interviewer to think more globally than would otherwise occur. So, rather than focusing exclusively on a 'slip/trip' that occurred as a result of hurrying, the interviewer would also consider the organizational factors leading to 'time pressure.'

Because of the sometimes terse injury descriptions in the injury reports available for the DIA study, we found that we had to assume that all factors mentioned in the report contributed to the injury, but we weren't always sure how they contributed. In the current study, requiring descriptions for each factor the interviewer enters in the matrix means that we are much better able not only to identify contributing factors with more certainty, but also to more readily place them in the sequence of events leading to injury.

Uses of Injury Interviews. Conducting systematic interviews of injured workers soon after the injury confers advantages on both the contractor and the researcher. The contractor can be made immediately aware of conditions and factors that contributed to a worker's injury so that amelioration can occur quickly. The data collected can also be used in *post hoc* analysis of injury etiology. The systematically expanded text descriptions resulting from both the specific questions about each type of injury and the interviewer's prompting the worker to recall the complete set of circumstances surrounding the injury provides a valuable resource for researchers to understand the entire set of events and factors leading to injury. The information available in the interviews is sufficiently flexible and complete that it can be coded using a scheme designed to shed light on the sequence of events leading to injury (5)as well as a scheme designed simply to identify all factors contributing to the injury (1).

It is clear from our experience with these detailed interviews conducted by an experienced professional using prompts that allow the injured worker to expand upon his/her injury and the circumstances surrounding it yields more complete data than do coded injury reports. Haddon's matrix is an invaluable part of the data collection process, not least because it leads to a fuller understanding of the origins of the most proximate contributors to injury. Whether it is practical for contractors or owners to conduct such interviews will be for them to decide, but for those with significant safety infrastructures at their worksites, this approach may be an attractive addition to their safety programs and would yield information valuable to ameliorating hazards. The information can be helpful both in immediate safety improvement actions at specific sites and, with systematic evaluation, in recognition of particular safety concerns present on many construction sites.

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La Medicina del Lavoro Med Lav 2006; *97*, 2: 199-206

Recent developments in human biomonitoring: non-invasive assessment of target tissue dose and effects of pneumotoxic metals

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Key words
Metals; biomonitoring; lung; exhaled breath condensate

Summary
Tobacco smoke and polluted environments substantially increase the lung burden of pneumotoxic chemicals, particularly pneumotoxic metallic elements. To achieve a better understanding of the early events between exposure to inhaled toxicants and the onset of adverse effects on the lung, the characterization of dose at the target organ would be extremely useful. Exhaled breath condensate (EBC), obtained by cooling exhaled air under conditions of spontaneous breathing, is a novel technique that could provide a non-invasive assessment of pulmonary pathobiology. Considering that EBC is water practically free of interfering solutes, it represents an ideal biological matrix for elemental characterization. Published data show that several toxic metals and trace elements are detectable in EBC, raising the possibility of using this medium to quantify the lung tissue dose of pneumotoxic substances. This novel approach may represent a significant advance over the analysis of alternative media (blood, serum, urine, hair), which are not as reliable (owing to interfering substances in the complex matrix) and reflect systemic rather than lung (target tissue) levels of both toxic metals and essential trace elements. Data obtained among workers occupationally exposed to either hard metals or chromium (VI) and in smokers with or without chronic obstructive pulmonary disease (COPD) are reviewed to show that – together with biomarkers of exposure – EBC also allows the simultaneous quantification of biomarkers of effect directly sampled from the epithelial lining fluid, thus providing novel insights on both kinetic and dynamic aspects of metal toxicology.

Riassunto
«Recenti sviluppi nel biomonitoraggio umano: valutazione non invasiva della dose a livello dell'organo bersaglio e degli effetti pneumotossici». *L'esposizione cronica a fumo di tabacco ed ad altri inquinati ambientali determina un accumulo polmonare di sostanze pneumotossiche, soprattutto metalli. Allo scopo di ottenere una migliore comprensione dei meccanismi attraverso i quali i tossici inalati inducono un danno polmonare, la valutazione della dose a livello dell'organo bersaglio, in questo caso il polmone, potrebbe essere molto utile. Il condensato dell'aria espirata (CAE) è un fluido ottenuto raffreddando l'aria esalata durante la respirazione a volume corrente ed è una nuova tecnica che può fornire una valutazione della patobiologia polmonare. Il CAE è formato quasi completamente da acqua, quindi rappresenta una matrice biologica ideale per la determinazione d'elementi metallici. Dati presenti in letteratura dimostrano come nel CAE si possono dosare vari metalli tossici ed elementi di transizione,*

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permettendo quindi di proporre questa matrice per la quantificazione della dose al bersaglio di sostanze pneumotossiche. La quantificazione della dose al bersaglio consente di avere informazioni aggiuntive rispetto a quelle ottenute con i tradizionali metodi di monitoraggio biologico in lavoratori esposti, che generalmente consentono di stimare la dose sistemica, ma non l'esposizione delle vie respiratorie ad inquinanti aerodispersi né la frazione trattenuta nel polmone, verosimilmente implicata nella patologia infiammatoria e degenerativa a livello polmonare. In questa breve rassegna sono discussi i dati ottenuti in lavoratori professionalmente esposti a metalli duri ed in fumatori con o senza bronco-pneumopatica cronica ostruttiva (BPCO), per mostrare come il CAE – oltre agli indicatori di esposizione – consente di valutare indicatori di effetto campionati direttamente dal film che riveste le vie respiratorie, fornendo quindi nuovi spunti per meglio comprendere sia gli aspetti cinetici che quelli dinamici della tossicologia dei metalli.

Introduction

Patophysiological events at pulmonary level can be identified relying on more or less invasive techniques, such as bronchoscopy and induced sputum. These sampling methods have allowed understanding of some of biological mechanisms in pulmonary diseases, and still represent reference techniques (7). Their invasiveness is a limiting factor precluding extensive application to clinic routine. More importantly, the associated inflammatory reaction (4) seems to limit the comparability between subsequent sampling times, thus preventing their use for monitoring purposes, which remains the most relevant approach to the use of biomarkers both in epidemiological and clinical settings.

Breath analysis appears to be promising to identify new biomarkers of processes involving the lung. In the last decade, there has been an increased application of exhaled breath analysis in pulmonology research, considering both exhaled gases and exhaled condensate (8). Exhaled breath analysis has enormous potential as an easy, non invasive means of monitoring inflammation and oxidative stress in the airways, particularly in non diseased subjects. Exhaled air can be collected without the need of unpleasant stimulation of the airways as in sputum induction or lavage sampling.

Whereas exhaled air has been examined for long time to measure volatile organic compounds in subjects exposed to airborne pollutants in either occupational or environmental settings (18, 29), exhaled breath condensate (EBC) is a relatively unexplored biological medium that could provide an assessment of lung pathobiology (19). The interest in EBC is justified by the fact that its collection is totally non invasive and does not cause any discomfort or risk to examined subjects (8).

EBC, which is obtained cooling exhaled breath during tidal breathing, is composed essentially of water, but it also contains slightly volatile and non volatile compounds which are expired as a bioaerosol. Bio-aerosols consist of small droplets joining the vapour stream during its passage over the mucous layer lining the lung (12).

Different molecules have been found and quantified in EBC, including hydrogen peroxide, lipid peroxidation products, prostaglandins, leukotrienes and cytokines (21). Owing to its lack of invasiveness, EBC could be particular suitable in risk assessment, where much of the clinical evaluations are performed in presumably healthy subjects. In addition, due to the fact that inhaled toxics can act locally on the lung, a technique allowing for the sampling of pulmonary fluids would be helpful to characterize the dose delivered to the lung, when it represents the target organ for inhaled toxic chemicals.

EBC collection is also suitable to assess biomarkers of local inflammation and oxidative stress, which may be sensitive endpoints for identifying early biochemical changes in the airways occurring in exposed subjects. This approach will probably overcome the limitations of traditional spirometric tests, which often indicate late and frequently irreversible lung dysfunctions.

As EBC mainly consists of water that is practically free of potentially interfering solutes, it is an ideal biological fluid for elemental determinations; EBC elemental analysis may be used to assess target tissue levels of pneumotoxic metals and essential trace elements, and hence the probability of local effects resulting from highly reactive or poorly soluble species retained by the lung for long time.

Mechanisms leading to EBC formation

Exhaled air is almost in equilibrium with water vapour at the body temperature. Owing to the very large surface area of the lungs, approximately 400 ml of water are lost by evaporation each day. Because the saturation of the exhaled air is nearly complete, the rate of ventilation effectively determines the amount of water lost from the lungs, which is relevant for airway heat transfer (5).

Exhaled water vapour condenses onto a surface when that surface is cooler than its temperature. Therefore, EBC consists almost completely of condensed water vapour. Water vapour does not behave as a solvent of non-volatile solutes, but rather it acts as a vehicle of exhaled molecules joining the vapour stream. Non-volatile molecules are expired as small particles, which are aerosolized and dispersed into condensed water vapour. These particles could be formed at a variety of sites, including the airways, upper respiratory tract, and even the upper gastrointestinal tract (13).

The number of detected exhaled particles during tidal breathing varies over a range from less than 0.1 to about 4 particles/cm^3, with a mean diameter of particles less than 0.3 mm (12, 14, 28). It is assumed, but not still proved, that aerosol droplets are formed from the extra-cellular surface fluid layer by turbulent flow and airflow deviation in branching points of the bronchi and alveoli, and that the amount may depend on the current velocity of the passing air and the surface tension (12). There is no demonstration that exhaled particles formation is kept constant. This makes their expiratory excretion rate a stochastic phenomenon, whose variability depends on sampling time and conditions, rather than on physiologic determinants. The variable dilution of droplets seems to depend on ventilation (the main determinant of evaporation) and condensation temperature (15), which determines the efficiency of water collection.

The concept of target tissue dose of pneumotoxic substances

Traditional exposure biomarkers relying on the urinary or blood concentration of either the parent compound or its metabolite(s) cannot be applied for assessing exposure to substances that exhibit their toxicity at the sites of first contact (20). One may also wonder whether this applies to toxicants such as polycyclic aromatic hydrocarbons (PAH) and certain metallic elements for which the effect of main concern is localized at the site of first contact – i.e. COPD, lung fibrosis, lung cancer, etc. – when exposure occurs by inhalation. In such instances, it might be more appropriate to rely on markers that reflect the dose delivered to the respiratory tract, which does not necessarily correspond with the absorbed dose as assessed by "systemic" biomarkers such as blood and urinary concentrations (figure 1).

The fraction of the dose absorbed by the digestive and/or percutaneous routes would indeed contribute little to the health effect of concern and, moreover, biotransformation capacities of the lung (locally) and the liver (systemically) are different. Therefore the relevance of urinary (e.g. 1-hydroxypyrene) or systemic biomarkers (protein or DNA adducts) to assess health risks associated with exposure to PAHs might be questioned. Although the contribution of percutaneous absorption of metallic elements is negligible and that occurring through the gastro-intestinal tract is limited for most metallic species polluting work environments (in most instances, only relatively large and poorly soluble particles are ingested), the systemic dose – as assessed relying on the blood and urinary concentration – may not be relevant to the risk assessment of pneumotoxicity. Indeed, for certain metallic elements, less soluble species are thought to be responsible for local effects (inflammation, cancer), whereas soluble compounds are readily taken up and excreted with urine. Efforts currently under-

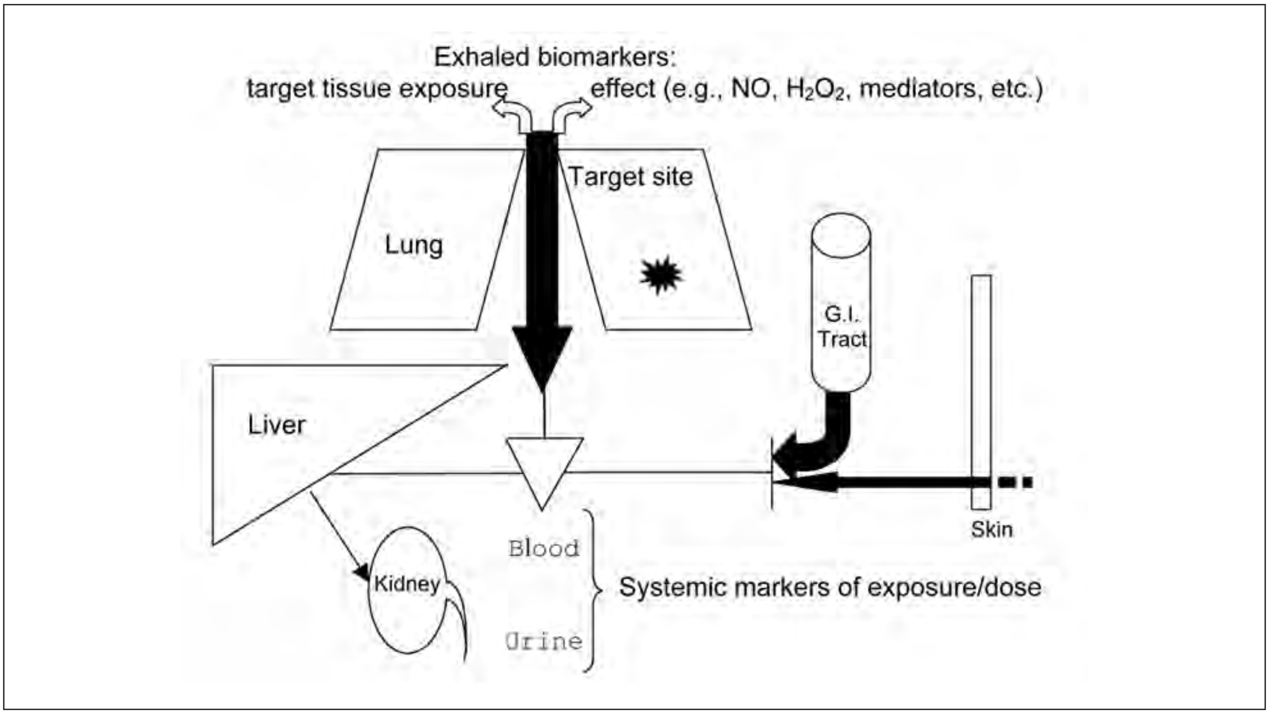

Figure 1 - The relevance of urinary or systemic biomarkers (protein or DNA adducts) to assess the risk of local effects associated with exposure to pneumotoxic substances might be questioned, as the retained dose responsible for local effects may not be correlated with absorbed dose, as measured using systemic markers either in blood or urine. (Adapted and modified after ref. 23)

taken to assess the local dose to the respiratory tract will be shortly reviewed, including studies aimed at measuring the EBC concentration of toxic metallic elements in field studies on workers occupationally exposed to cobalt and tungsten, in chromeplaters exposed to hexavalent chromium (Cr VI) and in patients with chronic obstructive pulmonary disease (COPD).

Exhaled breath condensate in workers exposed to hard metals

Hard metals are widely used in different industries, mainly because of their resistance to corrosion, temperature, and wear. The most important use is as a component of alloys (cemented carbides) and the main components are tungsten carbide (about 90%) and cobalt (about 10%) (1).

Occupational exposure to Co can lead to various lung diseases, such as interstitial pneumonitis, fibrosis, and asthma (1). Although the mechanisms of Co-induced lung toxicity are not completely known, there is evidence from both *in vivo* and *in vitro* experiments supporting the view that Co induces the production of reactive oxygen species (ROS) with subsequent oxidative stress (22). In addition, ROS generation by Co administration is significantly increased by co-exposure to W-C particles, through a physical-chemical mechanism of interaction (24).

Strict control of dust level and regular health monitoring are recommended for workers employed in the hard metal industry. Urinary Co excretion has been proposed as a biomarker of exposure because of its correlation with airborne Co concentration (1). However, this biomarker integrates the overall intake from different absorption routes (dermal and digestive routes) and can be used to assess the risk of systemic effects, rather than local effects on the respiratory tract.

In order to verify whether EBC may be employed for a better risk assessment among workers exposed to hard metals, we enrolled thirty-three workers exposed to Co and W in workshops producing either diamond tools or hard-metal mechanical parts (17).

Airborne levels of Co and W ranged from 0.1-37.4 and 0-4.9 mg/m^3, respectively. Our data showed that Co and W levels are detectable in EBC at nmol/L levels and clearly distinguished between exposed and non exposed subjects. In addition, Co and W EBC levels were correlated with respective urinary levels but, most of all, EBC Co, but not urinary levels, are positively correlated with biomarker of lung damage, such as aldehydes derived from lipid peroxidation. This suggests that exhaled elements may reflect the lung dose responsible for local toxic effects. Furthermore, the relationship between Co levels in EBC and urine seems to indicate that Co in EBC really may represent the fraction of body dose (represented by Co in urine), which has been inhaled and has not yet moved from lung tissue in the systemic circulation at the sampling time.

Another interesting conclusion that can be drawn from our data is that EBC could be also used for a better understanding of the physical-chemical interactions between Co and W in vivo. In fact, when we looked at the interaction between Co in EBC and W in EBC in the ANCOVA model with aldehydes in EBC as a dependent variable, we verified that W exposure has a synergistic effect *in vivo* on Co pneumotoxicity. This is in agreement with published data obtained from *in vitro* experiments (24, 25). In fact, although W carbide alone is known to be inert, there is evidence suggesting that the physical-chemical association of Co and W carbide generates electrons (provided by Co and transferred on the surface of W carbide), which can reduce oxygen, thus giving rise to ROS.

This study demonstrated that Co and W can be measured in the EBC of occupationally exposed workers and that the levels of these elements in EBC correlate with a marker of oxidative stress, namely malondialdehyde (MDA), thus suggesting the potential use of this matrix as a novel approach to monitor target tissue dose and effects occurring in the respiratory tract upon exposure to pneumotoxic substances.

Exhaled breath condensate in workers exposed to chromium (VI)

The respiratory tract is the major target organ for Cr [for both valence states, trivalent Cr (Cr III) and hexavalent Cr (Cr VI)] following inhalation exposure in humans. Chronic inhalation exposure to Cr (VI) is much more toxic than Cr (III), for both acute (short-term) and chronic (long-term) exposures in humans (4, 11).

Exposure to Cr (VI) in humans results in effects on the respiratory tract, with perforations and ulcerations of the septum (although less frequent today, due to strict medical surveillance), bronchitis, decreased pulmonary function, pneumonia, asthma, and nasal itching and soreness (4). Therefore, strict control of dust level and regular health monitoring are recommended for workers employed in chrome industry (2). Of the occupational situations in which exposure to Cr occurs, the highest exposures to Cr may occur during chromate production, welding, chrome pigment manufacture, chrome plating and spray painting; highest exposures to other forms of Cr occur during mining, ferrochromium and steel production, welding and cutting and grinding of Cr alloys.

EBC may be a suitable matrix to assess respiratory health status in workers exposed to Cr, due to its ability to quantify lung tissue dose and consequent effects in exposed workers (6). We assessed 24 chrome-plating workers employed in a chrome plating plant both before and after the Friday working shift, and before the working shift on the following Monday. The aim of this study was the evaluation of Cr levels in the EBC and in urine, and the assessment of early biochemical changes in the airways by analyzing EBC biomarkers of oxidative stress, such as hydrogen peroxide (H_2O_2) and MDA.

Ambient Cr levels were below the limit proposed by the ACGIH (3) for water soluble Cr(VI) organic compounds (50 μg/m^3). Cr in EBC and Cr in urine were much higher in exposed subjects than in controls at all time points. EBC Cr levels increased from the beginning (5.3 μg/l) to the end of Friday (6.4 μg/l), but were considerably lower on Monday morning (2.8 μg/l). A similar trend was observed for EBC H_2O_2 (which increased from 0.36 μM to 0.59 μM on Friday, and was 0.19 μM on Monday morning) and EBC MDA levels (which increased from 8.2 nM to 9.7 nM on Friday, and were 6.6 nM on Monday). EBC Cr levels correlated with those of EBC H_2O_2 ($r=0.54$, $p<0.01$) and EBC MDA ($r=0.59$, $p<0.01$), as well as with urinary Cr levels ($r=0.25$, $p<0.05$).

Looking at the different correlations between variables, Cr in urine and Cr in EBC seem to provide different information: there were weak or no correlations between urinary Cr and biomarkers of free radical production, whereas Cr in EBC correlated with higher and significant r values with both MDA and H_2O_2 levels in EBC, thus suggesting that they may be more representative of the lung dose responsible for local free radical production.

EBC can be considered a promising medium for investigating both long-term and recent Cr exposure at target tissue level and, together with biomarkers of free radical production, it can provide insights into the oxidative lung interactions between pulmonary tissue and pneumotoxic metals occurring in exposed workers.

In a subsequent work (16), to better understand inhaled Cr toxicity and kinetic, metal speciation (aimed at distinguish Cr VI and Cr III) was also performed both in ambient air and in EBC. In fact, whereas it is usually assumed that only Cr III is detectable in urine, there are no data whether a similar behaviour occurs also in EBC. In fact, different individual concentration of reducing agents (glutathione, ascorbic acid) in lung lining fluid may affect Cr reduction and subsequent lung toxicity. EBC quantization of those reducing agents could also permit to identity susceptibility biomarkers implicated in pulmonary Cr toxicity. The study involved 10 workers employed in a chrome plating plant. Two EBC samples were collected: one immediately after the end of the work shift on Tuesday evening and the other before the beginning of the work shift on Wednesday morning, about 15 h after the last Cr exposure.

The main results of the study were that (i) it is possible to determine Cr(VI) in EBC and (ii) the fractional contribution of Cr(VI) to total Cr decreased over time from the last exposure, but was still detectable after 15 h from the last exposure, thus ruling out its meaning as a simple marker of environmental contamination. This time-dependent decrease can in fact only be explained as an interaction between inhaled Cr(VI) and the pulmonary lining fluid, with a consequent reduction to Cr(III). The persistence of Cr(VI) in EBC reinforces the idea that the lower airways are the main target of Cr(VI) toxicity, as assessed by exhaled biomarkers of effect. Inter-individual variability in Cr(VI)-reducing capability might represent an important component of host susceptibility.

METALLIC ELEMENTS IN EBC FROM PATIENTS WITH CHRONIC OBSTRUCTIVE PULMONARY DISEASE

Exhaled elements were also assessed in patients with COPD, who were clinically stable at the time of the enrolment (26). The working hypothesis was that long term exposure to tobacco smoke (which is the most important factor leading to COPD) implies an increased lung uptake of toxic metals which, because of their stability, can also be used as tracers of environmental pollution. Lead (Pb), cadmium (Cd), Cr, nickel (Ni), and aluminium (Al) have been identified as major contaminants in tobacco smoke. Of course, they are also major pollutants in relevant occupational settings. Their EBC concentration should provide a quantitative estimate of lung tissue burden following long term exposure.

Our data showed that current normal smokers exhibited higher exhaled levels of Pb and Cd than those observed in healthy nonsmoking subjects, probably reflecting active tobacco smoking habit. The expected effect of tobacco smoke on exhaled metal levels were also observed in smoking COPD patients, whose levels of exhaled toxic metals were higher than those observed in ex smokers with COPD. However, it is worth to note that ex smokers with COPD (who quitted smoking for more than 2 years) showed still higher levels of toxic metals in EBC (mainly Cd) than those observed in nonsmoking controls. This means that exhaled metal levels may also provide a measure of cumulative long-term exposure to tobacco smoke and environmental exposure to toxic metals.

Exhaled breath condensate analysis was also shown to be useful for the evaluation of biomarkers of lung effect in COPD patients (9, 10). In particular, we focused on biomarker of lipid peroxidation, because it is evident that cigarette smoke exposure results in lung oxidative stress, and the inflammatory process observed in patients with COPD results in disturbance of the oxidant–antioxidant balance (27). Our group developed a reliable method to assess different aldehydic products derived from lipid peroxidation, showing that MDA, hexanal, and heptanal, but not nonanal, were increased in EBC of patients with COPD in comparison to nonsmoking control subjects. Only MDA levels were increased in EBC of patients with COPD compared with smoking control subjects (10).

Conclusion

The results of these studies highlight the potential of EBC as a medium for assessing lung dose and effects after exposure to inhaled pneumotoxic substances. The integrated use of EBC and classic biological matrices such as urine and blood, which reflect systemic exposure, may therefore allow the fundamental completion of the biological monitoring of pneumotoxic compounds. However, it must be stressed that methodological issues regarding EBC collection and analysis still call for harmonization and standardization of procedures. Further studies of validation are necessary prior to a widespread application of EBC-based methods in occupational settings.

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Acknowledgements: *Supported by the National Heart, Blood and Lung Institute (NHLBI), Bethesda, MD, USA (grant R01 HL72323). The contents of this article are solely the responsibility of the authors, and do not necessarily represent the official views of the NHLBI or the National Institutes of Health*

Med Lav 2006; *97*, 2: 207-214

Nurses' health, age and the wish to leave the profession – findings from the European NEXT-Study

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Key words

Nurses; health care workers; NEXT study

Summary

Background and objectives: *In many industrialised countries the number of workers with low health is expected to increase in the nursing profession. This will have implications for occupational health work in health care. The European NEXT-Study (www.next-study.net, funded by EU) investigates working conditions of nurses in ten European countries and provides the opportunity to evaluate the role of health with respect to age and the consideration of leaving nursing.* **Methods:** *26,263 female registered nurses from Belgium, Germany, Finland, France, England, Italy, Netherlands, Poland and Slovakia were eligible for analysis.* **Results:** *In most countries, older nurses considered leaving the profession more frequently than younger nurses. 'Health' was – next to 'professional opportunities' and 'work organisational factors' – strongly associated with the consideration of leaving nursing. However, more than half of all nurses with low health wanted to remain in the profession. This group reported rather positive psychosocial working conditions – but also the highest fear for unemployment.* **Conclusions:** *The findings indicate that 'the nurse with low health' is reality in many health care settings. Both positive supporting working conditions but also lack of occupational alternatives and fear of unemployment may contribute to this. Current economic, political and demographic trends implicate that the number of active nurses with low health will increase. Occupational health surveillance will be challenged by this. But NEXT findings implicate that prevention also will have to regard work organisational factors if the aim is to sustain nurses' health and to enable nurses to remain healthy in their profession until retirement age.*

Riassunto

«Salute, età e desiderio di lasciare la professione negli infermieri. Risultati dello Studio europeo NEXT». *In molti paesi industrializzati è previsto un aumento del numero di infermieri con scarse condizioni di salute, un fenomeno con implicazioni rilevanti per la medicina del lavoro nel settore sanitario. L'indagine europea NEXT (www.next-study.net, finanziamento UE) studia le condizioni di lavoro degli infermieri in dieci paesi europei e offre la possibilità di valutare lo stato di salute in relazione all'età e al desiderio di lasciare la professione infermieri-*

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stica. L'analisi presentata in questo contributo riguarda 26.263 infermieri di sesso femminile provenienti da Belgio, Germania, Francia, Italia, Olanda, Polonia e Slovacchia. Nella maggior parte dei paesi indagati, gli infermieri più anziani hanno dichiarato di aver pensato di lasciare la professione più frequentemente rispetto ai colleghi più giovani. Il fattore "salute" - assieme alle "opportunità professionali" e agli "aspetti dell'organizzazione lavorativa" - è risultato fortemente associato all'idea di lasciare la professione. Tuttavia, più della metà degli infermieri che hanno riportato scarse condizioni di salute ha anche dichiarato di volere rimanere nella professione. Questo gruppo ha riferito condizioni psicosociali di lavoro piuttosto favorevoli – ma anche un timore più elevato di rimanere disoccupato. I risultati dello studio NEXT mostrano che gli infermieri in attività con scarse condizioni di salute costituiscono una realtà in molti contesti sanitari. Sia la presenza di condizioni di lavoro adeguate che la mancanza di alternative occupazionali possono favorire questo fenomeno. Le tendenze attuali sul piano economico, politico e demografico indicano che il numero di infermieri in attività con scarse condizioni di salute è destinato a crescere. Questa situazione rappresenta una sfida futura per la sorveglianza sanitaria nei luoghi di lavoro. I risultati dell'indagine NEXT implicano inoltre che, al fine di sostenere le condizioni di salute e consentire agli infermieri di lavorare sani fino all'età del pensionamento, l'attività preventiva deve anche essere indirizzata ai fattori inerenti l'organizzazione del lavoro.

Introduction

Thirty years ago, JM Stelman wrote: 'If you ever wondered how people can manage to work with the sick and always stay healthy themselves, the answer is – they can't!' This statement combines four elements of the nursing work force:

– nurses' work,
– nurses' age,
– nurses' health,
– premature departure from the nursing profession.

The combination of these aspects is of direct relevance for occupational health work in health care and is the topic of investigation of this study.

In the past three decades the framework and context of nursing work in the industrialised world has changed. At all levels, the health care system has had to adjust to an economic environment focused on management efficiency which often results in an increase in workload for nurses (4). At the same time, there are indicators for an ageing nursing profession in many European countries and the following facts implicate that this age trend may be expected to continue:

Nursing shortage

Nursing shortage is reported to be an increasing problem worldwide including Europe. In 2002 it has been reported that most industrialized countries are or will be facing such nursing shortages (10), which are expected to grow up to 30 percent by the year 2020 (21). Retaining nurses may be regarded as one of the most promising ways to react to this development (7).

Economic growth

The health care sector has been termed the 'motor of structural change of European economies', pointing at it as an expanding economic sector (18). Indeed, this is already the case today in Germany, where – against the common economic trend – about 134.000 new jobs have been created from 1999 until 2003. This went hand in hand with an increase of the proportion of older nurses (50 years plus) from 12.2% to 16.5% (9).

European employment policies

Finally, an increase of employment in general and of older people in particular is in line with the Lisbon Strategy which set the target of an employment rate of 50% by the year 2010 of people aged 55-64 years.

The factors and trends described above indicate that premature departure could less and less represent an open pathway for older nurses or for those with reduced physical capacities. Instead, many would have to remain in their profession whether they want it or not. This has concrete implications for occupational health in health care.

In this contribution we aim at investigating – from an Occupational Health point of view – work, health status and the nurses' intention to leave their profession on the basis of data from the European Nurses' Early Exit Study (NEXT) (www.next-study.net). The NEXT was designed to investigate the reasons and circumstances of premature departure from the nursing profession in Europe. In particular, it investigated:

– the underlying causes for nurses to consider leaving the profession in different age groups with special attention given to the role of health;

– nurses with good or low health in relation to their wish to remain or to leave their profession. The underlying question is whether nurses can and want to remain in the nursing profession even though they consider themselves not to be healthy.

Methods

NEXT is a one-year two waves longitudinal study investigating working conditions, private life, health and future perspectives of nurses in 10 countries. It was financed by the European Union (QLK6-CT-2001-00475). Between 2002 and 2005 four self-report questionnaires have been sent out to nursing staff (all qualification levels) in hospitals, nursing homes and home care. In total, 56.000 people from more than 600 healthcare institutions have participated. The NEXT-Study design has been described in detail in Hasselhorn et al. (2003). This contribution is based on the NEXT baseline assessment carried out in 2002/3 (N=39,898). Total response rate for the baseline assessment was 51,4%, ranging from 32,4% (United Kingdom) to 76,9% (Finland) in the participating countries (7).

Intention to leave the nursing profession (ITL)

The intention to leave the nursing profession has been assessed by one item: "How often during the course of the past year have you thought about leaving nursing?". The response categories were 'never', 'sometimes a year', 'sometimes a month', 'sometimes a week', 'every day', and 'not applicable'. In the linear regression analysis, the continuous measure was used as outcome. For other analyses, the item was dichotomised 'so as to distinguish those considering leaving several times a month or more' (hereafter described as those thinking of leaving 'frequently') from those considering leaving less often or not at all (hereafter described as those 'not' thinking of leaving).

Operationalisation of dimensions related to the nurses' Intention to leave the nursing profession

On the basis of a model for 'premature departure from the nursing profession' conceived within the NEXT-Study (7), different dimensions of exposure have been defined which are assumed to contribute to the nurses' wish to leave the profession. These dimensions have been defined as follows (detailed description of scales and items are found in Kuemmerling et al. 2003).

Satisfaction with pay

Degree of satisfaction with pay in relation to personal needs, to other professions, and to nurses in other institutions (three item scale developed by NEXT).

Health

General health was measured by the SF-36 'general health scale' (Ware & Sherboune 1992). For descriptive analysis the variable was dichotomised: 'low health' (score 0 to 50; 26.3% of the participants in the sample), 'good health' (score 51 to 100). Psychological health was assessed by the six-item '*personal burnout*' scale from the Copenhagen Burnout Inventory (CBI) (1), which assesses the degree of general exhaustion.

Private conditions

Private conditions were summarised by applying the 'Work-Family Conflict scale' (WFC; 16, assessing the perceived conflict between work demands and private life), the total weekly working hours, the living status (with/without partner and/or children) and the perceived economic condition (NEXT single item).

Social work environment

The operationalisation of the social work environment comprises the 'quality of leadership' (four item COPSOQ scale) and social interrelations between nurses and the nursing management, colleagues and doctors (three NEXT items).

Work content

The work content was operationalised by measuring health care specific *'emotional demands'* (4 items, 3) and the degree of physical exposure by the NEXT *'cumulative nurses' lifting and bending score'* (14).

Work organisation

Work organisation was assessed by including *'quantitative demands', 'influence at work', 'possibilities for development'* (all scales from the Copenhagen Psychosocial questionnaire, COPSOQ; 13) and *'role conflict and role ambiguity'* (4 item NEXT scale).

Employment opportunities: individual

Employment opportunities have been subdivided. *Individual* employment opportunities indicate the respondent's perceived own job security ('Are you worried about becoming unemployed?', 'My job security is poor').

Employment opportunities: objective

Objective employment opportunities consist of indicators for the general labour marked for nurses (3 items, e.g. availability of vacant posts at work, regional employment situation for nurses).

Professional opportunities: individual

The *professional* opportunities concern the professional perspectives (one item 'How pleased are you with your work prospects?').

Data analysis

Significance of the differences in prevalence was calculated by the χ^2-test. Linear regression analysis was performed using the 'intention to leave the nursing profession' item as continuous dependent variable. Significance of differences between the explained variances of 'intention to leave the nursing profession' across age was calculated according to the formula provided by Cohen et al (2). The one-way ANOVA test was conducted to compare the means of the four 'health/intention to leave' combinations on the demand/control/support dimensions. All analyses were performed using SPSS 14.0.

Data selection

For assuring comparability of results only female Registered Nurses were selected for the present study. When measuring cumulative data from several countries, data from Poland and Slovakia was excluded because of systematically and substantially deviating working conditions (rather adverse), reported (lower) health and (lower) intention to leave the profession.

Results

Sample age distribution

Overall, 26.263 nurses were eligible for analysis. The country with the highest proportion of older nurse was Finland, where one out of four participants was 50 years old or older (table 1). Finland was followed by Great Britain (20.2%). Countries with a low proportion of older nurses (<10%) were Belgium, Poland and Italy. There are several explanations for differing proportions of older nurses in the countries. A healthy worker effect may be assumed to exist (or have existed) in most countries except in Finland, where the possibilities for leaving the profession have been restricted in recent years. Furthermore, national policies exhibit different retirement ages for older workers, for example in France the general retirement age is 60 years and in Germany it is 65.

Table 1 - *Participants in the current analysis (only female Registered Nurses) by age group*

		Age 18-29		Age 30-49		Age ≥50		All	
Country	Abbr.	N	%	N	%	N	%	N	%
Belgium	BE	835	25.2	2,162	65.4	311	9.4	3,308	100
Germany	DE	576	22.8	1,681	66.5	272	10.8	2,529	100
Finland	FIN	347	15.0	1,374	59.6	585	25.4	2,306	100
France	FR	547	21.3	1,635	63.7	386	15.0	2,568	100
Great Britain	GB	297	15.5	1,236	64.3	389	20.2	1,922	100
Italy	IT	543	14.3	2,938	77.5	309	8.2	3,790	100
Netherlands	NL	776	24.4	1,987	62.6	413	13.0	3,176	100
Poland	POL	571	13.4	3,310	77.9	366	8.6	4,247	100
Slovakia	SLK	462	19.1	1,627	67.3	328	13.6	2,417	100
All		4,954	18.9	17,950	68.3	3,359	12.8	26,263	100

Age and 'intention to leave the nursing profession'

Older nurses tended to consider leaving their profession less frequently than their middle aged and younger colleagues in particular (figure 1). This was significantly the case for Germany (χ^2-test, p<.001), Finland (p<.001), Italy (p<.01), Poland (p<.001) and Slovakia (p<.001). In France, an opposite age trend was found (p<.001). No significant differences were found for Belgium, Great Britain and the Netherlands.

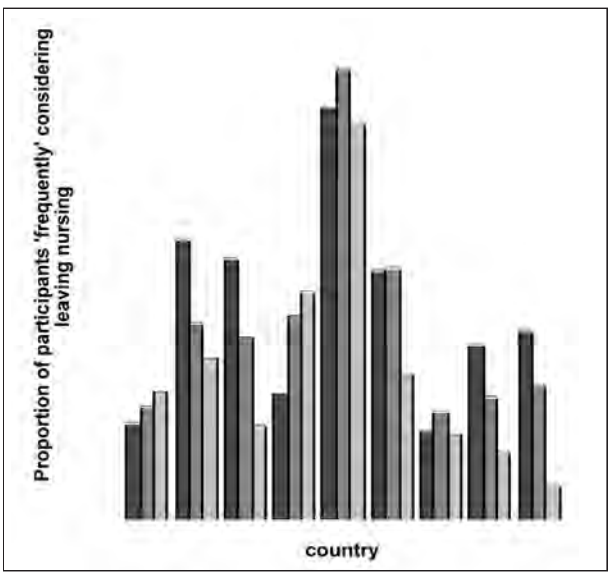

Figure 1 - Proportion of nurses frequently considering leaving the nursing profession – by age group (only female Registered Nurses; N=23,970).

Factors associated with the nurses' intention to leave the profession

Among the different exposure dimensions leading to the nurses' consideration of leaving the profession, three showed a significant age relatedness (figure 2). 'Professional opportunities' were significantly less strongly associated with intent to leave among older nurses than among middle-age and younger nurses. Furthermore, 'satisfaction with pay' was less strongly associated among older nurses. The association between pay satisfaction and intention to leave the nursing profession was, however, rather low also for the other age groups. The 'health' dimension showed a significant age gradient: for older nurses low health played a stronger role for considering leaving the profession.

Why do people with low health want to stay in the nursing profession?

Considering the substantial role that health has for nurses when considering leaving the profession, we are now investigating whether and why nurses with low health want to remain in their profession.

For analysing the association of a) health and b) intention to leave the nursing profession, the sample was dichotomised by general health ('low'=score 0 to 50, 'good'=51 to 100) and by the intention to leave ('frequently'=considering leaving several times a month or more, 'not'=considering

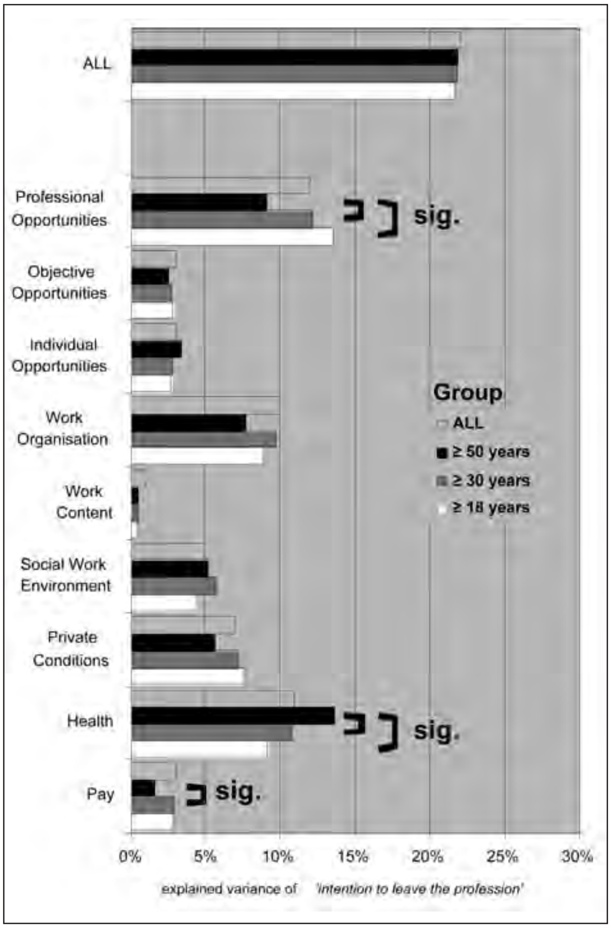

Figure 2 - Explained variance of 'intention to leave the nursing profession' among female registered nurses of different age groups (only female registered nurses in BE, DE, FIN, FR, GB, IT, NL; $n_{\geq 18}$= 3,763, $n_{\geq 30}$= 12,148, $n_{\geq 50}$= 2,413)

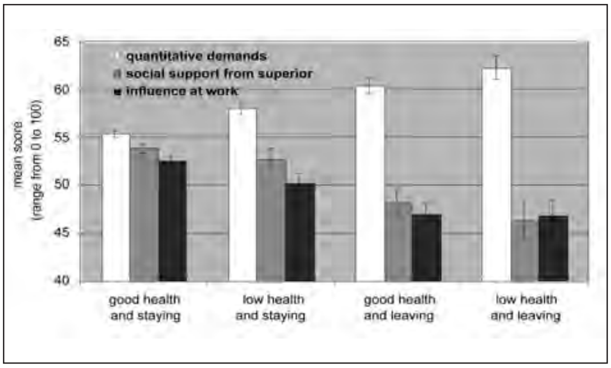

Figure 3 -Mean scores for the central dimensions of the demand-control-support model: job demands, influence at work and social support by four groups (adjusted for age, negative and positive affectivity; error bars indicate 95% confidence intervals; only female registered nurses in BE, DE, FIN, FR, GB, IT, NL; $n_{\text{good health + staying}}$=12,274, $n_{\text{lowhealth + staying}}$=2,729, $n_{\text{good health + leaving}}$=2,036, $n_{\text{low health + leaving}}$=1,012)

this less often). A four category variable was created combining these two factors (figure 3). It was interesting to find that among the 4,765 participants with low health, more nurses wanted to remain in the profession (n=2,729) than leave it (n=2,036).

These four categories were compared with respect to the core dimensions of the demand-control-(support) model (11, 12) to exemplify whether, how and to which degree psychosocial exposure differs between these four groups. Obviously, those with good health and not wanting to leave nursing (figure 3, left) reported the most fortunate psychosocial exposure. Interestingly, they were followed by the group of nurses with low health and still wanting to remain in the profession. This was found for all age groups (not shown).

Another aspect, however, also needs to be considered when assessing why nurses with low health want to remain in their profession. As figure 4 indicates, this group comprised the highest proportion of nurses worried not to find a new job when they became unemployed. This was the case in almost all countries and most pronounced in the younger and medium age groups (not shown).

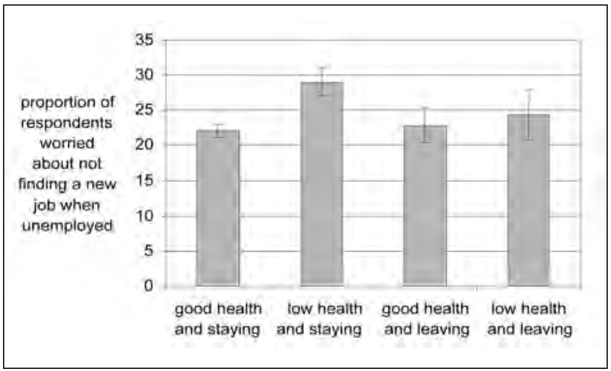

Figure 4 - Proportion of nurses worried not to find a new job when becoming unemployed by four groups (adjusted for age, negative and positive affectivity; error bars indicate 95% confidence intervals; only female registered nurses in BE, DE, FIN, FR, GB, IT, NL)

Discussion

Our findings indicate that the nurses' perceived health may constitute one of several relevant dimensions impacting on their consideration of leaving the profession. The association was significantly stronger among older nurses, a finding which is not self evident since low health was also frequently reported by the younger nurses (18.1% of all younger participants reported low health vs. 23.4% of the oldest participants; these data refer to all countries except Poland and Slovakia). Other NEXT data confirm that younger nurses with low health usually still regard the possibility to take advantage of different occupational opportunities whereas for older nurses the end of nursing usually indicates the end of professional work. We regard the end of the career due to low health as a legitimate occupational pathway. But occupational health experience in the past decades also shows that the possibility for premature retirement has decreased.

The NEXT data implicate more and more nurses want to remain in the nursing profession in spite of low health. Our analysis provides us with two basically different reasons for this: firstly, nurses with low health who want to remain in the profession rate their working conditions more positively (even when adjusted for negative affectivity).

This implicates that favourable working conditions – lower work demands, higher influence at work and higher social support – may enable nurses with low health to (want to) remain in the profession. On the other hand, further analysis shows that the fear of unemployment might be another relevant factor which keeps nurses in their profession.

Considering the expected continued increase in the number of nurses, the decreasing possibilities for premature occupational departure for nurses with low health in Europe and considering our findings, the conclusions for occupational health in health care are threefold:

1) The nurses with low health will play an increasing role in the work life within the health care sector, and the latter will have to adapt to this situation.

2) Health is an especially crucial factor for older nurses when it concerns their continued work in nursing.

3) Ways have to be applied to systematically improve and sustain the health of nurses (see, for example 5, 15, 17, 20). This may include targeted preventive approaches and regular occupational health surveillance programmes. NEXT findings, however, consistently indicate the close interrelatedness of work organisational factors and health among nurses (e.g. 8). In most cases, the reconsideration of work organisational factors will go beyond the scope of occupational health physicians. But he/she may forward such knowledge, for example within workplace health promotion programmes.

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La Medicina del Lavoro Med Lav 2006; *97*, 2: 215-220

Tuesday - June, 13 2006 - Semi Plenary

Risks of occupational exposure to optical radiation

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Key words
Optical radiation; Non-ionizing radiation; Laser; eye

Summary
During the past 40 years a wide body of biomedical research has been conducted to understand the factors which influence injury to optical radiation-particularly with respect to the eye. A primary motivation for much of this research has been the advent of lasers, since focal damage of the retina from a collimated beam exposure is possible at some distance. A wide range of research studies provided the basis for establishing human exposure limits for ultraviolet and infrared radiation as well as for intense visible light. The International Commission on Non-Ionizing Radiation Protection (ICNIRP) has published guidelines for human exposure, and these are available at no cost from the ICNIRP website (http://www.icnirp.org). Laser Maximum Permissible Exposure (MPE) limits used in international safety standards, such as those of the International Electrotechnical Commission (IEC) are based upon ICNIRP guidelines. Practical laser safety standards and regulations have evolved to promote the safe design and use of laser products. As a result of newer laser applications and increased knowledge of the biological effects, MPEs have been revised a number of times. Despite the existence of safety standards and regulations, accidental eye injuries from lasers still occur. Accidental exposure to welding arcs and intense lights occur more frequently, but the consequential loss of vision is much less, with permanent effects rare. Accidental human exposure information also adds to our understanding of ultraviolet, blue-light and laser induced retinal injury. Accidents are most frequently attributed to the lack of understanding of hazards and a failure to follow established safe work practices.

Riassunto
«Rischi da esposizione professionale a radiazione ottica». *Nel corso degli ultimi quaranta anni è stata condotta una vasta serie di ricerche biomediche al fine di comprendere i fattori che hanno influenza nelle lesioni da radiazione ottica, con particolare attenzione all'occhio. La motivazione primaria per la maggior parte di queste ricerche è stato l'avvento della tecnologia laser, dal momento che l'esposizione ad un raggio collimato a una determinata distanza può determinare una lesione focale della retina. I risultati di larga parte degli studi hanno fornito le basi per stabilire i limiti di esposizione, per l'uomo, per i raggi ultravioletti e per la radiazione infrarossa così come per la luce visibile intensa. La Commissione Internazionale per la Protezione da Radiazioni Non Ionizzanti (ICNIRP) ha pubblicato delle linee guide per l'esposizione umana, e queste sono disponibili senza alcuna spesa sul sito web di ICNIRP (http://www.icnirp.org). I limiti per la Massima Esposizione Permissibile (MPE) a laser utilizzati dagli standard di sicurezza internazionali così come quelli della Commissione Internazionale di Elettrotecnica (IEC), ricalcano le linee guida ICNIRP. Standard e regolamenti di sicurezza si sono evoluti così da promuovere la progettazione e l'utilizzo in sicurezza delle apparecchiature laser. In conseguenza delle nuove applica-*

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zioni e della migliore conoscenza degli effetti biologici del laser, i limiti di esposizione sono stati aggiornati diverse volte. Nonostante la presenza di standard di sicurezza e regolamenti, lesioni accidentali della retina dovute a laser si verificano ancora. L'esposizione accidentale nella saldatura ad arco ed a luci intense accadono più spesso, ma la perdita della vista che ne deriva è minima e gli effetti permanenti sono rari. L'esposizione accidentale aggiunge informazioni alla nostra comprensione del danno retinico da raggi ultravioletti, da luce blu e da laser. Gli infortuni sono più spesso attribuiti ad una carente valutazione dei pericoli e alla mancata osservanza di pratiche di lavoro sicure.

Introduction

With respect to ultraviolet and infrared radiation, as from arc welding, indoor workers can be readily protected (20). However, outdoor workers are chronically exposed to ultraviolet radiation from sunlight and protection of the eyes and skin for outdoor workers poses significant challenges for the occupational health specialist (15). Although IARC classifies sunlight as a Group I carcinogen, it is nearly impossible to protect to currently recommended ICNIRP exposure guidelines for the skin during summer months. Fortunately, humans have evolved under natural sunlight and possess many natural protection factors against solar ultraviolet radiation for both the eye and skin, but these are frequently not understood. The geometry of human exposure outdoors limits dangerous UV-B exposure to the top of the head and shoulders, since the dangerous radiant energy is generally of greatest significance only when the sun is high in the sky. The eyes are greatly protected by the upper lids and brow-ridge. Overcast skies actually redistribute UV-B energy toward the horizon and may actually increase exposure to less-exposed areas of the eyes and skin. The ICNIRP and a number of organizations have provided guidelines for worker protection and education. A very effective and simple method for the worker to know when protection is important is known as the "Shadow Rule," which indicates that high risk exists only with a short shadow: "Short-shadow, seek shade."

Significant occupational exposures

A wide range of potentially hazardous occupational exposures laser radiation are possible, but the probability of exposure to the more vulnerable eye is frequently very low, thus a potential for severe injury can occur from the direct exposure of the eye to a Class 3B or Class 4 laser beam. Occupational exposures to intense light, ultraviolet and infrared sources also exist. However, the potential for severe injuries is much lower, but an exposure to modest optical hazards is much higher since the optical radiation may not be collimated.

Although potentially painful erythema is an acute transient response in the skin to excessive exposure to UV, repeated over-exposures greatly increase the risks of delayed effects: accelerated skin ageing and skin cancer. Chronic UV exposure has been indicated to be the primary factor in the induction of non-melanocytic skin cancers (NMSC). Cutaneous malignant melanoma (CMM) is far less frequent, but the mortality is far greater. There is undisputable medical evidence that almost all skin cancers are related to solar ultraviolet (UV) exposure, and, specifically for melanoma – over-exposure during childhood of those having a familial genetic predisposition (e.g., those with red hair, freckles, etc.). Familial history of melanoma is a strong indicator, since in conjunction with UV over-exposure, one or two members of the family will have a cancer. Another risk-factor is the presence of more than 50 nevi over the body – a number that also depends upon both genetic factors and solar exposure.

Primary prevention is largely achieved by all means of *photoprotection* (avoiding direct exposure during the midday hours during spring and summer months when the sun is high; avoiding unnecessary exposures; protection by physical barriers, such as by working under shading structures during midday hours, wearing long-sleeve shirts and long trousers, broad-brimmed hat (at least 7-

cm brim reduces facial and neck exposure by five-fold). The use of sunscreens on uncovered parts of the body is then an adjunct. Health education remains a critical part of prevention. Many have recommended that more sensitive workers be counseled on outdoor work risks. A medical examination to detect signs of skin sensitivity to UVR – minor freckles on the face and/or shoulders, sun-induced, star-like, large freckles, and determine the number of nevi on arms, legs and trunk should take place as a pre-employment examination. This could also be expanded by an historic record of the number of severe sunburns, travels in sunny countries, practice of outdoor sports in open fields or water sports.

The net result will be the assessment of the risk of developing later in life all forms of skin cancer and, as a consequence, the worker can be counseled to aim as much as possible to assignments with minimal sun exposure and the importance of adopting strict photoprotective measures.

Laser hazard evaluation and risk classification

Current laser safety standards throughout the world follow the practice of categorizing all laser products into several hazard classes, and control measures are specified for each class, based upon the actual hazards posed by the laser beam. Generally, the scheme follows a grouping of four broad hazards classes: 1 through 4. Class 1 laser products cannot emit potentially hazardous laser radiation and pose no health hazard. Classes 2 through 4 pose an increasing hazard to the eye and skin. The classification system is useful, since safety measures are prescribed for each class of laser. More stringent safety measures are required for the highest classes.

The laser safety classification system greatly facilitates the determination of appropriate safety measures. Laser safety standards and codes of practice routinely require the use of increasingly more restrictive control measures for each higher classification. Hence routine measurements are normally not required.

Class 1

Class 1 is considered an “eye-safe”, no-risk grouping. Most lasers that are totally enclosed (for example, laser compact disc recorders) are Class 1. No safety measures are required for a Class 1 laser. Class 1 lasers are frequently referred to as “eye-safe” lasers. In the past few years, a new, conditional class has been introduced: Class 1M, which is effectively “eye-safe” unless the beam is directly viewed with optical instruments. Two conditions exist whereby optical instruments can collect more energy and increase the ocular hazard. Condition 1 is the most obvious and the most serious case: where a telescope or binocular is placed in the collimated laser beam and can introduce far more energy into the eye if there is a retinal hazard, or concentrate the energy on the cornea for laser wavelengths outside the retinal hazard region. The second condition is where a hand magnifier or jeweller’s eye loupe is used to examine a highly diverging laser beam (generally emitted from an optical fibre) and recollimate the beam so that it can be concentrated on the cornea or focused on the retina. This is a rather unrealistic viewing condition except when service technicians examine the tip of an optical fibre. The safety criteria for this second viewing condition are now being re-examined by standards committees, such as IEC TC76 with a plan to either restrict the applicability or to relax the currently over-stated risks in the current edition of IEC 60825-1.

Class 2

Class 2 refers to visible lasers that emit within the 400-700-nm spectral band with a very low power (less than 1 mW) that would not be hazardous even if the entire beam power entered the human eye and was focussed on the retina. The eye’s natural aversion response to viewing very bright light sources protects the eye against retinal injury if the energy entering the eye is insufficient to damage the retina within the aversion response. The aversion response is composed of the blink reflex (approximately 0.16-0.18 second) and a rota-tion of the eye and movement of the head when exposed to such bright light. Current safety standards define the aversion response as lasting 0.25 s. Thus, Class 2 lasers have an output power of 1 milliwatt (mW) or less that corresponds to the permissible exposure limit for 0.25 s. Examples of Class 2 lasers are laser pointers and some alignment lasers. Another conditional sub-class, Class 2M is analogous to Class 1`M, but the optical hazard is applicable only for visible lasers that would be Class 2 if measured only with a 7-mm collecting aperture.

As a note, at one time, US safety standards also incorporated a sub-category of Class 2, referred to as "Class 2A". Class 2A lasers, which were not hazardous to stare into for up to 1,000 s (16.7 minutes). Most laser scanners used in point-of-sales (super-market checkout) and small inventory scanners are Class 2A, but this class was no longer required when the exposure limits were adjusted (6) such that a point-source laser was no more hazardous if viewed for any duration greater than 10-100 s.

Class 3

Class 3 lasers pose a hazard to the eye, since the aversion response is insufficiently fast to limit retinal exposure to a momentarily safe level, or if damage to other structures of the eye (e.g., cornea and lens) could take place. Skin hazards normally do not exist for incidental exposure. Examples of Class 3 lasers are many research lasers and military laser rangefinders.

A special subcategory of Class 3 is termed "Class 3R" (once termed Class 3A in US standards). The remaining Class 3 lasers are termed "Class 3B". Class 3A lasers are those with an output power between one and five times the AEL for the Class 1 or Class 2. Class 3R should be thought of as a transitional class, since the laser beam irradiance exceeds the applicable exposure limit (EL), referred to as the "maximum permissible exposure (MPE), but injury is unlikely from a standpoint of probabilistic risk assessment, i.e., the likelihood that the eye will be perfectly positioned, focused for worst-case viewing (retinal hazards) and the person unusually sensitive become very small. The "R" in Class 3R refers to "reduced requirements" for product safety standards and very limited control measures are required for the user. Examples are many laser alignment and surveying instruments. In the 1.2-1.4 mm spectral band the Class 3R may not exist for some CW lasers where the range between Class 1 and Class 4 becomes very small.

Class 4

Class 4 lasers may pose a potential fire hazard, a significant skin hazard, or a diffuse-reflection hazard. Virtually all surgical lasers and material processing lasers used for welding and cutting are Class 4 if not enclosed. All lasers with an average power output exceeding 0.5 W are Class 4. If a higher power class 3 or class 4 is totally enclosed so that hazardous radiant energy is not accessible, the total laser system could be class 1. The more hazardous laser inside the enclosure is termed an "embedded laser".

Recent changes

In 2001, the world safety community recognized a need to make some minor revisions in the traditional laser classification systems, with the creation of a Class 1M and Class 2M and expand Class 3R for greater consistency in dealing with the potential for optically aided viewing. This effort recognized the value of having conditional classes. It is hoped that there will be no further changes in classification to avoid confusion; however, the subject of further refinements sometimes arise in standards committees. Past efforts to refine and sophisticate the classification system have been voted down because they added complexity, where simplicity was desired. The value could only be if they indicated different control measures. For the user, the class achieves the first step of hazard evaluation with the indication of appropriate control measures without the need to consult a laser safety advisor (LSA) or Laser Safety Officer (LSO).

If a high-power, Class 4 laser is partially enclosed such that the risk of occupational exposure is very low, the level of control can be greatly reduced, but it is not necessary to invent another "conditionally safe" class. It is best to try to educate people that Class 4 does not necessarily imply a serious risk, and that the controls adopted should be appropriate to the circumstances, rather than defining a new class for "conditionally safe" products. The current system of classification is based on the level of hazard with only an implication for the degree of risk, and this is the basis of the recommendations given in the revised user guidelines. The Class indicates the potential hazard of the product, but the actual risk is not fully defined by the class, since it depends on the environment in which it is located and the people potentially exposed. For example, a high-power, Class 4 industrial, material-processing laser that is Class 4 because the enclosure does not have a fully light-tight enclosure, and perhaps does not have a roof could be quite acceptable in locations were the ceiling is close to the enclosure, but not in another location where there are walkways at a higher level that provide a direct view into the enclosure. In a user safety standard, the laser safety expert might classify the enclosure adequate for Class 1, but the manufacturer might have to retain the Class 4 label, since the system could be installed in any location.

Laser measurements

To those in radiation protection, it is at first somewhat surprising to learn that instrumentation and measurements are not the focus of laser safety. Laser measurements often require sophisticated equipment and fortunately are seldom essential for laser hazard evaluation, since the manufacturer must classify the laser product, and as noted above, actual use of the MPEs (ELs) is infrequent (1, 5, 20).

Unlike some workplace hazards, there is generally no need to perform measurements for workplace monitoring of hazardous levels of laser radiation. Because of the highly confined beam dimensions of most laser beams, the likelihood of changing beam paths and the difficulty and expense of laser radiometers, current safety standards emphasize control measures based upon hazard class and not workplace measurement (monitoring). Measurements must be performed by the manufacturer to assure compliance with laser safety standards to assure proper hazard classification. Indeed, one of the original justifications for laser hazard classification related to the great difficulty of performing proper measurements for hazard evaluation.

In this regard, MPEs are exposure limits measured at the points in space where individuals are potentially exposed and are used for occupational safety and health assessments. These originate from ICNIRP. The product-safety committee, IEC TC76, has gone on record on a number of occasions over the last 20-30 years that it recognizes WHO and ICNIRP as the source of the MPEs. IEC develops product safety standards that regulate emission and employ Accessible Emission Limits, AELs, which are derived by IEC from the MPEs and other considerations.

Laser eye protection

Laser eye protection becomes of great importance when engineering controls such as enclosures, baffles and barriers are inadequate to assure that persons will not enter the nominal hazard zone (NHZ), where a potential ocular exposure will exceed the applicable MPE. There are many commercial laser eye protectors available and standards have been written to test them. Issues remain as to whether some of the tests related to filter damage are realistic and are not just a costly added expense. Some existing testing standards require the eye protection to withstand levels far in excess of skin injury thresholds, with the result that many are critical of these requirements (figure1). Efforts are underway in the US to prepare a more realistic standard for eyewear (1), but this has not been published. On the international scene, ISO TC 94 is examining the same issue. The protective factor is normally expressed as a logarithmic quantity referred to as the optical density (OD). The OD is the negative $\log_{10}$ of the transmittance (8).

Figure 1 - The absurdity of testing laser eye protectors to withstand kilowatt laser beams

Conclusions

Laser technology has become mature in the past three decades and is ubiquitous throughout industry, science and medicine. Laser safety programs are encountered in a large variety of workplaces. The keys to the safe use of lasers are firstly: enclose the laser radiant energy if possible; and if not possible, control measures become essential and training of those working with laser becomes paramount for safe use.

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La Medicina del Lavoro Med Lav 2006; *97*, 2: 221-225

Mobile phones. Precautionary options

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Key words
Mobile phones; radiofrequency; precautionary principle

Summary
Mobile phones have been in use for over two decades and are ubiquitous in the western world for at least ten years. There has been scientific interest and public concern about the possibility of adverse health effects from this relatively new use of non-ionising electromagnetic energy both at the level of the handset and the base station. The proliferation of base transmitter stations in the early 1990's caused a resurgence of interest in the possible health effects of low level RF in general and several significant studies investigated the issue generally using broadcast transmitters as a more predictable source of exposure. Handsets, although of much lower power are closely coupled to the users body and deserve special attention, which they have received. From this research, a high level of assurance of safety has emerged and this is reflected in secure international exposure standards allowing more or less unrestricted use of the technology from a public health point of view. Nonetheless, some research remains unsettled, the science is incomplete in some areas and in the minds of some the unknown provides an uncomfortable level of risk. This debate is unlikely to see an early resolution and so precautionary approaches are increasingly supported. There are a wide range of actions, which have been regarded as precautionary, but ultimately minimisation of public exposure is likely to be the only strategy which could provide a benefit if any risk is later found. There are practical ways of achieving this, but not all proposed strategies seem to recognise them.

Riassunto
«Cellulari. Misure preventive». *I cellulari sono in uso da circa 20 anni e si sono diffusi in modo capillare in tutto l'occidente da almeno10 anni. Ci sono stati interessi scientifici che preoccupazioni generali sulla possibilità di effetti avversi sulla salute derivanti dall'esposizione a energia elettromagnetica non-ionizzante, che l'uso dei cellulari comporta, derivante sia dall'apparecchio che dai ripetitori. Il proliferare di ripetitori nei primi anni '90 provocò un'ondata di rinato interesse per gli effetti sulla salute provocati dalle radiofrequenze a bassa intensità e numerosi rilevanti studi hanno approfondito tale argomento principalmente utilizzando trasmettitori radio come fonte più frequente di esposizione. I cellulari, sebbene siano a bassa emissione, sono strettamente a contatto con il corpo di chi li usa e meritano pertanto particolare attenzione come hanno finora avuto. Da questa ricerca è emerso un alto livello di garanzia di sicurezza nell'uso di tali dispositivi che si riflette in sicuri standard di esposizione internazionali che consentono un uso più o non vincolato della tecnologia dal punto di vista della salute pubblica. Tuttavia alcuni aspetti della ricerca devono ancora essere esplorti, la conoscenza a riguardo è lacunosa e ciò determina in alcuni un'alterata percezione del rischio. Il dibattito è lungi dal vedere una rapida soluzione, pertanto viene utilizzato un approccio di tipo precauzionale. Esistono numerosi provvedimenti che vengono considerati precauzionali, tuttavia, in ultima analisi, la minimizzazione dell'esposizione pubblica rappresenta probabilmente l'unica strategia in grado di produrre beneficio nel caso che alla fine emerga un rischio. Esistono molti metodi per raggiungere tale risultato, ma non tutte le strategie proposte sembrano applicarli.*

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Mobile Phones are an evolution of both the telephone and the radio-telephone which arrived some twenty five years ago. Within in a decade these "cellphones" became a firm contender to become one of the most successful technological innovations of the twentieth century. Since 1990, the expansion in availability of mobile telephone networks and affordable handsets has grown to the extent that many emerging economies are now relying on radiofrequency based rather than fixed wire telephone networks for future communications infrastructure.

The technology arrived at a time when standards for human radiofrequency exposure were becoming stabilised with publication of definitive documents by both the International Radiation Protection Association (7) and the Institute of Electric and Electronic Engineers (IEEE) (2). Both of these standards used a dosimetric approach which at the ultra-high frequencies (UHF) used by mobile telephones was based on thermal effects which are unarguably the limiting biological acute effect. This early work was based on extrapolations from animal experiments but subsequent human studies and advanced computer modelling have shown the thresholds chosen to have been soundly based and they have not required substantial revision in the light of subsequent knowledge (1).

There has always been a scientific interest in the possibility of effects of radiofrequency energy absorption other than those resulting from heating or electro stimulation and concern about the possibility that such effects may occur at lower levels than the standards and even cause the effects which accrue with cumulative dose over time. Evidence to support these hypotheses has been sparse and never successfully replicated to the extent where a sustainable public health issue has been accepted (8, 9). Nonetheless, the inevitable ongoing research which at any point in time presents some unanswered questions has resulted in calls for precaution by both some scientists and a significant minority of the general public.

My experience of working in the development of Standards, particularly in Australia and New Zealand, is that whilst most citizens are prepared to accept the determination of science with regard to safety in standards formation, there is still a frequent request for a precautionary overlay. Given that public submissions are called for in the production of these standards, this is not a request which should be lightly overlooked, but it is important to be clear about what the precaution sets out to achive. For example, in the case of 1 GHz frequencies used for mobile telephone communication, environmental exposure, such as from base stations, allows for absorption of no more than 0.08 W/kg of energy, well under one-tenth of the basal metabolic rate of human tissue at rest, a level at which there is no perceptible or detectable biological response or change (1) . The margin of safety in this case compared to the thresholds of any noticeable effect is much more than an order of magnitude. Thus it is self evident that any reasonable concern cannot be that the Standard as it was intended is not protective enough and in general that assurance is widely accepted.

Concerns which do come up from time to time are more regarding the possibility that there might be effects as yet unknown, even unsuspected, and they might occur at a level at a fraction of the Standard. Still, there really is no consistent opinion as to what these might be or where they might occur. Following the suggestions about childhood leukaemia and extra low frequency magnetic fields, similar possibilities have been investigated for RF, but unlike the situation with ELF, there is no residual evidence and this possibility does not need to be pursued more than any other (5, 11).

With regard to the exposure from mobile phone handsets, this is generally regulated by limitation on the allowable specific absorption of energy from the phone into the user's head by standards which limit the permitted specific absorption rate (SAR). The Standards for this were set long ago, before mobile phones were contemplated, on the basis of the inevitably non-uniform absorption of radiofrequency energy under all circumstances, even exposure to a uniform plane wave in a far field. This work has also been subject to much more sophisticated analysis in recent times and whilst it is probable that the margin below effects is less than that for whole body exposure it is nonetheless adequate and prevents any established adverse effects (1). In practice, most mobile phone exposures may, under adverse signal conditions, approach the region of a quarter or a half of the Standard and so the level of headroom which is provided is adequate to provide a workable mandatory limit. The situation of average exposure to far fields is rather different with most exposed members of the general public receiving exposure two orders of magnitude below the Standards at most, although again, the possibility of occasional close proximity to transmitters does justify the existing Standards thresholds to enable a practical standard to which strict compliance can be assured.

The question then arises, if the public request for a precautionary approach is to be heeded, how can this be done? The only logical path to answering this question must be to first define what it is that is causing concern, irrespective of the scientific merits of these concerns. To summarise this in one word, the concern must be regarding exposure, that is, how much RF energy either an individual or a collection of individuals in a community is exposed to. That would seem reasonable to most people, but even then, it is not quite a simple as that. What do we mean by exposure? Is it the maximum or peak exposure that matters or is it the average exposure? Furthermore, is there any conceivable effect of cumulative dose? The science we have, as reflected by the Standards methodology, nowadays argues firmly against the dose-time integration idea, although that was not always the case. The original rationale for the factor of five in the IRPA Standard between occupational and general public exposure was based on the five-fold difference between a 40 hour week and 168 hour calendar week. These days the rationale and justification for the same number is different (6). Given that any benefit of a precautionary approach which attends to the matter of limiting exposure, is protecting against an unknown effect, which occurs at an unknown level, minimisation of exposure, or perhaps of unnecessary exposure seems to be the best that can be achieved and still make some sense. With regard to the questions about the relative importance of peak, average or integrated levels, the only answer can be "all of the above", since the data does not exist to define the mechanism or effect which might benefit from such a precautionary approach.

There has been much confusion about terminology in this area. At times, the idea of the Rio-derived "precautionary principle" has been proposed. This idea, which arose in environmental science has been widely written about and is generally regarded as a "better safe than sorry" paradigm, particularly in the case of minimising the impact of likely environmental damage from rare events. That is somewhat different to the idea of reducing levels to improve peace of mind in the absence of any data which could justify a likely benefit, even in the long term. This idea has been more specifically defined as "prudent avoidance" (10) based on the principle that if there are two paths to achieve the same end and if one seems to be safer than the other, then many people will be more comfortable with the apparently safer path. That idea seems self evident but in practice runs into a lot of problems when it becomes a commercial or governmental policy because of suspicion that the real reasons for the approach may not have been disclosed. Some authorities have claimed precautionary merit in lowering science based Standards. In most cases, such reductions are a half or a quarter or even as much as a tenth of the formal standards and make no difference at all to the level of public exposure other than rating it as higher compared to the proper Standard. Such measures, which I call "pseudo-standards", may sometimes gain political advantage, particularly in a local jurisdiction, which can be marketed as obviously different to practice elsewhere. However, even if an unsuspected problem turned out to be accepted, threshold reduction measures are unlikely to have made any difference at all, because all they do is reduce the headroom. From this argument, it is evident that the only measures which might make a difference are those which generally reduce overall public exposure. These would have to arise from using less RF, either doing without some services it provides, or replacing it with something else. In reality, there is nowhere near the required objective scientific data to justify such measures and no call whatever from the majority of responsible public health authorities to do so. In the light of that, practices of this type would be unsustainable and probably subject to being legally overturned in free-market economies, because they would be likely to reduce customer choice and damage competition for no perceptible or seriously arguable gain.

Nevertheless, returning to the only possible goal of protective measures, that of exposure minimisation, that can conceivably be achieved without reduction of service perhaps accepting modest cost, provided it is evenly applied across a market (to avoid unfair competition) by the use of more efficient technology. For mobile telephones, given the point to point nature of each circuit, that would include more efficient use of power and spectrum and confining the propagation of signal to as near as possible of the line of the active circuit. Paradoxically, one of the best ways of achieving this is to ensure that the base stations are as near as possible to the users. That is paradoxical, because the frequent call, at least initially, from many people concerned about public exposure, is to ask for the sites to be put further away, thereby causing them to use more power and needing higher gain antennas to achieve coverage.

Analysis of the development of first, second and third generation mobile telephone technology shows that the need for conservation of spectrum and of battery life in handsets has, for engineering and marketing reasons, resulted in steady progress toward far more efficient systems. In particular, the use of techniques of adaptive power control, whereby both ends of a circuit reduce power to the minimum required to sustain a signal has resulted in large reductions of power levels. The magnitude of these is such that in well designed networks, driven by predominantly engineering and spectrum considerations, the average level of power is less than one-third of that without such systems operating. Furthermore, new innovations in spread-spectrum technology, including improved and new techniques for dynamic directionality of base antennas, reduces ambient levels of RF-EME even more. These techniques do result in genuine exposure minimisation and therefore do meet the real goals of those wishing to apply radio frequency technology in a precautionary way (4).

In Australia and New Zealand, a requirement for such measures is included in both the national Standards (3, 12). The absolute level of the limiting thresholds which have been chosen, in the case of these Standards following those recommended by ICNIRP, have no influence on precautionary or minimisation approaches. However, the formal requirements in the Standards to take minimisation steps is an ongoing obligation of operators. When this requirement is measured against performance of new systems it is the continuously improved engineering and enhanced efficiency of new generation systems which do provide genuine reductions in exposure even in the presence of greatly increasing use.

In my view, such approaches should provide genuine reassurance to those members of the public asking for a precautionary approach and in my experience it does if the relevant issues are properly and objectively explained. However, in order to ensure a proper and fair understanding of such measures from a medical, scientific and evidence based point of view, it is also important to point out that no health benefits from such reductions should be expected or inferred, as on the basis of all that is known, the established standards thresholds already provide complete protection. It is also appropriate to continue to criticise and in some cases outlaw promotion of politically based pseudo-standards below the established thresholds and the false claims of health benefits which are sometimes promoted with them.

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Med Lav 2006; *97*, 2: 226-232

The development of clinical prediction guides requires reproducible decision-making outputs: a field study

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Key words

Decision-making; quality assurance; health care; guidelines; clinical practice rule; evidence based decision making

Summary

Background: *The decisions taken by occupational physicians (OPs) generally show low reproducibility and reflect some uncertainties linked to the decision making process.* **Aim:** *The aim of the study was to evaluate the variability of different OP decisions in order to assess their reproducibility, which is regarded as a quality factor of the professional practice.* **Methods:** *4 OPs examined the records of 100 selected hospital workers with impaired health conditions in order to take decisions about job fitness, advice to workers, referral to clinical physician, need for further investigations, report of occupational disease and recommendation for the general practitioner. The variability of inter-individual decision was measured by percent agreement and Cohen's kappa test.* **Results:** *After accounting for variability expected by chance, the agreement among decisions on job fitness ranged from fair to substantial, but high variability was observed for most other assessments.* **Conclusion:** *The observed inter-individual variability for some decisions taken by different OPs represents a crucial aspect to be dealt with, as the reproducibility of medical decisions is indispensable for the clinical prediction guides to be built and adopted for improving the practice.*

Riassunto

«Lo sviluppo di linee-guida cliniche richiede la riproducibilità delle valutazioni finali: uno studio sul campo». **Introduzione:** *Le decisioni prese dai Medici del Lavoro generalmente sono condizionate da una bassa riproducibilità, mostrando pertanto alcune incertezze legate al processo decisionale.* **Scopo:** *L'obiettivo del lavoro è stato quello di valutare la variabilità delle decisioni prese da diversi medici specialisti in Medicina del Lavoro al fine di misurare la riproducibilità delle loro valutazioni che rappresenta un fattore di qualità nella pratica professionale.* **Metodi:** *Un gruppo di 4 Medici del Lavoro ha preso in esame le cartelle di 100 lavoratori ospedalieri che presentavano differenti disturbi di salute, allo scopo di assumere decisioni mediche in merito all'idoneità lavorativa specifica alla mansione svolta, consigli non prescrittivi rivolti al lavoratore, invio a consulenza specialistica, necessità di eseguire ulteriori esami integrativi, denuncia di malattia professionale e raccomandazioni rivolte al medico di medicina generale. La variabilità della decisione inter-individuale è stata misurata con l'uso della percentuale delle decisioni concordanti e con il test kappa di Cohen.* **Risultati:** *Considerando la frazione attesa di variabilità casuale, la concordanza tra le decisioni sull'idoneità lavorativa specifica variava da moderata a sostanziale, mentre si osser-*

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vava un'elevata variabilità per la maggior parte delle altre decisioni. **Conclusioni:** *La variabilità inter-individuale osservata per alcune decisioni prese da diversi Medici del Lavoro costituisce un aspetto cruciale da tenere in considerazione, in quanto la riproducibilità delle decisioni mediche è un requisito indispensabile per l'elaborazione e l'utilizzo sul campo di clinical prediction guides nella pratica professionale.*

Introduction

Medical examinations take place for a wide range of purposes, from health protection and public health reasons, to social security, sport practice and education. In particular, medical examinations are extensively used as a tool to grant access to work. In this case the goal of the medical examination is to assess fitness or eligibility for a certain position. Although the development of standards concerning medical examination is complicated by the existence of several different and sometimes conflicting documents (law, guidelines, recommendations, official reports) there is an increasing demand for the highest standard of professional competence (14) and a more effective practice based on evidence of effectiveness (3). The implementation of a health program should, therefore, satisfy requisites of need, relevance, scientific validity and effectiveness (12).

In spite of these assumptions, emphasizing the need to act according to an evidence-based practice, concern has been expressed about some discrepancies observed when different occupational physicians (OP) take a medical decision on the same case (4, 5, 9). Irreproducible decisions are considered the result of lack of convincing evidence because of obsolete data, lack of applicability to that condition of evidence from medical literature, incorrect interpretation of data (18). Irreproducible decisions reflect uncertainties, which may interfere with the decision-making process and act as a barrier for making appropriate decisions. To reduce the uncertainties and to improve the decision taken in fairly commonly encountered conditions the application of clinical prediction guides or rules was proposed. In fact, physicians' practice is facilitated by the adoption of set of rules, which are more specific than clinical guidelines and can effectively assist them in the decision process. The first example of a widely applied rule is the Ottawa ankle rules, developed in the early 1990s (23). The main reason for developing this rule was to reduce the number of ankle x-rays prescribed for minor problems. The development, based on a detailed analysis of the decision process by different physicians, assumed that a high inter-observer reliability of the components of the process should be taken into account to be included in the rule (16, 24).

This study aims at investigating the decision output resulting from the medical examination of workers by different OPs as a quality requisite for a standardized approach to deal with complex clinical problems requiring multiple decisions.

Material and methods

A group of 100 subjects with different health disorders (muscle-skeletal, allergic and irritant, infectious, chronic-degenerative diseases) was selected from a population of about 2,500 health care workers employed in a teaching hospital. Selection criteria included length of employment >5 years and the existence of an impaired health condition likely to be encountered in the working population and requiring multiple decisions by the OP. The 4 OPs, who were informed about the goal of the study and gave their consent to participate, separately evaluated the 100 cases. The physicians were graduates of the occupational medicine postgraduate school and experienced 5-8 years of OP work in the same setting.

Information about health condition, specific job and workplace-related risk factors was included in a standardized file for all the 100 cases selected. In particular, each case file included detailed information about the worker's specific disorder requiring OP evaluation (comprehensive history, results from medical exams, basic laboratory and other assessment carried out according to the standardized protocol). In addition, each file included information about the skill needed to perform the job and about the hazards linked to the work itself or to the environment. The procedure of case administration was described in detail elsewhere (9). All 100 files, properly blinded by a nurse, were separately submitted to each OP, who was marked by a blind code, during 20 sessions with a length ranging from 60 to 90 minutes. Each physician was invited at the same time to analyze the submitted file and to take a decision by filling a standardized evaluation form. The decisions to be taken included (i) assessment of fitness for the specific job (3 choices were possible: (a) fit for the job with no work restrictions; (b) physically or mentally unfit for the job; (c) fit for the job with one or more work restrictions or workplace changes), (ii) advice to the worker, (iii) request for further laboratory or physiological investigation, (iv) referral to clinical physician, (v) report of occupational disease, (vi) recommendation for the general practitioner. According to the national law requiring mandatory fitness assessment for jobs entailing exposure to ionizing radiations (IR), 2 separate medical evaluations were requested, one regarding fitness for exposure to IR, the other for exposure to all other hazards excluding IR. The decisions taken by the physicians on the case were analyzed in a way to ensure the confidentiality of the individual decisions.

The inter-individual variability among the decisions was analyzed by the percent of agreed decisions and by the strength of agreement (Cohen's kappa test or k) (17). The percent agreement was calculated as the difference between the sum of the decisions and the number (n) of disagreed decisions [% agreement = (100 – n of disagrees) x 100]. The percent agreement, in particular, was calculated for (i) the work fitness assessment for exposure to IR and (ii) the work fitness assessment for exposure to all other hazards excluding IR, for pairs (1–2, 1–3, 1–4, 2–3, 2–4, 3–4), triplets (1–2–3, 1–2–4, 1–3–4, 2–3–4) and the whole group of OP, respectively.

The strength of agreement provides evidence of the true agreement among decisions. On the basis that the estimated agreement expected by chance between 2 observers is 50% and that all agreement above 50% can be considered the agreement beyond the chance (true agreement), k is calculated according to the formula: (observed agreement expected by chance)/(100% agreement expected by chance) (17). k varies between 0 (agreement due to chance alone) and 1 (perfect agreement). According to literature (15, 17), the degree of agreement between the decisions was scored as follows: 0 to 0.2 slight, 0.21 to 0.40 fair, 0.41 to 0.60 moderate, 0.61 to 0.80 substantial, 0.81 to 1.00 almost perfect. Statistical analysis was carried out with the SPSS statistical software 10.0.6. Standard Version.

Results

The distribution of the frequency (%) of different decisions is shown in table 1. A decision of fitness for work (no restrictions) was taken in the range of 36% to 52% of 100 workers employed in jobs involving exposure to all risk factors (excluding IR), and in the range of 30% to 44% of 43 workers with IR exposure. No difference (mean±s.d) existed for the work restriction decision between the group of workers exposed to all risk factors (excluding IR) and the group of workers exposed to IR (56%±6 vs 59%±4). A decision involving multiple work restrictions (i.e., more than one restriction) was taken for percentages of workers ranging from 5 to 14. The decisions taken by OP about advice to workers, request for further investigation, referral to clinical specialists and report of occupational disease were more variable (table 1). The average time (±s.d.) spent to take the decisions for each case was different among the OPs (13±4 min for OP1, 8±3 min for OP2, 13±3 min for OP3, 5±2 min for OP4).

The individual OP's gap from the average decision depends on the type of decision. In the case of decisions on job fitness, a limited gap can be observed (figure 1, top), whereas a greater variability exists when decisions different from job fitness are taken (figure 1, bottom). The decisions of limited fitness for work were mostly related to biomechanical factors, ionizing radiations and exposure to sensitizers (figure 2). The inter-observer variation

Table 1 - *Frequency (%) distribution of 4 occupational physicians (OP1, OP2, OP3, OP4) decisional outputs*

Decisional output	OP1	OP2	OP3	OP4
Job fitness for workers exposed to all risks (excluding IR) (n=100)	44	36	38	52
Job fitness for workers exposed to IR (n=43)	44	37	30	30
Job restrictions for workers exposed to all risks (excluding IR) (n=100)	54	64	60	47
Job restrictions for workers exposed to IR (n=43)	53	58	65	60
Multiple work restrictions (n=100)	11	14	8	5
Advice to the worker (n=100)	43	41	56	17
Further investigations needed (n=100)	54	18	51	10
Clinical specialist referral (n=100)	50	16	30	19
Occupational disease reported (n=100)	10	8	8	1
Recommendations to the GP (n=100)	16	5	18	4

IR: ionizing radiations; GP: general practitioner

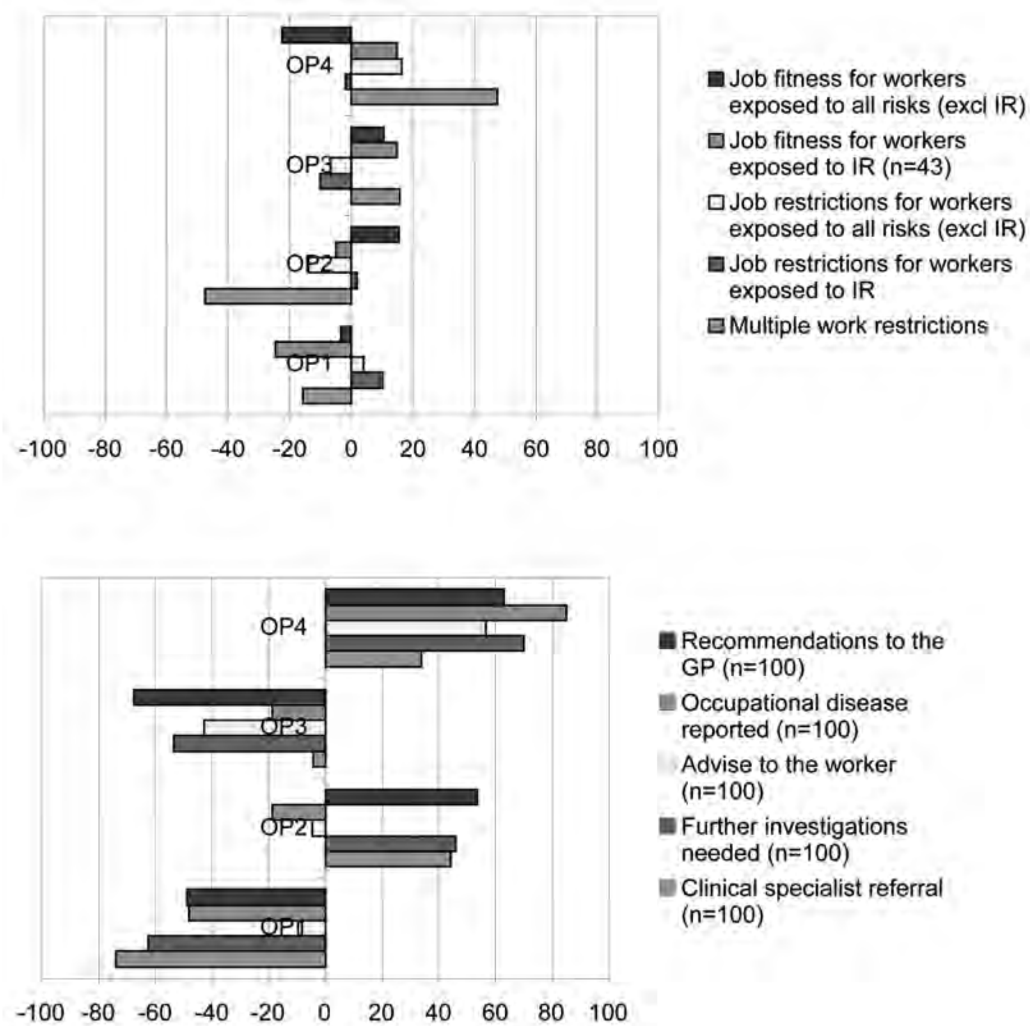

Figure 1 - Individual gap of decisions taken by 4 occupational physicians (OP) on job fitness (top) and of decisions other than job fitness (bottom) from the average decision (= 0)

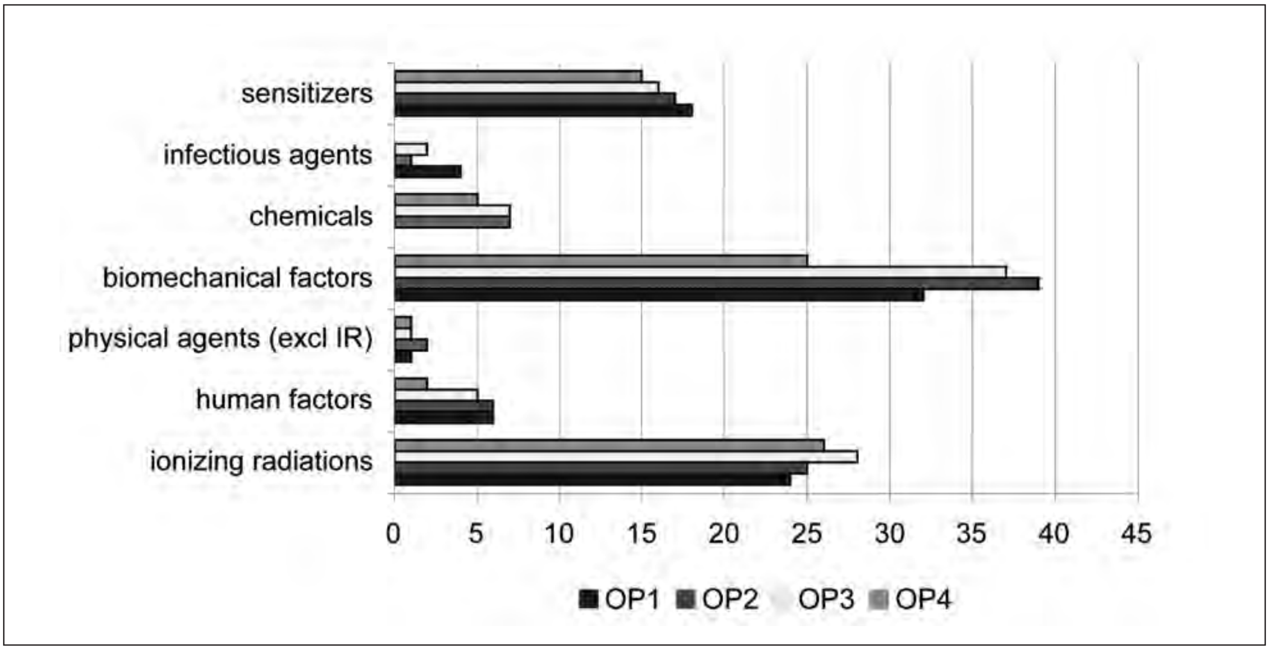

Figure 2 - Prevalence of job prescriptions given by 4 occupational physicians (OP) according to risk categories

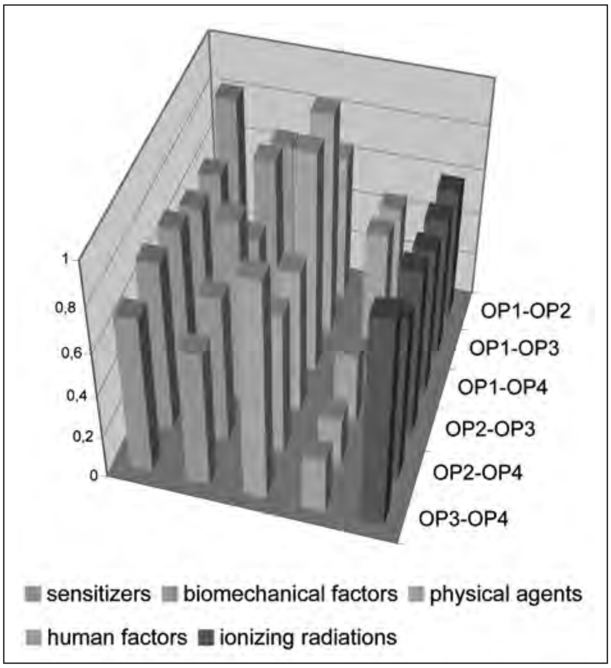

Figure 3 - Strength of agreement (k) for decision on job restrictions between pairs of occupational physicians (OP) according to the risk category According to literature (11, 12), the degree of agreement between the decisions is scored as follows: 0 to 0.2 slight, 0.21 to 0.40 fair, 0.41 to 0.60 moderate, 0.61 to 0.80 substantial, 0.81 to 1.00 almost perfect

is partial for decisions involving exposure to ionizing radiation and sensitizers, whereas the decisions involving exposure to biomechanical factors were more variable. The strength of agreement among the risk-related work restriction decisions is shown in figure 3. Higher values of k (mean±s.d) are related to the decision taken in the case of workers exposed to physical agents (0.83±0.2), followed by workers exposed to sensitizing agents and to ionizing radiations (0.73±0.1). A higher strength of agreement among the pairs of OPs was observed for job restriction decisions taken for work with sensitizing agents (from 0.65 to 0.83) and for exposure to IR (from 0.60 to 0.95), compared to a low strength of agreement for work restriction related to human factors (from 0.03 to 0.52).

Discussion

Medical decision making is becoming increasingly complex. The way in which clinical data are used affects the accuracy of the diagnosis and therefore the choice of the intervention and, ultimately, the outcome of the subject. Incorrect or inappropriate use of information will result in imprecise diagnosis and intervention, which could end in an ineffective and inefficient health outcome. Like the current clinical practice of many specialists (1, 2, 11, 13, 20), occupational health decisions are challenging since decisions taken by different OPs on the same problem are scarcely reproducible. In fact, the same inter-observer variability already observed in the past (4, 5) is partly confirmed in this study. Several causes can explain the variability of the decision of OP: (i) the complexity of the problem, where different factors including several involved stakeholders may influence the decision, (ii) the uncertainty of the outcome of the decision, due to the observation of different outcomes in different studies, (iii) the need to act according to regulations or legal obligation, (iv) the expectation of the subject or expectation by the different stakeholders about the cost and the effectiveness of the decision, (v) peer pressure compelling professionals to act in a way similar to that of their colleagues, (vi) the evolving technology, whose existence may constitute by itself an imperative to its use. This situation requires that medical decisions be based on standardized behaviors to approach clinical problems. Therefore, in addition to clinical guidelines, the development of more specific tools (the clinical prediction guide or rule) was proposed to assist in the decision-making process (16). Whereas the guidelines provide a general way to deal with the clinical problem, the clinical prediction rules are a specific decision making tool for helping to take intervention decisions. The incorporation into the rules of a number of variables would allow precise and appropriate decision, taking into account the need to consider the validity of the rules according to the different setting and clinical context. The rules could therefore represent a conscientious application of the best available evidence to each problem and assist professionals in the practice. On the other hand, it is expected that OPs' decisions be based on their ability to identify valid evidence which can be delivered when needed and would make easier to change the decision-making-process according to the evidence based occupational health paradigm (7). Given that a gold standard seldom exists and the validity of the experts' opinion in providing satisfactory answer to problems is questionable (21), valid sources of evidence should be available and the development of a base of evidence in occupational health should be built in order to provide appropriate answers (22, 25). If the existence of reliable sources of information represents a requisite for a correct decision-making process, the OP should be able to effectively access the information to find appropriate solutions. Therefore, the lifelong learning process of OP should be continuously updated and restructured by introducing specific training objectives aiming at developing appropriate skills to deal with a problem: how the problem is transformed into an answerable question, how the information is searched and appraised and how the decision is taken (6, 8, 10, 19).

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Med Lav 2006; *97*, 2: 233-239

The new structure and contents of employers' juridical responsibility for workers' health and safety in the post-industrial system

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Key words

Labour law; employers' responsibility; post industrial system; depression in the work-place

Summary

1. The enlargement of the labour law application area in the post-industrial system. 2. The enormous growth of differences in productivity between workers and its consequences on the employer's safety obligation. – 3. Depressive disorders as a typical professional risk in the post-industrial system and the employer's prevention responsibility. – 4. Harassment in the work-place as a typical pathologic consequence of the de-standardization of jobs. The specific employer's prevention responsibility in this field. – 5. A conclusive remark.

Riassunto

«Nuova struttura e nuovi contenuti della responsabilità dell'imprenditore per la sicurezza e la salute dei lavoratori nel sistema post-industriale». *Nel sistema post-industriale la responsabilità dell'imprenditore in materia di sicurezza e salute vede non soltanto il proprio ambito di applicazione ampliato rispetto all'area tradizionale del lavoro subordinato, ma anche il proprio contenuto maggiormente articolato e diversificato rispetto al passato. Il passaggio dal lavoro tradizionale al lavoro prevalentemente applicato ai flussi di informazione produce anche un enorme aumento delle differenze di produttività tra i singoli lavoratori, cui consegue un aumento del ruolo affidato ai sistemi gestionali di motivazione e incentivazione della produttività, ma anche un aumento della pressione che tali sistemi possono esercitare sul lavoratore: donde anche un aumento del rischio di disturbi depressivi causati da eccesso di stress e un ampliamento del contenuto specifico della responsabilità contrattuale gravante sull'imprenditore in riferimento a questo rischio. Causa di danno grave per il benessere psichico del lavoratore è anche un altro fenomeno che può probabilmente considerarsi in qualche misura correlato con il passaggio dal sistema industriale a quello post-industriale: il c.d. mobbing, per la prevenzione del quale pure assumono rilievo nuovi profili di responsabilità specifica dell'imprenditore, che vengono esaminati nell'ultima parte della relazione.*

First of all I would like to thank the International Commission for Occupational Health for inviting me to this Congress and entrusting me with the task of this report. Although aware of its difficulty, I have very gladly accepted this task, because I am deeply convinced of the necessity of new synergies between labour law and other disciplines. And not only between labour law and other traditional social sciences. Labour law scholars are today fully conscious of the necessity of reinforcing the communication between their discipline and labour sociology, industrial relations, labour economics and games

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theories; but not so many perceive the necessity of a more intense communication with other less contiguous disciplines, such as labour medicine and psychology, as well as with biology and neurosciences, inasmuch as they can offer important means of explanation and interpretation of human and social behaviours; this also makes possible a more precise definition of the content of juridical rules that apply to those behaviours.

This interdisciplinary communication is one of the main commitments of the Department of Labour and Welfare Studies of the University of Milan, to which I belong together with economists, sociologists, psychologists, human resources management experts (the same commitment, of course, that can be seen in many other Departments of Labour Studies which in the last two decades have sprung up in many European Universities). Here is the frontier of the development not only of labour economics and sociology, but also of labour law: the future of labour studies will be more and more entrusted to this kind of capacity for building bridges between different approaches, for creating, at every step, new cerebral synapses in the great collective brain of social sciences.

This encounter and confrontation with you is a precious occasion for taking a further step forward in this direction: the subject of this report can be an interesting test bench of the feasibility and fecundity of this multidisciplinary approach. I obviously am not able to fulfil this task all alone, but only try to propose some hypotheses of joint work between you and us.

The structure of employers' juridical responsibility for workers' health and safety has undergone several transformations in the passage from industrial to post-industrial system, *i.e.* from a system essentially focused on the production of material goods to a system essentially focused on the production of immaterial goods: information, new ideas, projects, services, design, and so on. I'll try to outline the main changes in the structure of this responsibility, without claiming to be able to single out all the links and connections between them.

1. – One of the most important changes must be indicated in the enlargement of the labour law application area.

The fact is that subordination – *i.e.* the worker's subjection to the employer's directive power – is no more the element that defines and identifies the worker's position of dependence on the employer.

On one hand, in the post-industrial economic fabric subordination is no longer indispensable for the organic integration of a worker into the firm's organization, for the activation of synergies between his/her role and that of all the other organization's members. In the traditional model the integration needed the coordination of the worker's activity with that of others in a given space and time; it needed the employer's directives and control; now the integration is made possible, even at a great distance and without rigid temporal constraints, by means of information technology and on-line coordination.

On the other hand, worker's position of weakness towards the employer not necessarily coincides with the position of juridical subordination: modern labour economics identifies several possible causes of contractual weakness, which produce the same effect not only within the traditional employer/employee relationship, but also in the relationship that exists between a firm and a self-employed worker: this too can suffer

- from the monopsonistic distortion of the local labour market (monopoly of demand for work *vs.* plurality and abundance of supply of work),
- from information asymmetries that typically characterize labour markets,
- from the "lock-in effect" of an idiosyncratic investment in human capital (*i.e.* the investment that can be fruitful in one firm only, not in others).

This is why the European Communitarian and national laws in the last two decades have progressively enlarged the area of application of protective disciplines beyond the boundaries of the subordinated work area, making reference more and more widely to the new notion of workers in a position of economic dependence: *parasubordinati* in Italy, *arbeitnehmeränliche Personen* in Germany, *travailleurs dépendants non salariés* in France, atypical workers in the United Kingdom or in the US, and so on.

This change in the basic figure to whom labour law refers has showed up in the field of health and safety protection before it has in other fields. The European Union's directive n. 1989/391/CE –

without referring to subordination defines the beneficiary of the protection granted by health and safety Communitarian rules as any person working in a continuative way for an employer, including trainees and apprentices, with the sole exclusion of domestic workers (sect. 3.*a*).

In fact, a more precise and articulated definition is needed, in order to reasonably delimit the employer's responsibility. His/her duty to guarantee health and safety obviously cannot be extended to the worker who is only occasionally hired, except regarding the safety of the machinery and of the firm premises where the occasional service has to be performed. And the need for health protection is not the same in the case of the self-employed working in a continuative and exclusive way for a single company and in the case of the self-employed who have a plurality of clients: to the latter the possibility of choice typically guarantees an effective contractual power and thus an effective control over the quantity, quality, effort and operational modes of their work.

Moreover, the employer's responsibility cannot have the same content with regard to the position of a person who works in a continuative way inside the employer's premises and with regard to the position of a person working in the same continuative way but anywhere else, at home or in other places where he/she decides to work. If the employer's responsibility towards the traditional manufacturing homeworker is essentially focused on the safety of the work instruments that are provided by the employer, *i.e.* on the risk of physical injuries, the responsibility towards the modern tele-commuter, who works on ideas and information creation and flows, is essentially focused on the risk of an excess of working stress for his/her mental well-being.

2. – The last observation introduces us to another very important consequence of the shift from the industrial to the post-industrial system on the content of the employer's responsibility for workers' health and safety: the enormous growth of differences in productivity between workers who operate in the production of immaterial goods, even when they belong to the same professional category.

When I began to deal with work problems, as a trade union organizer, almost forty years ago, one of my tasks was to negotiate piecework tariffs. At that time two thirds of European workers were blue-collar; and I could observe that, if in a plant the mean performance was 100, the weakest worker could do 80, while the brightest one could rarely do more than 135 or 140. The productivity gap between the brightest one and the weakest one could thus go from 80 to 140. Today two thirds of European and three fourths of North American workers no longer operate on raw material, but mainly on immaterial production: data acquisition, memorization, elaboration, combination, transmission, and particularly creation and communication of new ideas (in the United States 36% of the work force is employed in *creative* jobs). Well, if we consider two junior clerks and put them through a very simple test concerning data acquisition and/or elaboration, it may happen that the time spent by one of them in fulfilling the task is half the time spent by the other; but it may also happen that it is one tenth, or one hundredth. For example, if you ask two junior clerks to find all the addresses of people with a driving licence living in a certain zone, it may happen that one of them, particularly clever in utilizing Internet opportunities, is able to complete the list in half an hour and that the same task takes a week or even more for the other. And when it comes to creative jobs, the difference of productivity can be indefinitely larger.

The great difference in productivity between two workers belonging to the same professional category can be observable before the beginning of the work relationship; and in this case the weaker worker will not be hired, or will be only offered a precarious and poorly paid employment. But it can also happen that the difference in productivity is not observable in a first phase and shows later, when the stable work relationship is already underway. In this case the problem arises of the gap between the very low minimum productivity level that the law system can assure to the employer as the minimum due level of performance, and the much higher productivity level that the employer can obtain in two alternative ways:

- by firing the inefficient worker and replacing him/her with a more efficient one; or (if the substitution is made impossible by the institutional context)

- by putting the worker under stress in order to obtain a greater effort by him/her. And here some very difficult juridical questions arise.

While today it is beyond question that there is a difference between the minimum level of performance efficiency that the law is able to guarantee to the employer and the level that the employer can lawfully try to obtain, by means of communication, motivation and incentive strategies towards the employees, it is not as clear how far the performance efficiency can be lawfully pursued by means of such strategies and how much pressure can be lawfully exerted on the worker.

In the era in which work mostly consisted in operating on raw materials, the incentive could be constituted by piece-work payments; and unions were committed to negotiating the maximum level of physical activity that could be rewarded in that way. But piece-work payments are not easily applicable when the worker operates on information flows. And the more different each personal position is from the others – as happens in the post-industrial system – the more difficult it is for unions to exert a control on the pressure to which workers are exposed.

In this context, the sole effective limit to that pressure consists in the protection of the worker's health. The problem is that when the work is of an intellectual nature, the health at stake is mental health; and the working stress with which the mental equilibrium is compatible varies greatly from one person to another. It is often very difficult to identify this personal equilibrium in advance.

In post-industrial firms one of the most widespread incentive systems is the s.c. *management by objectives* (MBO), which foresees

- the codetermination of the expected performance between the worker and the head of the office or of the branch, followed by a bilateral performance review between them;

- the awarding of the bonus correlated to the degree of verified fulfilment of agreed objectives.

This incentive system is, *per se*, perfectly lawful; but if it is utilized in a way that ends up by putting the worker under an excessive pressure, it can have effects that are in fact incompatible with the employer's duty of protection of workers' health, depending on the general values and parameters of the system or on the way the scheme is implemented by the head of the office or of the branch. It has recently happened that even the top managers of a large retailing chain with many thousands of employees – who were responsible for an MBO scheme in force in the firm – were charged with mistreatment and mental damage suffered by a few individual employees.

3. In fact, the typical damage denounced by post-industrial workers as a consequence of an excess of working stress consists in mental depressiveon diseasesorders. One of the juridical questions that arise at this point, and that it is more difficult to cope with, is the question relating to the causal link between the employer's behaviour and the onset of the disease. In a person prone to mental depression the crisis can be caused by a working stress as well as by another stressor, *i.e.* source of stress or of difficulty or of pain, encountered in any other area of his/her life.

It is difficult to say uUp to what point it is ist the duty of the employer to foresee the possible onset of the depressive crisis in each employee and to adjust the incentive and motivation schemes in relation to the particular conditions of each, regarding this specific risk.? But what is certain is that the manager of the future will have to be selected on the basis of his/her ability to avoide conflicts inside the firm and to reduce, as far as possible, any other factor of emotional harm, in relation with the different types of possible stressors, without harming the company's capacity of stimulating its employees' effort; and that the employer will bear a responsibility for specific management training in this field.

Psychiatric epidemiology tells us that in western societies about 48 per cent of people suffer from a mental disorder once in their lifetime; and that most of them would have avoided the pathologic episode if they hadn't met an acute, high intensity stressor, or a durable, low intensity one. Moreover, we know that a stressor of the first or of the second type, which can trigger the depression crisis, can strike everybody almost once in a lifetime. If only half of those who come up against such a shock fall into a depression, this is due to the fact that this half is constituted by subjects with particular psychopathologic sets of genetic characters (endophenotypes). This vulnerability to the working stress, the predisposition to suddenly go through the working life as an unbearable burden, is traceable at every professional level, from the highest to the lowest. The super-efficient chief executive, as well as the most humble office clerk, after a phase of high performances and brilliant achievements, sometimes facing some minor difficulties, can undergo a mental breakdown that totally or partially impairs his/her productive capacity. And it is not always easy to identify the last straw.

Today the sub-threshold psycho-pathology complements the syndromic, episodic or chronic psychopathology by defining, in a lifetime perspective, the pre-existent context in which acute or durable stressors can have a pathologic impact, causing mental disorders. It is evident how the sub-threshold approach can provide employers with new tools for the prevention of work-related depression disorders; and how an enrichment of the content of employers' responsibility can ensue from the progress of medical science in this field.

Here a singular contradiction arises between different juridical principles applying to the same work relationship. On one hand, in order to protect the worker's right to privacy, the law forbids the employer to make any inquiry about his/her personal medical history (except for diseases which can affect the technical performance of the contractual worker's duties). On the other hand, in order to prevent the risk of depression arising from working stress, we could deduce from the sub-threshold psycho-pathology approach, in the light of we could deduce from the general protective rule, the duty for the employer to ask the worker about elements of his/her personal mental health history that can be relevant for the implementation of safety obligations. The contradiction can perhaps be resolved by combining the right for the worker not to disclose the anamnestic information and the opportunity for him/her to communicate it to the employer atd any moment during the work relationship, so signalling a specific personal risk; in the first case the employer will not be held responsible for the consequences of lack of awareness of the worker's peculiar problem.

But the communication between the employee and the management on this delicate matter must not only be made possible: it must also be made easier and in some way also solicited. In the US since the end of the eighties some large companies such as Ford, General Motors, Westinghouse, Wells Fargo Bank, McDonnell Douglas, Hewlett Packard, IBM, Rank Xerox – have stricken struck a partnership with the National Institute for Mental Health in order to launch a new scheme, named *Managing Depression in the Work-place*, which foresaw has foreseen many initiatives: courses for managers and heads aimed at providing them with the capacity (certainly not of making diagnoses, but at least) of realizing at the very first step that an employee is beginning to suffer from depression and correctly cope with the problem; updating of medical centres' competences inside each corporation; design of flexible forms of working forms susceptible suitable to be proposed to depressed workers, in order to facilitate their medical treatment and, at the same time, avoid the trauma of being excluded from the work-place for many weeks or months. A scheme of the same kind was has been promoted in the UK since the first early nineties.

Here again a juridical problem arises: to what extent, in a company of large dimensions, must the activation of such specific schemes today be considered as corresponding to the standard, so falling forming part ofinto the employer's brief? And what is the company dimension limit over which this specific duty begins to apply?

A task that the labour law scholars and courts will have to fulfil, with the help of medical science, will be to identify a continuous dimension of preventive activities and behaviours, on which an indicator of juridical responsibility should shift, in relation to the company dimensions and to the structure of work relationships. On this line we should be able to fix a limit at the left of below which there certainly isn't any employer's juridical responsibility, and a limit beyond at the right of which the preventive activity is certainly part of the employer's contractual duty. But we must recognize that between the two limits a large segment is included, representing a series of preventive activities that cannot be considered as object of a contractual obligation for all the companies: the content of the obligation increases in correlation with the company's dimension and with the degree of integration of the individual work into the firm's organization.

4 Depressive diseases/disorders can be triggered not only by an excess of pressure exerted on the worker in order to enhance his/her productivity, but also by a worker's harassment activated by the employer, by the branch or office head, or even by the worker's peers, his/her colleagues, with the view of inducing him/her to resign. In Italy this phenomenon is today commonly termed "mobbing": in the last few years we have been witnessing a new upsurge in complaints about mental diseases caused by s.c. "mobbing", *i.e.* systematic harassment in the work place.

This too is a phenomenon whose remarkable diffusion is presumably linked to the shift from industrial to post-industrial productive system and from material to immaterial production: in the new context coordination and integration between the workers of an office or of a company branch require a degree of psychological harmony among them that wasn't indispensable between blue collars inside the traditional industrial factory; and in the new context – as we have already said – between two workers belonging to the same professional category a much greater difference in productivity can be observed than can be observed between two manual workers in the industrial factory. Harassment is often the bad reaction of the employer or of the head of the office, or even of the office staff, to the poor level of worker's performance efficiency, be it caused by a voluntary lack of effort, or by an objective lack of capacity, in a juridical context in which the law is able (or decides) to guarantee only a low efficiency level and pursues the equality among workers and the containment of working stress by means of the traditional prohibition of the dismissal of the inefficient ones.

What makes the problem go beyond the field of employers' misconduct against his/her employees, and become a problem of typical *professional risk* in the post-industrial productive fabric, is that in the (wider and wider) area of possible non -juridically sanctioned lack of efficiency – it is often impossible to establish whether the conflict between the worker and his/her superiors or colleagues has been triggered by the worker's behaviour or by the superiors' or colleagues' behaviour: the phenomenon is often understandable and explainable only as a *systemic* phenomenon, arising from a causal circle in which it is incorrect to attribute the first fault, or the "objective" responsibility, to one or to the other. The systemic psychology school teaches us that in reference to phenomena of this kind one must abstain from "arbitrary punctuations": in many cases the problem can't be considered and tackled as caused by an individual behaviour, by the defect of one side of the system, but must be considered and tackled as caused by a defect of the system itself as a whole.

For example, it can happen that the slightly inefficient worker begins to perceive that the most important part of the work to be done is entrusted to the more efficient ones, so that his/her position in the flow of everyday activity is more and more marginal. This perception causes the worker to feel that his/her presence in the work-place is less important, less expected every day by the workmates; so he/she becomes more inclined than others to stay home for a mild indisposition; his/her higher level of absenteeism increases his/her unreliability and consequently his/her marginalization in the organization of work; he/she begins to protest; colleagues perceive him/her as a liability and unwelcome presence; they begin to argue with him/her about trivial matters; the inefficient worker is penalized in the distribution of work instruments and space inside the firm premises; the worker reacts by a reduction of application; this increases the efficiency gap between him/her and the others, inducing the office head to a further reduction of reliance and of the content of tasks that are assigned to him/her; if the worker doesn't resign, the vicious circle can end up with the worker's fall into a depressive crisis.

It happens quite often that the specialist in occupational psychology handles a case of incipient disfunction assuming the role of worker's therapist, when the most effective therapy could be a systemic one: because the at this point the sick organism must be identified in the work-place organization, rather than in the individual worker.

The main juridical problem, in this field, arises from the fact that civil employer's responsibility doesn't require the criminal or even malicious intent of harming the worker: the employer's responsibility be it considered as a contractual or as a tort responsibility – arises from the objective event of the worker's harm, when it is possible to affirm that it could have been avoided by the employer applying the professional diligence that can be reasonably required in a case of the same kind.

Most recent juridical and sociological studies about this phenomenon, followed by a few early judicial decisions, distinguish the case of the voluntary harassment exerted by the employer, the head of the office or the colleagues ("bossing": according to the Hege definition, at least three or four aggressive actions within a month, for a spell of at least six months, are required in order to make it possible to speak of "mobbing" in the strict sense of the word), and the merely culpable failure to adopt the appropriate measures that are necessary for avoiding the impoverishment of professional content of the working position, the deterioration of personal and professional relationships between the weak worker and his/her colleagues, or culpable excess of pressure on him/her ("straining"). But in this second case too the employer is responsible for the psychic harm caused to the worker, if it could be avoided with the diligence reasonably required, according to the best standard of human resources management. And where the boundary line is of the required diligence, it is really difficult to establish at the theoretical level.

The studies in the last decade about this phenomenon single out three possible factors that create a fertile terrain where the vicious circle can be installed:

- an organizational culture highly characterized by a drive to conformism, where diversity is perceived as a danger for mutual cooperation;
- a work organization characterized by a poor job design, which causes role ambiguities, role conflicts, low workers' control over their job in terms of autonomy and participation in the determination of their objectives;
- leadership styles characterized by an excess of authoritarianism or of laissez-faire.

It is probably impossible to identify a specific employer's juridical obligation of correcting *in limine* such characteristics of the organizational context, right from the start: the principle of exemption from judicial control of management's choices prevents the courts censuring the omission of this or that initiative focused on the company climate. But when the vicious circle has been installed and an employee has been harmed, the fact of having taken appropriate initiatives aimed at improving the work-place climate – even if they have not been fully effective can be of substantial help for the employer to avoid the responsibility for that damage, which will be ascribed only to the single person who has misbehaved against the victim.

What may be needed, in particular, is the activation inside the companies – also by means of collective agreements of awareness campaigns, climate improvement and bridge-building measures, instruments of *intra moenia* mediation, specific figures of managers and advisors in charge of the prevention of undue tensions, permanently at the disposal of workers who can need help, advice or protection. A new chapter, which will presumably become more and more important in the matter of health and safety in the work-places. And perhaps also a new chapter of the future labour legislation, at the national and perhaps also transnational level.

5. The great value of labour law lies in this: it ensures that the work contract *i.e.* the juridical relationship which allows the labour market to function and thus allows, so to speak, human work to be made a tradeable good becomes the instrument capable of guaranteeing that work itself is never treated *only* as a tradeeable good. In other words, its commitment is to guarantee that work is (and where it is not it becomes) the main means of expression, development, emancipation and security of the human person: security against need, certainly, but also against any harm to the human person's psychophysical integrity and well-being.

ACKNOWLEDGEMENT: *I am particularly indebted for the indispensable and precious help that I have been given in the psychiatric field by Giovanni Cassano (University of Pisa) and on that of organizational and labour psychology by Gabriella Pravettoni and Silvia Gilardi (University of Milan)*

La Medicina del Lavoro Med Lav 2006; *97*, 2: 240-257

Integrating Occupational Health, safety and worksite health promotion: opportunities for research and practice[1]

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Key words

Occupational health; health promotion; occupational hazards

Summary

Background: *There is emerging evidence that coordinating and integrating worksite health promotion and occupational health and safety enhances the effectiveness of efforts to promote and protect worker health, and growing attention internationally to the importance of integrating worksite health promotion and occupational health and safety.* **Objectives:** *(1) To present the rationale and scientific evidence for coordinating and integrating worksite health promotion and occupational health and safety as a means of enhancing the effectiveness of efforts to promote and protect worker health; and (2) to discuss recommendations for research priorities and future directions.* **Methods:** *Review of the literature, drawing mainly on studies from the United States and Europe.* **Results:** *The strongest evidence available supports the efficacy of this intervention model in promoting smoking cessation, particularly among blue-collar workers; some evidence additionally indicates significant effects for other health behaviors. Little evidence is available to date documenting the impact of these programs on occupational health and safety outcomes.* **Conclusions:** *Priority research directions include: social epidemiological research to identify key work-related factors associated with hazardous occupational exposures and risk-related behaviors, and to identify the underlying causes of social disparities in worker health; methods development research aimed at developing both appropriate measurement tools and new intervention approaches; efficacy and effectiveness studies to examine the effects of integrated interventions on both occupational health and safety outcomes as well as health behavior changes; assessments of the process of intervention implementation, including intervention implementation evaluation, cost assessments, and process-to-outcome assessments; and dissemination and durability studies, to identify strategies to promote the sustainability and dissemination of evidence-based programs.*

Riassunto

«Integrare la salute, la sicurezza e la promozione della salute sul posto di lavoro: opportunità per la ricerca e la pratica». *Vi sono prove sempre più convincenti e un'attenzione crescente a livello internazionale sul fatto che la coordinazione e l'integrazione dei programmi di promozione della salute sul luogo di lavoro e delle pratiche di salute*

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[1] This paper is extracted in part from a commissioned paper, prepared for The National Institute of Occupational Safety and Health, *Steps to a Healthier US Workforc*e Symposium October 26-28, 2004, Washington, D.C. Adapted with permission. See http://www.cdc.gov/niosh/steps/2004/symposium.html

e sicurezza occupazionali incrementino l'efficacia degli sforzi attuati per promuovere e proteggere la salute dei lavoratori. Gli obiettivi di questo contributo sono: (1) presentare la base razionale e l'evidenza scientifica che giustificano l'impiego della coordinazione e dell'integrazione dei programmi di promozione della salute sul luogo di lavoro e delle pratiche di salute e sicurezza occupazionali come uno strumento efficace per migliorare la promozione e la protezione della salute dei lavoratori; (2) delineare raccomandazioni relative a priorità e future direzioni della ricerca nel campo. Il metodo utilizzato è la revisione della letteratura, soprattutto nell'area statunitense ed europea. Le prove disponibili più convincenti sono relative all'efficacia di questo tipo di interventi nella promozione dell'abbandono del fumo, in particolare tra i colletti blu. Vi sono prove di efficacia anche per quanto concerne altre abitudini di salute, mentre è a tutt'oggi scarsa l'evidenza relativa all'impatto di questi programmi sugli esiti di salute e sicurezza occupazionali. Le direzioni prioritarie di ricerca sono: l'indagine socio-epidemiologica finalizzata a identificare i fattori lavorativi associati all'esposizione occupazionale e ai comportamenti a rischio e a individuarne le cause in relazione alle disuguaglianze sociali nella salute dei lavoratori; ricerche in ambito metodologico finalizzate allo sviluppo di adeguati strumenti di misura e di nuovi approcci di intervento; studi di efficacia ed efficienza per esaminare gli effetti degli interventi integrati sugli esiti di salute e sicurezza occupazionali e sui cambiamenti dei comportamenti di salute; valutazione dei processi di implementazione degli interventi, inclusi i giudizi sull'implementazione stessa, la valutazione dei costi e delle modalità di raggiungimento dell'esito; studi divulgativi e di durata degli effetti, al fine di identificare strategie per promuovere la sostenibilità e la divulgazione di programmi basati sull'evidenza.

Introduction

There is emerging evidence that coordinating and integrating worksite health promotion and occupational health and safety enhances the effectiveness of efforts to promote and protect worker health. Integrating worksite health promotion and occupational health and safety is a core principle of numerous international efforts and declarations in support of worker health (31, 122-125), and has been the subject of growing interest internationally (5, 17, 11, 21, 104, 110, 119). In this paper, we summarize the rationale and empirical evidence for integrating occupational safety and health (OSH) and worksite health promotion (WHP), as the foundation for a discussion of recommended research priorities and future directions.

Our lens for this review focuses more attention on the US than elsewhere. Following US practice, WHP typically focuses on individual health-related behaviors such as not using tobacco, weight control, a healthy diet, physical activity, seat belt use, influenza vaccinations, adherence to screening guidelines (e.g., mammography screening, blood pressure, cholesterol), substance abuse prevention, case management (e.g., diabetes), and sun exposure prevention, as key examples (54, 86, 117, 118). Worksites provide an important setting for influencing health behaviors through educational efforts designed to reach large numbers of workers not accessible through other channels, and offer the potential for support of long-term behavior changes, mobilization of peer support, use of environmental supports, and the possibility of offering comprehensive multi-level interventions repeatedly over time as a means of building and sustaining interest in behavior changes (5, 11, 17, 21). In comparison, OSH interventions are designed to minimize workers' exposures to job-related risks, including exposures to physical, biological, chemical, ergonomic and psychosocial hazards (70). Supported by international standards (13, 50, 51), these interventions may include changes in the organization and environment, such as the use of product substitution, engineering controls, and job re-design, as well as through individual efforts, including use of personal protective equipment, generally seen as a supplemental measure. These interventions are predominantly within the domain of management decisions, rather than of individual worker actions (21), and may also be the subject of joint decision-making by labor and management through collective bargaining or less formal means.

Content	Level of Influence		
	Individual/Interpersonal	Organization/Environment	Multi-Level
Occupational health and safety (OSH)			
Health promotion (WHP)			
Integrated OSH/WHP			

Figure 1 - Matrix of interventions supporting worker health

Figure 1 illustrates the ways in which OSH and WHP may be aimed across multiple levels of influence (78, 114). At the individual/interpersonal level, interventions aim to educate individual workers and build social norms supportive of worker health, for example through educational classes or one-on-one training programs. Interventions at the environmental/organizational level of influence aim to modify the work environment or organization in support of worker health outcome. By the term "environmental/organizational," we mean to encompass both the work environment or organization, including for example work climate and organizational policies, and the physical environment, including for example the potential for exposures to dusts, fumes, vapors, noise, ambient temperature, and other potential hazards. Increasingly, interventions are coordinating efforts across the individual/interpersonal and environmental/organizational levels in recognition of the mutually reinforcing capabilities of comprehensive approaches to worker health, which we term here multilevel interventions (110).

Within the US, the National Institute for Occupational Safety and Health (NIOSH) concluded in 1984 that simultaneously addressing worksite occupational safety and health and worksite health promotion would "make possible a 'synergism of prevention' to improve the health of workers through comprehensive risk reduction" (83). More than 20 years later, this is not yet the norm in the US, although there have been a handful of studies that have examined interventions that integrate OSH and WHP, for example, addressing smoking cessation and reduction of hazardous occupational exposures. In Europe, by contrast, the European Network for Workplace Health Promotion defines worksite health promotion to include occupational health and safety (59). This approach follows the Luxemborg Declaration on Workplace Health Promotion in the European Union, adopted in 1997, which included as part of WHP "improvement in the work organization and working conditions; promotion of active employee participation; and strengthening of personal skills" (31, 59). In light of the different approaches and contributions that US and European studies have made, we focus this paper on reviewing US studies that provide emerging empirical evidence in support of integrated vs. stand-alone approaches, and draw upon selected European examples to illustrate the effectiveness of integrated interventions.

Rationale for integrating occupational health and safety and worksite health promotion

We outline here four overarching reasons for integrating these two parallel approaches. These reasons provide a balance between the "business case" for integrated programs – focusing on potential cost savings and productivity gains for employers – with the "worker case" for integrated programs – focusing on clear benefits for workers as a result of a holistic approach to worker health. As we recognize the potential benefits, we are cognizant, too, that there are potential risks associated with integrated approaches. For example, for workers, creating opportunities for management to have access to personal information about health behaviors may present concerns that managers could misuse this information.

1. Workers' risk of disease is increased by exposures to both occupational hazards and risk-related behaviors. Occupational disease and injury continue to account for a considerable proportion of the burden of disease. In the US, for example, occupational health and safety surveillance data indicate that 6.1 million illnesses and injuries occurred in 1997 in private-sector employment settings; 6,238 workers died of occupational diseases in that same year. Between 1973 and 1997, the number of lost workdays attributable to occupational illnesses and injuries rose from 1.9 million to 2.9 million per year (84). In the European Union, an estimated 500 million work days are lost per year due to poor working conditions (62). Health behaviors also play a significant role in a range of health outcomes; for example, tobacco use accounted for more than a half a million deaths per year across the 15 member states of the European Union before its enlargement (97) and about 440,000 deaths per year in the US (14, 15).

The effects of these risk-related behaviors and job risks are not independent of one another. Take, as an example, exposure to tobacco (110). Some of the same toxic agents present in tobacco smoke are also hazards in the worksite (e.g., benzene), and thus, workers who smoke may be doubly exposed through their exposures on the job. In addition, tobacco smoke and toxic agents found in the worksite may interact synergistically, increasing the profound effect beyond the simple addition of the two exposures alone (e.g., asbestos). Workplace chemicals may also be transformed into more harmful agents by smoking. For example, the heat generated by burning tobacco may increase the toxicity of other chemicals inhaled as smoker inhales a cigarette. Similarly, tobacco use has been associated with another type of occupational risk, stressful work organization, such as low job control (76).

2. The workers at highest risk for exposure to hazardous working conditions are also those most likely to engage in risk-related behaviors. Exposure to both occupational hazards and risk-related behaviors are concentrated among those employed in working class occupations, meaning those employed in blue-collar or service occupations as typically defined in US studies (36, 81) or in lower supervisory, technical, semi-routine or routine occupations, as defined by the United Kingdom's new National Statistics Socio-Economic Classification System (85). Workers in these occupations are more likely to be injured or become ill due to workplace hazards than are professional employees. For example, 1997 data indicate that truck drivers and laborers were the occupations with the most injuries and illnesses involving days away from work, followed by nursing aides and orderlies (84). Risk-related behaviors also are concentrated in working class occupations and workers with lower levels of education. In the U.S., the smoking prevalence among blue-collar workers (including craftspersons and kindred workers, operatives, transportation operatives, and laborers) is 37% for men and 33% for women (36), compared to 23% for the population overall (77). Barbeau and Krieger additionally reported while there is no socioeconomic gradient in quit attempts, those with the most socioeconomic resources are most successful with quitting (7). Similar socio-economic gradients have been reported in the UK for tobacco, as well as other health behaviors such as diet, physical activity, and patterns of alcohol use (55) although exceptions also have been noted. For example, one cross-national study of risk factors for poor health found that the social gradient in fruit and vegetable consumption was present in the United Kingdom but not in France, illustrating the potentially important role of culture in disparities in dietary patterns (35).

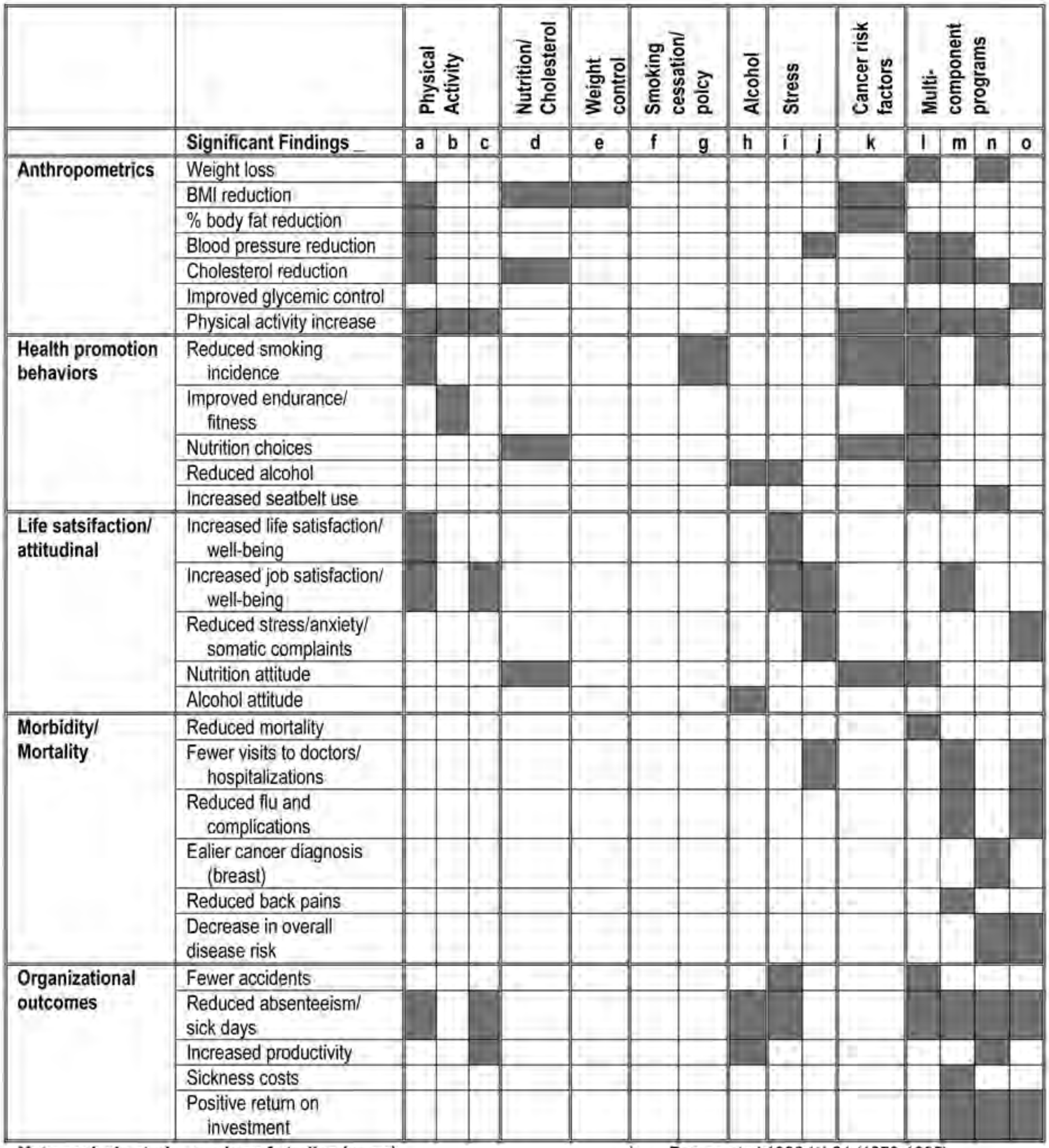
Evidence also indicates that exposures to job hazards and risk-related behaviors are correlated. For example, we found that blue-collar workers exposed to hazards on the job were more likely to smoke than their unexposed counterparts (105). Similarly, increased exposure to hazards on the job has been linked by others with unhealthy dietary habits among blue-collar workers (57) and with binge drinking (19). These dual exposures also are associated with a range of short-term adverse outcomes, including increased absence from work, psychosocial distress, and poorer general health (73, 119).

3. Integrating worksite health promotion and occupational health and safety may increase program participation and effectiveness for high-risk workers. Workers at highest risk for job exposures may be more likely to participate in integrated OSH/WHP programs than in WHP programs that focus exclusively on health behaviors. There is evidence from the risk communication field that people place highest priority on those risks that are involuntary, outside personal control, undetectable, and that seem unfair (4, 33), features that often characterize occupational hazards. Accordingly, workers may perceive management actions to reduce workers' exposures to occupational hazards as of greater importance than personal health behavior changes, and may feel that the benefits of individual health behavior changes are insignificant in the face of exposures to workplace hazards (110). Skepticism about management's commitment to improve worker health may reduce workers' interest in participating in health promotion programs at work (79, 104, 120). Conversely, employer efforts to create a safe and healthy work environment may foster a climate of trust and thereby enhance workers' receptivity to messages from their employer regarding health behavior change. In a study of blue-collar workers, we found that workers who reported that their employers had made changes to reduce hazardous exposures on the job were significantly more likely to have participated in smoking cessation and nutrition programs than workers not reporting management changes (106). Reduction of job risks may be required to gain credibility and to increase receptivity to health education messages about individual health behaviors (41, 107). In addition, programs integrating messages about job risks and risk-related behaviors may increase workers' motivations to make health-behavior changes (105). Wellness programs that fail to address the hazards of work miss significant sources of health-related problems and costs, both to individual workers and employers. At the same time, occupational health and safety programs that ignore risk-related behaviors may be underestimating workers' understanding of the complexities of health and well-being (119).

4. Integrated occupational health and safety/worksite health promotion efforts additionally may benefit the broader work organization and environment. A growing literature demonstrates the benefits of worksite health promotion programs in terms of both direct costs (e.g., reduction in health care costs) (39, 89) and indirect costs (e.g., reductions in costs resulting from lost production as a result of reductions in productivity or increases in work absence) (1, 32, 38, 39, 45, 100). In addition, research also has documented the cost effectiveness of OSH interventions to prevent occupational diseases (63, 64). Within this growing literature, comprehensive programs integrating employee wellness, disability management, employee assistance, and occupational medicine have been shown to result in long term savings in medical care utilization and expenditures and reductions in sickness absence (89, 74). In addition, some experts have posited that the overall success of the organization is enhanced through coordination of rather than competition for resources (17, 21, 123). It is imperative that future research document ways in which integrated OSH/WHP programs may further the mission of the organization through support for a healthy and productive workers within a healthy work organization.

Examining programs independently: Research on worksite health promotion (WHP) and occupational safety and health (OSH)

Worksite health promotion: WHP research has documented the efficacy of these programs across a wide array of outcomes, including changes in anthropometric measures, health behaviors, life satisfaction indicators, and measures of morbidity and mortality. In general, results from randomized studies of worksite health promotion have found modest yet promising effect sizes (28, 71, 114). Figure 2 summarizes the results of meta-analyses of programs targeting physical activity, nutrition/cholesterol, smoking cessation and tobacco control policy, alcohol use, stress, and cancer risk factors, as well as multi-component programs. The studies included in these meta-analyses represent a range of



Meta-analysis study, number of studies (years)

a. Shephard 1996,[115] 52 (1972-1994)
b. Dishman et al 1998,[117] 26 (1979-1995)
c. Proper et al 2002,[119] 8 (1981-1999)
d. Glanz et al 1996,[120] Nutr=10, Chol=16 (1980-1995)
e. Hennrikus et al 1996,[122] 43 (1968-1994)
f. Cochrane
g. Eriksen et al 1998,[125] 81 (1968-1994)
h. Roman et al 1996,[114] 24 (1970-1995)
i. Bamberg et al 1996,[116] 27 (1983-1992)
j. Murphy 1996,[118] 64 (1974-1994)
k. Janer et al 2002,[16] 45 (1984-2000)
l. Heaney et al 1997,[121] 47 (1978-1996)
m. Pelletier 1996,[123] 26 (1993-1995)
n. Pelletier 1999,[124] 11 (1995-1998)
o. Pelletier 2001,[126] 12 (1998-2000)

Figure 2 - Health risk reduction through various WHP by significant findings

study designs; although authors of these meta-analyses place the most weight on the results on randomized controlled studies, other study designs were included. Methodological limitations to the studies included in these meta-analyses include inadequate sample sizes; the use of non-randomized designs; differential attrition across study groups; analysis at the individual level failing to take into account group randomization; and the use of inadequate measures, including sole reliance on worker self-reports rather than additional objective measures, such as biochemical assessments.

A key priority for future research in this arena is attending to the persistent, and in some cases growing class-based disparities in health behaviors. These disparities point to an important gap in current worksite health promotion efforts and suggest a critical need for new approaches to behavioral interventions for working class populations. These disparities may be due, in part, to less access to worksite health promotion programs for blue-collar and service workers (43, 72), less participation by these workers in programs when they are available (71), lower efficacy of interventions among blue-collar and service workers compared to white-collar workers, and/or increasing stress among blue-collar and service workers (68). Kristensen (61) observed that WHP programs focusing on health behaviors are typically concentrated in rich industrialized countries with low morbidity/mortality, in the formal and urban sectors of the economy; and in large companies. As a consequence, unless this concern is address, these programs could actually contribute to increasing inequalities in health outcomes.

Occupational safety and health: OSH programs have traditionally been concerned with reducing hazardous exposures at work that can lead to work-related injury, illness and disability, and also may include emergency response programs (116). Research on the effectiveness of OSH programs in the US is relatively new, compared to the worksite WHP field. The aim of intervention effectiveness research in OSH is to evaluate the impact of interventions to prevent work-related injuries and illnesses.

The peer-reviewed literature contains only a limited number of OSH intervention effectiveness studies conducted in the 1980s and early 1990s, which have been reviewed by others (40, 44, 56, 58, 95, 102, 126). Most reviews to date have concluded that OSH intervention studies were more likely to focus on improving workers' knowledge and behavior of hazards than on engineering or administrative improvements in the work environment. Inherent in any such review is identification of methodological limitations, which for some studies included small sample sizes of workers within a single worksite, quasi-experimental or non-experimental study designs, lack of a theoretical framework to guide intervention and evaluation, and outcome measures based solely on worker self-reports rather than additional and perhaps more objective outcomes, such as reductions in hazardous exposures. Similar such concerns have been raised in reviews of worksite health promotion intervention studies. As is also the case in worksite health promotion research, with a few exceptions OSH programs in small businesses have been largely understudied (9, 27).

Integrated Occupational Safety and Health/Worksite Health Promotion (OSH/WHP) Programs

Despite a clear rationale for integrating and coordinating worksite occupational health and safety and worksite health promotion and increasing discussions of the benefits of integrated OSH/WHP interventions (5, 11, 17, 20, 21, 23, 26, 53, 101), empirical evidence supporting the promise of this approach is only beginning to emerge. Early research in this area focused on worker surveys simultaneously assessing job risks and health behaviors (16, 60) and small scale studies (75, 93, 98, 99).

There are a growing number of reports of best practice within single worksites. For example, Johnson and Johnson "Live for Life" program encompasses health promotion, occupational health and safety, employee assistance, disability management and other benefits (52). Administrative systems were established to promote cross-utilization of resources rather than "silos of service." A financial impact study found that this effort resulted in a cost savings on employee health care and administrative costs of about $8.6 million per year. Other companies have similarly reported the benefits of worker health programs that integrated health promotion, occupational health and safety and other benefits supporting worker health, among them UAW-GM (29), Chevron (121), 3M (2), Glaxo Wellcome (113), and Citibank (87, 88); in Europe, Volkswagen, DaimlerCrysler, and others have been cited (62). These initiatives by vanguard companies have begun to change the dialogue about approaches to employee health, increasing to focus on integration within companies.

Our work and that of others, summarized in table 1, begins to provide a systematic assessment of the efficacy and effectiveness of integrated OSH/WHP interventions. The strongest evidence available supports the efficacy of this intervention model in promoting smoking cessation, particularly among blue-collar workers; some evidence additionally indicates significant effects for other health behaviors. Little evidence is available to date documenting the impact of these programs on occupational health and safety outcomes.

Defining integrated OSH/WHP programs: As illustrated in figure 1, integrated OSH/WHP studies may be conducted across multiple levels of influence – targeting individual workers, the worksite organization and environment, or across multiple levels. Because reductions in job risks rest heavily on employers while individual workers must be included in any efforts to reduce risk-related behaviors, integrated interventions are most likely to be aimed at multiple levels of influence. There are circumstances, nonetheless, where interventions may separately target individual or organizational/environmental levels of influence, as we illustrate below.

Following standards for rigorous testing interventions, optimal assessment of the efficacy of integrated OSH/WHP programs generally relies on random assignment of worksites to the intervention, in order to control for secular trends in worksite initiatives and in worker health behaviors. Yet there are some research questions that cannot be effectively addressed in randomized trials, such as the impact of interventions that change the structure of OSH and WHP within the worksite organization, given the need for management initiative and commitment to such structure changes. Research to date has tested the efficacy of integrated OSH/WHP programs delivered by researchers; there remains a significant need for observational research to estimate the effects of structural changes in the operations and functioning of OSH and WHP.

Research assessing integrated OSH/WHP programs: Table 1 summarizes key studies assessing the effectiveness of integrated OSH/WHP interventions. Included in this table are summaries of a series of studies we have conducted to examine the efficacy of interventions integrating worksite health promotion and occupational health and safety across multiple levels of influence. The first of these studies, conducted as part of the Working Well Trial, found statistically significant effects for smoking cessation (109).

Our second study, WellWorks-2, asked the question: Does the addition of worksite occupational health and safety increase the effectiveness of worksite health promotion only (109)? Using a randomized, controlled design, 15 mid- to large-size manufacturing worksites were randomly assigned to receive either worksite health promotion only (WHP Group, eight worksites); or worksite health promotion plus occupational safety and health (WHP/OSH Group, seven worksites). We hypothesized *a priori* that the integrated OSH/WHP intervention would have the most relevance to workers in hourly positions where exposures to hazards on the job were more common than among salaried jobs. Smoking quit rates among blue-collar (hourly) workers in the OSH/WHP condition more than doubled relative to those in the WHP condition (11.8% vs 5.9%; p=0.04), and were comparable to quit rates of white-collar (salaried) workers. We found no differences in quit rates between groups for salaried workers. We found no significant changes in fruit and vegetable consumption, either in the sample overall or by job type. These findings nonetheless indicate the potential significant contribution of an integrated OSH/WHP intervention in promoting smoking cessation among blue-collar workers. We

Table 1 - *Studies Integrating OSH and Health Promotion*

Study	Design	Intervention Outcomes	Intervention‡	Results	Setting
WellWorks-1[48] ● ● ● ●	RCT* worksites	Smoking cessation Dietary habits		▪ Significant improvements in smoking cessation and fruit and vegetable consumption for all workers ▪ Significant improvements in fiber consumption for laborers	Mid-to-large manufacturing worksites (N=24 sites)
WellWorks-2[93] ● ● ● ●	RCT* worksites	Smoking cessation Fruit and vegetable consumption OSH exposures		▪ Significant improvements in smoking cessation among hourly workers ▪ Significant improvements in OSH programs	Mid-to-large manufacturing worksites (N=15 sites)
The Brabantia Project[58] ● ● ● ●	Quasi-experi-mental pre/post design	Lifestyle score (smoking, physical activity, hours sleep, BMI alcohol use, fat intake) Health risk General stress reactions Working conditions Absenteeism		▪ Improved cardiovascular health (due to improved serum cholesterol in men) ▪ Improved working conditions (due to improved perceived psychological demand and improved ergonomic conditions) ▪ Reduced absenteeism (8.1% reducetion in experiemental group, 4.8% reduction in the control group)	Three Dutch Brabantia worksites (N=3 sites)
Healthy Directions/ Small Business[99] ● ● ● ●	RCT* worksites	Fruit and vegetable consumption Red meat consumption Multi-vitamins Physical activity		▪ Significant improvements in physical activity and multi-vitamin use for all workers ▪ Larger effects for workers than managers for fruits and vegetables and physical activity	Small manufacturing worksites (N=24 sites)
MassBuilt[102] ● – ● ●	Methods developmnt	Smoking cessation		▪ 19% quite-rate among baseline smokers at final survey ▪ Particpation in pro-active intervention components associated with a three-fold increase in quitting	Construction apprentices in union program
Tools for Health[101] ● – ● –	RCT* worksites	Smoking cessation Fruit and vegetable consumption		Not yet available	Unionized construction laborers

* Random controlled trial with levels of randomization

‡ Intervention: Individual Organization

	Individual	Organization
OSH	●	●
WHP	●	●

also found that worksites in the HP/OSH condition made statistically significant improvements in their health and safety programs compared to HP only sites (66). Significant improvements in an exposure prevention summary rating (developed as part of this study) (65) in the intervention worksites was offset by a smaller and non-significant improvement in the control worksites, rendering the pattern of results promising but not statistically significant (67). We also found that worker participation in intervention programs was significantly higher in the OSH/WHP condition than in the WHP condition (48), as measured by process tracking of the intervention "dose" delivered in intervention sites. According to estimates by Colditz, if this intervention was disseminated to the population of blue-collar smokers in Massachusetts, an estimated 2,880 cases of lung cancer could be avoided, with additional benefits expected to accrue in other tobacco-related diseases (18).

Several additional studies add to the evidence supporting the efficacy of an integrated OSH/WHP approach to worker health. A study of an integrated OSH/WHP intervention aimed at improving diet and physical activity evidenced of the efficacy of integrated interventions among working class, ethnically diverse workers employed in small manufacturing businesses (111). Two additional studies have tested the efficacy of integrated OSH/WHP interventions with construction workers. These interventions were designed to target the individual/interpersonal level of influence because the intervention is not delivered at a specific worksite setting, as is appropriate for construction workers who often move from job to job. Nonetheless, messages about job risks are clearly incorporated into intervention messages. In one study, designed to promote tobacco use cessation and increased consumption of fruits and vegetables among construction laborers, a one-on-one telephone counseling intervention was based on motivational interviewing and a set of written materials designed specifically for this audience, and messages around occupational hazards and fitness for work were incorporated into the intervention (8). In a second study, we promoted tobacco use cessation among building trade apprentices during on-site training programs; again, messages about occupational health and safety are incorporated into the intervention. Both studies showed significant intervention effects (10, 112).

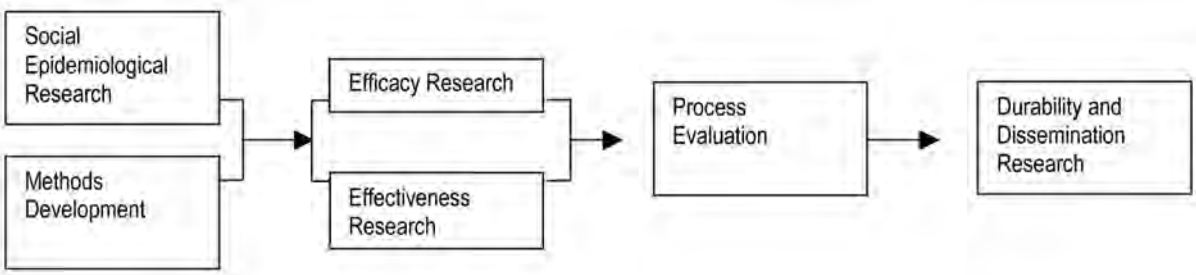
The Brabantia Project included in table 1, which targeted work organization factors as part of the OSH focus, provides an example of a European approach to integrated OSH/WHO programs (74). Organizational and psychosocial factors influencing worker health are a common element of a comprehensive approach to worker health in Europe (3). The Brabantia study found that manufacturing employees in the intervention condition made significantly greater changes than those in a non-intervention control groups on key outcomes, including reduction in ergonomic risks, cardiovascular health risk, and job stressors such as psychological job demands and low job control. Overall, sickness absence in the intervention dropped (15.5% to 7.7%) versus control (14.3% to 9.5%) groups, which yielded a positive financial return on its investment in the project.

To summarize, although research testing the efficacy of OSH/WHP interventions is only in its infancy, emerging evidence to date suggests that these interventions hold significant promise for improving worker health behaviors, especially among working class populations, and have the potential to contribute to OSH programs and outcomes. This research provides a useful foundation for future research in this area.

Research agenda: Issues for future research

A broad range of research questions need to be addressed in order to maximize the potential impact of OSH/WHP interventions. Figure 3 presents an organizing framework for our discussion of five overarching research directions, including a summary of key research directions. This outline follows research frameworks describing the appropriate sequencing of research within cancer prevention and control (42) and cardiovascular disease prevention (82). Such research does not always proceed in a linear fashion, but may require circling back to “earlier” steps in the process to address newly-defined research questions (34, 42).

We begin with two key foundations for intervention research. First, social epidemiological research is needed to identify key work-related factors associated with hazardous occupational exposures and risk-related behaviors, and to identify the underlying causes of social disparities in worker health. Interventions to improve worker health must be solidly based on an understanding of the patterns and distributions of worker illnesses and injuries in the population, including attention to differences in hazardous exposures and health outcomes by race/ethnicity, gender, and occupational class and of the broader social, cultural, economic and political processes underlying these disparities (49). Second, there is a need for methods development research aimed at developing both appropriate measurement tools and new intervention approaches to integrating WHP and OSH. Before large scale, randomized controlled trials can be appropriately launched, important challenges must be addressed, such as identification of the overall risks and risk perceptions of this population; assessment



Summary research directions

Social epidemiological research
OSH data by race/ethnicity and gender
Expanding our understanding of social contextual determinants of worker health outcomes
Understanding the dual impact of job risks and risk-related behaviors over the life course
Methods development research
Further specification of integrated interventions
Further development of measurement tools
Assessing intervention efficacy
Assessment of intervention efficacy for OSH and worksite health promotion outcomes
Assessment of the efficacy of diverse types of integrated OSH/WHP interventions
Assessing intervention effectiveness
Assessment of the efficacy of interventions for diverse groups of workers
Consideration of a range of research methodologies
Process evaluation
Intervention implementation evaluation
Cost and related analyses
Assessment of worksite characteristics associated with participation
Process-to-outcome analyses
Dissemination and durability research
Research on the sustainability of organizational and behavioral changes
Research on the process of dissemination of tested interventions

Figure 3 - Framework for research directions: On integrating OSH and health promotion

of the feasibility and acceptability of the intervention in a specific population; assessment of potential participation in an intervention study; development and testing of reliable, valid measures for assessing outcomes within the defined setting; and preliminary small-scale tests of planned interventions (42). Third, efficacy studies are needed to examine the effects of integrated interventions on both occupational health and safety outcomes as well as health behavior changes. Fourth, effectiveness studies are needed to evaluate the generalizability of tested interventions to new settings or with new populations. Here, we follow the distinction made between efficacy trials, which provide tests of an intervention under "optimal" conditions, and effectiveness trials, where testing is conducted under "real world" conditions (42, 82). Fifth, research is needed on the process of intervention implementation, including intervention implementation evaluation, cost assessments, and process-to-outcome assessments. Finally, research is needed to assess the long-term applicability of these intervention approaches through dissemination and durability studies, that is, testing methods to promote the sustainability and dissemination of programs where sufficient evidence is available to indicate that an integrated intervention is efficacious, and to promote maintenance of changes in health behaviors and the work environment resulting from interventions.

This sequence of research phases will necessarily be conducted in a political, economic, and social context that surrounds worksite-based research (25, 69). Researchers from the WHP and OSH fields are certainly aware of the challenges of this terrain, replete with power differences between managers and workers; management's interest in controlling costs and increasing productivity, and how these factors play into their support or lack thereof for OSH and WHP; and workers' concerns about maintaining privacy and other essential rights, and their resistance to management-initiated efforts to 'correct' workers' 'poor' health behaviors (24, 71). Acknowledgement and articulation of these realities is not only critical to conducting sound research in the workplace, but also helps to clarify the very questions we pose and the assumptions underlying them. By questioning these basic assumptions, we are able to shed light on ideologies underlying our research questions (25). For example, we recognize that for employers, it is critical to have information about the economic implications of integrated approaches for the 'bottom line,' and several WHP and OSH studies have calculated outcomes such as cost-effectiveness and return-on-investment (63). Equipped with this information, employers can determine whether and how to pay for WHP or OSH interventions in the overall economic context of their businesses. By addressing these questions through our research, however, it is essential to acknowledge the limited scope of these research questions from a public health perspective. In addition, cost-based research could be characterized by workers and their advocates as a callous calculation of what workers' health is *worth* to the business. Being clear on our questions, assumptions, and methods is particularly critical for scientists attempting to work across disciplines. Within our own disciplines, we often take for granted many shared assumptions and fail to challenge one another. There is, thus, an inherent set of challenges in inter-disciplinary collaboration, as well as an enormous opportunity to pause, question, and reflect on comfortable assumptions held by individual disciplines (115).

To accomplish this research agenda, it is important to attend to several key challenges. There is a need for diversification of research methods, with particular attention to the development and adaptation of methods that bridge OSH and WHP. Studies must be designed with careful attention to maximizing the generalizability of research findings. Too often only larger, more affluent, stable worksites are available for study, and the results of investigations may not be applicable to small businesses or those with more transient workforces. In addition, there is a need for valid and reliable measurement tools that permit consistent assessment of outcomes across worksites participating in the research, and that are appropriate for diverse groups of workers. Finally, measurement of the full range of outcomes resulting from integrated OSH/WHP interventions requires access to worksite data permitting measurement of morbidity indicators, health care utilization, absenteeism, and related issues.

Discussion/Conclusions

Occupational health and safety and worksite health promotion clearly share the common goal of promoting worker health, with complementary functions in protecting and enhancing the health of workers, and thereby provide an important opportunity for coordinated and integrated efforts (104, 108, 110). These goals are supported by international guidelines. For example, the World Health Organization's Regional Guidelines for the Development of Healthy Workplaces defined a healthy workplace as one that aims to create a healthy and safe work environment, ensure that worksite health promotion and occupational health and safety are an integral part of management practices, foster work styles and lifestyles conducive to health, ensure total organizational participation, and extend the positive impacts to the surrounding community and environment (123). These guidelines further underscored the benefits of such coordinated efforts, including their contributions to a positive and caring image for the company, improvements in staff morale, reduced turnover and absenteeism, and improved productivity (123).

As we move forward with an agenda for integrating OSH and worksite health promotion, it is critical that rigorous scientific evidence be the cornerstone of our planning. Advancing knowledge in this area requires that we attend to barriers for scientists, including the real work of assembling multi-disciplinary teams and identifying funding sources to support integrated studies. Research to develop and test effective intervention strategies integrating OSH and WHP requires an interdisciplinary approach. In the US, it is typical for experts in these areas to read different journals, attend different professional meetings, and employ different research methodologies. Indeed, these diverse backgrounds have contributed to differing ideological perspectives about responsibility for worker health. The belief that worker health begins with individual behavior change sets in motion a different set of intervention strategies from the legal formulation in the US of the Occupational Safety and Health Act, which starts from the assumption that management bears primary responsibility for worker health and safety on the job (108). Overcoming the segmentation of these fields ultimately will require an inclusive, comprehensive model of work and health, providing for resolution – or at least understanding – of our differences assumptions, vocabulary, research methods, and intervention approaches (12). It is possible to expand communication streams across disciplines to support transdisciplinary/inter-disciplinary strategies, for example, through shared journals or further shared symposiums such as this one.

We have attempted to define a comprehensive agenda for future work, structured in a step-by-step fashion. The development and dissemination of effective intervention methods will be enhanced as research is implemented across the full spectrum of the phases of research – from methods development studies through dissemination research. By combining what we have learned to date from testing of WHP and OSH interventions, we are well poised to launch the next generation of research in support of worker health.

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Acknowledgements: *We greatly appreciate the dedication, persistence, and thoroughness of Christopher Speed, who made important contributions to this paper in the role of research assistant. We also thank Kerry Kokkinogenis for her work in production of the manuscript. We are indebted to the comments of reviewers on a draft of this manuscript, including Drs. Paul Landsbergis, Charles Levenstein, Margaret Quinn, and Gregory Wagner. Our thinking on this topic has been greatly informed by our collaborators, among them, Karen Emmons, Elizabeth Harden, Mary Kay Hunt, Anthony LaMontagne, Deborah McLellan, Anne Stoddard, Lorraine Wallace, and Richard Youngstrom, and by the worksites and unions collaborating on our research. We additionally appreciate the thoughtful comments of discussants of this paper at the NIOSH Symposium, including Drs. Joan Eakin, Laura Linnan, and James Merchant*

Med Lav 2006; *97*, 2: 258-271

The stress-disequilibrium theory: chronic disease development, low social control, and physiological de-regulation

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Key words
Stress; chronic disease; social control

Summary
The Stress – Disequilibrium Theory is based on a new generalized analytic three-level model based on thermodynamics to describe the process of physiological risk development. This approach explains how low social control could cause chronic disease through chronic de-regulation of our highly integrated physiological systems. Could low external social control lead to low internal physiological control: i.e. compromised self-regulation - and then disease? The theory implicitly explores the evidence for the physiological causes of chronic diseases, including cardiovascular diseases, at a high level (i.e. a non-reductionist level) and in a unifying manner - to provide a potentially easier linkage to the broad social policy consequences implied by the global economy. Evidence from our own recent Heart Rate Variability monitoring and job strain research (5) is presented which assesses the effect of low control on autonomic regulation on the heart. The theory is consistent with the Demand/Control Model, and could be considered its underlying theoretical explanation.

Riassunto
«La teoria "stress-squilibrio": sviluppo delle malattie croniche, basso controllo sociale and de-regolazione fisiologica». *La teoria "stress-squilibrio" si fonda su un nuovo modello analitico generale a tre livelli che, partendo dalla termodinamica, descrive il processo di sviluppo del rischio fisiologico. Questo approccio illustra il meccanismo attraverso cui una condizione di basso controllo sociale possa causare malattia cronica attraverso la cronica de-regolazione di sistemi fisiologici altamente integrati. Può un basso controllo esterno condurre ad un corrispondente basso controllo fisiologico interno, ossia ad una compromessa autoregolazione e dunque alla malattia? La nostra teoria valuta l'evidenza scientifica relativa alle cause fisiologiche delle malattie croniche - comprese le malattie cardiovascolari - ad un livello alto (ossia ad un livello non riduzionistico) e in maniera unificata, così da fornire un legame potenzialmente diretto con le conseguenze su larga scala che l'economia globale può comportare sulle scelte di politica sociale. In questo contributo viene inoltre presentata l'evidenza scientifica proveniente dalla nostra recente ricerca sul monitoraggio della variabilità della frequenza cardiaca e lo strain lavorativo (5), che studia l'effetto del basso controllo sulla regolazione cardiaca a livello del sistema nervoso autonomo. La nostra teoria è in linea con il modello di stress domanda/controllo e può esserne considerata la spiegazione teorica sottostante.*

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The need for a high-level physiological explanation for social causes of chronic disease

There is increasing evidence around the world of a growing chronic disease problem that is associated with our contemporary forms of economic and social organization. Much of it involves diseases that are potentially stress-related - such as cardiovascular disease, mental disorders, and musculoskeletal disorder. Four types of evidence now converge to suggest that a significant portion of this burden is work and economic system related, and then, very possibly, related to low control in social organizations.

This new information raises a question about how the specific physiological risk mechanisms would operate. To address this question, this paper attempts to present in outline form a new stress physiological theory to describe how low social control could contribute to the development of chronic disease through de-regulation of our highly integrated physiological systems. The theory implicitly explores the evidence for the physiological causes of chronic diseases at a high level (i.e., a non-reductionist level) and in a congruent manner - to provide a potentially easier linkage to the broad social policy consequences implied by the global economy.

To preface the discussion, three summary claims are made about the nature of the current global social challenges to health, although the brevity of this paper prevents the necessary full discussion of these points. It is claimed that there is: (a) a convergence in the profile of work-related chronic disease in advanced societies – diseases which are also increasing; (b) increasing similarity of psychosocial job characteristics observed in empirical studies across the world; and (c) there is an increasing accumulation of epidemiological evidence of “work relatedness” of a broad range of chronic diseases in which low workplace/economic system control is a central cause. For example, three recent reviews of 137 studies [heart disease (2); mental disability (20); and musculoskeletal disorders (4)] find support for low workplace control as a chronic disease risk factor.

Low control and explanation of the inverse social class gradient in health

There is now a major debate about the cause of the increasing socioeconomic gradient in health (i.e. higher mortality in lower social class) in the face of rising material well-being. The mortality in most of the countries discussed is comprised of chronic diseases that could easily be stress-related products of our modern social life. The two main cited causes (11) are absolute material deprivation and relative material inequality, but opponents have presented convincing arguments against the comprehensive validity of either explanation.

One little noted problem is that applying the traditional stress models of chronic disease (below) actually exacerbates this mystery. In these models illness risk is based on high levels of sympathetic arousal - i. e., mental demands. However, these demands are actually somewhat higher in higher classes, not lower classes (where physical hazards are far higher). Thus mental demands cannot explain the social gradient in putatively stress-related morbidity: mental demands may be slightly more common in upper classes, but disease is surely not.

Even less discussed, but just as noteworthy, is the fact that much of the gradient differential remains intact in societies with the lowest levels of inequality (Sweden, Denmark, and the Netherlands) - and is associated with low control at work. Low workplace control is, of course, more common for low status individuals, and in fact is a defining quality of low social status in many analytic descriptions.

Toward a theory of low social control and stress-related chronic disease: a high-level physiological theory

Thus, we would propose that what is now needed is a new stress model based on “how absolute low social control, in major socio-economic institutions, causes chronic disease,” as a third explanation for the inverse social gradient in health.

Most of the traditional stress models utilize the physiological pathway of high levels of sympathetic arousal for extended duration without relaxation as the pathway to illness risk, and thus focus on the magnitude of the environmental stressor confronting the individual as the major risk factor - not the individual's limitations of control.

The perspective of this paper is that the requirement of coordination - of ordering - of specification of a precise response - is the determining "load" for the central control system in information theoretic and general thermodynamic terms. The Second Law of Thermodynamics limits the possibility of precisely specifying the nature of the response needed by each of a large number of physiological subsystems - this paper's major claim. Such "coordination burdens" could play a major - but so far under-illuminated - role in physiological response pathology. These limits are independent of the better-known limits relating to "calories" consumed, calories burned or physical loads applied – which are related to the First Law of Thermodynamics.

The social policy implication of the Stress-Disequilbrium Theory of Chronic Disease Development is that requirements for coordination have been pushed to extremes in the context of long-term stressor exposure of humans in their social environments - our 24/7 global economy for example - with the result of a diminished capacity for physiological coordination, and finally chronic disease development.

Could restriction in the degrees of freedom of the organism's response to the environment - "low external control" - lead to "low internal control:" restriction in its internal degrees of freedom for physiological coordination? Certainly there is no question that External work demands would lead to Internal work demands, i.e., physiological loads. However, if internal control is limited by external control, the implications are significant.

In terms of phylogenetic evolution, it may be recalled that huge resources are internally devoted by warm-blooded mammals to maintain "control" over physiological states: a regulated "milieu interior." The high cost is an order of magnitude higher food intake per unit of body weight by humans compared to reptiles. The payoff is the precise self-regulation that is the foundation for our complex cognitive and social development. What if lack of external control destroys our expensive internal capacity for self-regulation?

The overwhelming complexity involved in dynamic understanding of multiple cross-linked physiological systems leads us inevitably to search for a simple "general principle" - to avoid becoming lost in details and expending all our resources. Is there a possibility that a satisfactory higher-level explanation (non-reductionist) (7) could be found - a macro-level physiological explanation? For example, one related to low social control? Such an explanation would be closer to the necessarily macro-level social policy solutions for the above health risks.

What would "high-level" theory mean in this context? One implication is that a deficiency at a high level alone (for example, low control) could be sufficient explanation of disease, without major contribution of lower level deficiencies, such as bio-molecular deficiencies. Using a hypothetical analogy, we will briefly outline the meaning of such a provocative proposition.

Consider a feudal warlord defending his fiefdom from a rival warlord by raising a local army for battle. Suppose only half of the 500 troops needed by the warlord muster and that the warlord looses the battle, and with this, his fiefdom. Analysts could look for high and low level causes. At the low level, it might be noted for example that extended rains fell and the crops planted on the northern slopes of the warlord's valley had low yields, poorly fed locals, and few troops. Based on this low level explanation, we might suggest that the warlord institute an improved crop fertilizer program to reduce malnutrition and troop failures.

However, a high level expert - a military strategist - would say that the warlord lost his kingdom simply because he failed to field a large enough army. This is a high level explanation because it focuses on one of the warlord's two primary functions: (a) fielding an army and (b) commanding it in battle. The military strategist does not need or want to know how the troops get there - only that there are enough. A warlord has many resources to get the recruiting job done if some troops fail to appear because of hunger - one of many low level problems which are minor tactical issues, determining no major advantage by themselves. To the military strategist the low level explanation related to crops and fertilizer seems a marginal and partial approach to general problem of securing fiefdoms (it is not a sufficient cause). The high level answer is seen as providing a more powerful explanation. These logics do not really completely exclude each other, they relate to different levels of action (7, p. 201).

The missing link for understanding limitations on ordering capacity: Second Law thermodynamics

Our approach to high-level explanation of the low social control/disease linkage is to search for a formulation of the limitations on physiological "ordering capacity": a limit on the organism's ability to internally organize its adaptive interactions with its environments. Application of thermodynamic principles lies at the root of our understanding chemical reaction possibilities, and therefore provides a basis for understanding limits of plant and animal capacity for transforming nutrients and environmental inputs into capacity to control their own internal and external "work" - and is a natural place to begin.

If we can find an analytic form for such limits, then it is possible to assess whether our contemporary social organizations are pushing us beyond those limits. Understanding cycles of exhaustion and restoration are part of common sense wisdom about our limitations on our capacity to organize complex tasks. Imagine it's a Friday night after a brutal week, and your spouse suddenly suggests, "Honey, let's do the income taxes - tonight." Almost anyone's reaction would be: "Not now, I'm exhausted. Let's do it next week." We get some assistance here from our common awareness of physiological limits on metabolic activity provided by Thermodynamics' First Law: the conservation of energy. However, these limits may be insufficient to provide answers for ordering capacity issues.

The natural location to extend the search for limitations in human control capacity is in the second cornerstone message of thermodynamics: limits on the efficiency of transformation of disordered energy into ordered energy in the Second Law. The Second Law provides this type of limit: the efficiency of a heat engine is always less than 100%: there is always less useful energy in the form of ordered work from a heat engine than energy that is input in the form of heat (disordered energy). The following question illustrates some of the difference between First and Second Law: "Could we just consume more food to resolve our feelings of being out-of-control in a complex global economy - or - would that just lead to obesity?" The well-known First Law's "calorie calculus" does not provide a full answer.

Theoretical biologists now are turning consistently to Second Law's thermodynamic principles to explain complex living systems, for example, Recordati's "thermodynamic model of a central nervous system" (14, 15). Kauffman has postulated that the definition of a living entity is based, beyond ability to reproduce, upon the "ability to perform a thermodynamic work cycle". Prigogene (13) has used non-linear forms of thermodynamics to formulate a theory of "self-organizing systems". Environmental economists use the Second Law as their foundation for understanding the limits to sustainability in material goods production: "without reference to entropic throughput 'it is virtually impossible to relate the economy to the environment'" (Daley, 1989; cited in 8, p. 9).

A three-part stress paradigm: controller - system - environment

The Stress - Disequilibrium Theory is based on a new three-level thermodynamic model structure to describe the process of physiological risk development. This "Environment/System/Controller" model clearly fits the stress paradigm. The "stress paradigm" requires understanding of three elements simultaneously: our physiological system, our environment, and our controller: the central nervous system. The typical stress problem formulation involves understanding the effects on the central nervous system of the challenges to our physiological systems that come from adapting to environmental challenges.

The standard Second Law model is thus usually graphically depicted as a two-part model: a System located within an Environment - where two flows of energy/order link the two (figure 1-top). As we begin to examine implications of a thermodynamic approach, however, we immediately recognize it needs a modification to fit Stress Theory. We must add a "Central Controller" - which creates a three-part model (figure 1-Bottom). Our new model is actually only a nesting of one standard thermodynamic model within another - now a two-level model. The extension adds a new level involving a Central Controller - i.e. central nervous system (CNS) to administer homeostatic/allostatic regulation (14).

Crucially, the nesting of one system/environment pair within another gives rise to a second set of energy-to-order flows (NegEntropy flows as explained below). In this context the controller exports ordering capacity to the System (here our full physiological system) by coordinating diverse physiological sub-systems to achieve the maximal state of readiness for actions in the Environment outside - Flow 3. Very importantly, it also creates a second new flow - which has significant implications as we attempt to understand development and utilization of Ordering Capacity in complex living systems (Flow 4).

Our addition of the Controller allows us to explicitly address processes where the CNS coordination of internal physiological work is well known to exist. These physiological processes and their coordination would be measured in laboratory or clinical monitoring of, for example: blood pressure, blood sugar level, etc.

Definitions

Before returning to further examination of limiting principles, it is useful to propose definitions of relevant social situation characteristics and general physiological processes. "Work" is defined as the purposeful and precise organization of the organism's actions to meet unpredictable demands for

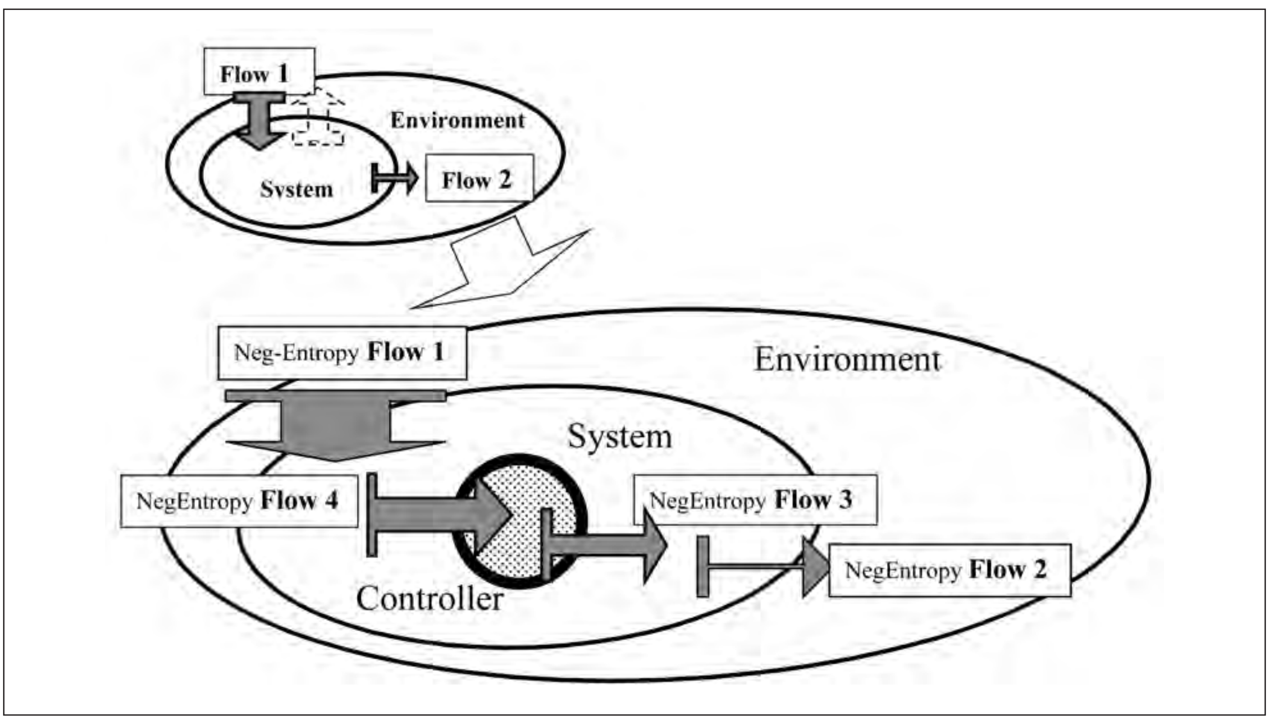

Figure 1 - Extended three-part Model with controller and entropy flows

action from the environment (external work). Our definition emphasizes that the organism's response to the environment must usually be precise. The magnitude of Work depends on the amount of ordered energy transferred by the organism (system) to the environment (also how Work is defined in physics). In no case is energy transferred without order considered to be "Work" (or likely to be useful for the organism).

Ordering involves the concept of "control." Required action from the environment usually requires precision in response, or the right choice, right timing, right combination. The environment sets the terms rigorously. These requirements reduce the Degrees-of-Freedom of Response available to the organism - and reduce its control. Precise and effective action in the External environment requires coordination of Internal physiological and behavioral capabilities. This precise coordination is a different challenge than using muscles to lift weights: it is "ordering work," related to the Second Law. Internal control is exercised by the central controller - for example the CNS - to orchestrate the energetic and purposeful activity of sub-systems into overall organism response that is exactly suitable to the environmental challenge. Total internal physiological work is equal to the internal energy and internal ordering coordination requirements of both externally focused and homeostatic needs. Environments that require both energetic response, and high precision imply high demand and low control situations: the familiar High Strain construct - external Strain - from the demand/control model (9, 10).

External Control measures the limitations on the organism's "degrees to freedom" to operate determined by factors outside the organism's control in its environment. For example, external environmental restrictions can interfere with the execution of the strategy that the organism has chosen - or - they could limit the internal physiological possibilities – limiting internal control, i.e. self-regulation. We are such effective self-regulators that we can sometimes exercise control over our external environments. The organism can periodically control its own behavioral context to permit, for example, long-term rest and sleep without threat.

Formulating ordering capacity limitations from Second Law energy-into-order principles

The basic Second Law principles are simple. The first concepts have to do with the relationship between Energy and Order. Thermodynamic "Work" is Ordered Energy with few Degrees of Freedom - which fits well with our Work definition above. A classic example is the steam engine's piston: all energy is channeled to one direction of motion that is predictable and usable. Disordered Energy, heat, is energy with many random degrees-of-freedom: for example the gas molecules in the steam being input into the steam engine. It is undirected Energy. The disorganization component of energy is called Entropy. Its opposite, the Ordering Capacity of energy, is its NegEntropy (which becomes Work when energy is "added" - very roughly). Dyson (1954): defines the difference between work and heat in this manner: "Heat is disordered energy. Energy can exist without disorder. For example, a flying bullet."

Another set of concepts is crucial for our goal above: thermodynamics formulates limitations for energy and order transformation. The First law of Thermodynamics is the well-known conservation of energy principle. The Second Law of Thermodynamics is most commonly stated to predict that: "the order or the universe runs downhill (toward a totally uniform "grayness" of nothing but random fluctuations). Fortunately for living organisms, this fate occurs only within a closed system (see below). The Second Law yields Efficiency Criteria that absolutely limit the amount of Work (for example: 25% for a steam engine) that can be obtained from an amount of disordered energy (Heat). There are no perpetual motion machines - period. This is the root source of our limitations on ordering capacity.

Living systems represent a special type of thermodynamic equilibrium - that of an Open System. Maintenance of life requires maintenance of gradients: constant, improbable deviations from "true total equilibrium (a dead, inert, "grey," uniform state)". The concept of equilibrium for stable living systems (homeostasis) thus describing an equilibrium of flows.

The inevitable tendency of the system to move toward the inert "true equilibrium" can only be offset by importing energy from outside the system and exporting entropy from the system (i.e., importing negative entropy). Thus, the processes of maintaining life within living organisms on earth are dependent on the flow of negative entropy (NegEntropy) from the environment into the system to maintain these differentials. Flow 1, in figure 1 happens, for example, via the photosynthesis process that transforms disordered heat energy into ordered (low-entropy) chemical components to support life.

The other flow in the Standard Model occurs when the ordering capacity is "used up" as the organism does its Work in the environment: Flow 2. Extensive coordination of internal physiological processes is required for individual behaviors, and complex social interactions. All represent "work" in the definition above, channeling energy with many of Degrees-of-Freedom into the constrained release of that energy into a few degrees of freedom - embodying information about just the right time and place etc. Such actions produce order in the environment, thus decreasing its entropy. This represents an export of NegEntropy to the environment from the system (which has gained entropy) - NegEntropy Flow 2.

We now turn our attention the two new flows: Flow 3 and Flow 4 of the three-part model.

REGULATING THE ORGANISM: USING UP THE ORDERING CAPACITY (FLOW 3)

The primary challenge for the organism is that which is outlined by Ashby (1): in order to protect the organism from the impact of unpredictable external demands, the organism's "controller" must have as many strategies as possible available (Theory of Requisite Variety).

Ashby in his classic chapter on "Requisite Variety" lays out the conceptual foundations of such a process of internal coordination (regulation) to meet environmental challenges. The goal of "Regulation [is to] block the flow of variety. [from the organism's environment, and thus keep the organism's internal variable stable] … The perfect thermostat would be the one that, in spite of disturbance, kept the temperature constant at the desired level." Ashby illustrates using an example in which the unpredictable environment has its actions blocked by the regulator of the organism so that the organism can maintain its internal physiological stability. The well-equipped regulator has such a wide variety of action possibilities that can respond to all the environmental disturbances in such a manner that all of the outcomes fall within the acceptable range. With this simple example presented in a logically general game theory format (Figure 2), Ashby demonstrates "the Law of Requisite Variety: Only variety in [the regulator] can force down the variety in [the environment] - only variety can destroy variety".

In reality, all control examples show that ordering capacity of the controller – expressed above as variety of response options - is used up as it is transported to the environment during the control activity (Flow 3), and thus must be periodically renewed, or would be depleted. Such cyclical operation also characterizes the energy-to-order transformation in the steam engine.

Measuring ordering capacity

Our concepts of "Ordering Capacity" for physiological self-regulation would based (a) on the number of physiologically independent control subsystems available to facilitate environmental response or homeostatic adjustment, and secondly (b) on the available dynamic range of control of each of these systems – the more control states, the greater the potential "health" of the response capacity.

In thermodynamics assessment of NegEntropy/Entropy is based on an enumeration of the total possible states that the system's elements can occupy. The more states, the greater the Entropy - that is: the greater the unpredictability that any very specific combination of system elements would randomly occur (i.e., correctly guessing the winning lottery number). Such a formulation has been empirically validated for our steam engine, for human sensory motor task response (6), and is also consistent with recent empirical data on levels of

The goal of Regulation [is to] block the flow of variety [from the organism's environment] which would disturb its internal variables.
•"The perfect thermostat would be the one that, in spite of disturbance, kept the temperature constant at the desired level."

The Law of Requisite Variety:
Only variety in the Regulator (R) can force down variety in the Environment (E)

Ashby's Proof is a logically general game theory example:

- R's goal is to insure selection of a specific desired set of outcomes (= k).

- E moves first.

- Given Response pairs (R, E) : (1,C) (2,A) (3,B) (9,A),
Then the Outcome of game is: k k k l

- If R had more choices, it could probably get "k" more often.

Thus, only variety in R's moves can force down the variety in the outcomes, k.

Table 11/5/1; Ashby, 1956			**R**move	
		#A	**#B**	**#C**
	#1	**f**	**f**	**k**
	#2	**k**	**e**	**f**
Emove	**#3**	**m**	**k**	**a**
	#4	**b**	**b**	**b**
	#5	**c**	**q**	**c**
	#6	**h**	**h**	**m**

Figure 2 - Ashby's theory of requisite variety, Cybernetics, 1956

cardiac risk in stressor exposure before fatal arrhythmias. Skinner found that a reduction of the cardiac system's degrees-of-freedom – as assessed by the "correlation dimension" – from 2.5 to under 1.2 (with 1.0 as the theoretical minimum) was associated with lethal tachycardia in pigs (17), and in human cardiac patients (18).

The missing flow - creating ordering capacity: the negentropy pump (Flow 4)

The central thermodynamic challenge of high-level ordering capacity is problem of turning large amounts of "cheap" disorganized energy into large amounts of precisely ordered energy ("expensive"). Generalized (disordered) energy is cheap, in that it is relatively plentiful. The problem is its disorganization – a lot of disorganized energy is often be worse than no energy at all (i.e., explosions). We can presume there will be significant efficiency losses in this transformation – but we will still harvest enough ordered energy (Work) output to support action at the level of human behavior, as opposed to, for example, the phytoplankton scale.

There is one important new explanatory challenge at this point. We must answer the question: how can our understanding of the simple sources of "ordered energy" we know of in our natural environment (i.e., photosynthesis, ATP, etc.) be transformed into a model of the limitations on high-level ordering capacity – Flow 4 – that our Central Nervous System requires? Neither First Law-based metabolic analysis, nor current neurophysiological understandings sufficiently illuminate the ordering capacity issue presented here (an important discussion beyond the scope of this paper). Since this answer is not available elsewhere in physiology or, in fact, even in applied thermodynamics, we must develop it in outline form in this paper, in the "NegEntropy Pump" text below. This represents an addition to the laws of thermodynamics as currently applied to complex systems, a major intellectual challenge. However, without some such formulation we have no pathway for applying the Second Law to understand chronic disease development.

We can find a clue in a broader reflection about the steam engine example. The above statement about the steam engine's limitations for turning steam energy into ordered work is conventionally based on analysis of operating characteristics of the process such as steam input and output temperature. However, there is really a second level of explanation that must be invoked to support our extended argument. This steam engine structure additionally determines how the energy-to-order conversion process will operate. And ordered energy at an entirely different level was also needed to *manufacture the steam engine structure* in the first place. The steam engine is the "stored energy" output of some other lower-level manufacturing process that builds steam engines. The physical properties of the steam engine - its piston size and stroke, its insulating properties represented a "constraint structure," which will determine how it "squeezes" all the random Degree-of-Freedom of the energy of the steam molecules, into the limited but very useful variability of the steam engine's one-degree-of-freedom reciprocating stroke. This "constraint-on-degrees-of-freedom" idea yields a very important example of a general principle for the biological discussion below. Separate, but linked, thermodynamic analyses must be performed at multiple levels to understand the implications of the Second Law on the overall ordering capacity of a complex biological system.

The Concrete Bridge Example

The entire process of creating "ordering capacity at a higher level" might be considered analogous to building a huge concrete bridge across the Rhine. The first stage is to construct the formwork for the concrete bridge. In the last stage hundreds of tons of free flowing concrete are poured in, to harden after a few days into an elegant structure able to carry hundreds of tons of load. The first step, construction of the bridge formwork is a rickety-looking affair, based on the simplest of components - plywood panels - but it is a supremely accurate process taking many months of meticulous, low-level labor. The concrete had better be put in the right place the first time. By carefully expending much "ordering capacity" at a low level, one can create a very large-capacity ordering structure at a higher level: a beautiful bridge capable of decades of regional transport service.

We can extend the Concrete Bridge analogy to biological systems. The plywood might be likened to a low level enzyme in a complex protein synthesis process. Although the enzyme represents "stored energy" at its own low level (a moderately complex output at that level), it is very low in NegEntropy compared to the complex protein output of the final process. Like pouring the concrete, the biological "wash" of amino acid molecules, plus Generalized Energy (ATP, oxygen, etc) consists of cheap, low NegEntropy inputs (relatively). Without the precise "formwork" of the chemical enzymes this process would lead to expensive, possibly toxic, biological waste.

As the organism adds levels of functional complexity - in order to achieve the goal of precise regulation - it must add levels of control specificity. To get a high level of complex order - one must add a constraint structure at each level to reduce the enormous range of possible states to the small number that represent action possibilities of the organism. The organism requires very specific actions (and multiple versions, as noted above), but the huge variability produced by assemblages of millions of input components is astronomically large - leaving negligible possibly that the right combinations would occur at random.

As each level of functional organization is created, some actions must be tested and reinforced, while others are tested and rejected. Through this process "constraints" are created on the available range of actions. The organism will, for example, create an enzyme that promotes a special type of reaction, but do nothing to promote another reaction. Thus, constraints created are really pathways that are favored and which use up much of the reaction resources. The "Constraint Structure" is actually a specific-action promoter designed to facilitate precise regulation at a higher level (below we use the term platform structure). Another example - systems of negative feedback loops which constantly return the system to an equilibrium after its small departures - represents such "structure" also, created at one level and a platform for action at level above (if the deviations are too large, the feedback mechanisms become non-linear, loss stability and the system can become "chaotic").

We can see this "constraining" process in the facilitation of actions of enzymes at the molecular level, as they position on substrate molecule in just the right position to react with one another - which dramatically increase the reaction speed of one particular reaction. Similarly, the efficiency of metabolic processes are based on very tightly constrained levels of blood sugar, etc. (negative feedback-based), and effectiveness plummets when tight regulation deteriorates.

Once the constraint structure is in place, random energy (cheap) can now be input at a high level - and the constraint structure will turn it into very precise high-level work. This Platform Structure will be then used like a bridge formwork to squeeze cheap energy - at the next higher level - with many degrees of freedom into energy with few degrees of freedom, i.e. to constrain Heat into Work (or to transform a multi-purpose substrate into specific protein output). This is now happening at the higher level.

Sequential steps of this process, each building on the level below, can eventually allow the cheap disorganized energy to become highly complex Work: this is the NegEntropy Pump. What is created at the highest level of the Controller, is then a set of high energy action-potential possibilities available to be used as environmental challenges arise. This "fully loaded" repertoire would correspond with Ashby's image of the Responder for a complex organism with maximal variety.

Such a formulation was our goal. We cannot claim to have outlined the only relevant pathway, however, we have traced one formulation, of broad generality, that implies an analytic limit.

EVIDENCE FOR THE ORDERING CAPACITY MODEL AND ITS IMPLIED LIMITATIONS

A full discussion of the many levels of physiological evidence for these hypotheses is beyond the scope of this short paper. Even a full discussion of the implications of the basic science propositions above for physiological process and disease development cannot be included here. The longer discussion (see web manuscript: Stress-Disequilibrium Theory at www.jcqcenter.org see: 30th anniversary) evolves nine principles relating to the basic science approach above and its extension toward explanation of disease: the 3-part model; independence of levels; consumption of ordering capacity; the NegEntropy Pump; gradients cyclically returned to baseline; and multi-level homeostatic processes; instability of flows/equilibrium shifts and disease; creation of high-level physiological functions; and inversion of the constraint effect for sentient organisms.

Using these principles we can trace a path along which Ordering Capacity might be "pumped-up through seven-levels of physiological control" - from photosynthesis of organic molecules, all the way up to control of complex behavior in a human Fight/Flight social behavior. Empirical research long ago demonstrated that Second Law limitations do indeed directly govern the chemical processes, at least the lowest two levels of this formulation. For example, the basic equation of chemical reactions, the Gibbs Free Energy equation, can be used to predict the human body's basic molecular and protein-synthesis chemical reactions with a high level of empirical accuracy. The equation predicts reaction rates based on the internal ordered energy of inputs (i.e., their NegEntropy), temperature (i.e. ambient disordered heat energy), and then the entropy (NegEntropy) of their outputs.

Furthermore, we feel evidence of Second law-like limitations can be found at the top levels, both at Level Seven (the low control/high demand psychosocial epidemiology chronic disease noted above) and in the research described below at Level Six: autonomic regulation of cardiac output (3). We attempt to demonstrate via a continuum of evidence, that laws which are obviously valid at lower levels, also apply to higher-level phenomena. However, we are currently aware of relatively little Second Law limitation evidence at the middle levels. Thus, an unbroken chain of ordering capacity limitation evidence - the necessary strong confirmation of overall validity of the theory in a Second Law context - is still only a hypothesis. However, the suggestion is clear.

For example at Level Six, Collins, Karasek and Costas (2005) (5) show the strong association between low workplace social control and diminished cardiac high frequency power (HFP - i.e. parasympathetic cardiac autonomic control capacity) - in 48-hour Holter monitoring during a work and rest day period for a sample of 36 healthy middle aged males in high strain and low stain jobs (jobs assessed by questionnaire, event diary, and occupational titles). Low job control was associated with significant reductions in vagal control of the heart/parasympathetic response that persisted after work, during the entire 48-hour monitoring period ($p = .004$). Low external control at work (also high strain work) appeared to be associated with a "depletion" of vagal control capacity from the week's work that persisted for most of the weekend.

This demonstration of an extended limitation on normal function of the autonomic nervous system may help explain, for example, the increased risk of high blood pressure with high job strain-related elevations in blood pressure. Heart rate is described by Sloan et al (19) as having the function of stabilizing the blood pressure, through its response variability. In this case, the heart rate is "the controller" and the blood pressure is "the controlled." It can be easily hypothesized that parasympathetic vagal response controls the heart rate (at least its main influence). With the heart rate variability controlling the blood pressure - this yields a two-step linkage to a chronic disease endpoint, and empirical support of our broader hypotheses about chronic disease development. This is also consistent with our observation that the purpose of the variability in the controller's response is to maintain the stability of the organism in the face of environmental demands.

Conclusion

We have outlined a Second Law-based thermodynamic formulation to explain how low external control could restrict internal physiological self-regulation and cause chronic disease, and have found empirical support for this formulation in a short review. Our initial definition of External Control makes it clear that an individual's external social action strategies for addressing external challenges could be cut off by external organizational constraints - cutting out major portions of his/her Ashby response matrix. We have also examined the general processes by which low external control prevents the development of internal Ordering Capacity to begin with. For example: low level inputs are not synthesized, homeostatic contexts are not maintained, translation of inputs into effective high level action platforms is not accomplished. These can be in turn due to a myriad of social determinants that limit options available in a socially constrained world.

A high level explanation of chronic disease

We have also attempted to sketch the basis of a generalized explanation which could help explain multiple chronic diseases and co-morbidity. Additionally it is a "high level theory" where functionality and control capacity limits at any level could plausibly be a sufficient explanation of disease - hypothetically without major contribution of lower level causes. The high level failures of control capacity could be themselves sufficient to explain disease - as in the case of our unsuccessful War Lord.

The explanation above shows that levels within a complex organism, although clearly connected, could operate partly separately in terms of energy-to-order transformations. In the long term low-level processes would indeed contribute to ordering capacity by contributing to the building of the control capacity platform - the reflection of linkage between the levels. However, in the short term such contribution may not have had time to occur because of many efficiency limitations, reflecting the independence of levels – and leaving higher levels vulnerable in terms of their own level-limited ordering capacity.

An important implication of the theory is that overwhelmed ordering capacity for the organism as a whole could cause failure of high level functions first since this is the originating location of coordinated response. Acute disease onset could occur without failure of low-level functions. This could be the case for regulation-related chronic diseases, and a reason that social organizational changes in control structures could have direct health promoting effects.

Many of our pharmaceutical cures and genomic explanations, are now addressed to low-level physiological deficiencies only. Certainly they have effects at multiple levels, but their predominant low-level focus means that the independence of intervening levels would diminish their direct effects - since each level could have its own independent energy-to-order transformations. It is the social environment, setting the context at the very highest level, which must be redesigned to promote more effective capacity development. Our high-level explanation of health risk could directly confront the economic ideological explanations that drive the development of the social institutions that produce most of the social stressors in the first place.

The linkage between organization of work and physiological ordering capacity

The nature of much work in modern society's social institutions is to create Order out of Disorder - as opposed to our species' original obligations to meet purely biological needs. Global competition continually fosters increases in production capacity, efficiency, and creates ever-deeper engagement by workers in the work demands of their complex organizations. And the serious new problem that "low external control" could lead to "low internal control" is further supplemented by the other equally serious problem in our global economy: increasing work "demands."

Thus, according to our ordering capacity-based definitions, our social institutions could directly create a type of internal physiological demands for individuals that could directly increase their risk of chronic disease. The complexity of these "social organizational challenges" also occur during a "disordered" daily cycle of rest and refresh in a 24-hour, 7-day week economy, with all adult family members often focused first on their work.

Many modern methods of work organization have made work more difficult - in ordering capacity terms - than it was in the time of our genetic adaptation to the natural environment challenges as hunter-gathers. For example, Frederick Taylor's Principles of Scientific Management, introduced at the beginning of the 20th century manufacturing era, focuses on increasing work actions that involve sympathetic arousal to increase work output, while eliminating periods without apparent production as "waste" - i.e., rest - which are often periods of parasympathetic balance. Similarly, current lean production Just-in-Time and Critical Path Methods of work organization methods have as their central principle that resources should be removed from the production process until it just begins to fail - to avoid organizational waste. This creates pressure for workers to make up the slack, always on the edge of failure - always maximally aroused.

The current challenge of the global economy

The global economy is rapidly creating new levels of social organization that could reduce, rather than improve, the overall possibilities of maintaining stable life platforms. The work situation less-and-less often provides a long-term platform for life and family development - something that in earlier times was provided in a package along with skilled performance and a wage - as a "job" a daily platform of stable, manageable, and sustaining activity. This is the equilibrium of flows that our Central Controller of our Second-Law based model is charged to maintain, here understood at the level of daily life.

Alternatively, if the worker can maintain an easy equilibrium is his/her context, work can be used as the platform for personal development in a career; it is the basis of a meaningful identity and social role in the society (family, career, etc.). The central question remains closely linked to the themes of this paper: how much "long-term, broad-ranged control" the worker has over his/her life, via his/her employment or main social role. This broader form of social "control" is the freedom to act using your repertoire of skills, within the social structures where you have made your social investments and where your get your major life-sustaining rewards.

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Cardiovascular risk as a paradigm of the negative consequences of stress at work: a large amount of data and huge problems

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Key words
Cardiovascular risk; stress at work; social disparities

Summary
The relation between stress and coronary diseases is controversial. Both positive and null or negative results are equally obtained. An explanation of this can be that the most widely used stress questionnaires are not able to collect all the factors that constitute stress perception. Indeed, from a clinical and experimental perspective, the stress/coronary diseases relation is evident. More consistent results are obtained between coronary diseases and socio-economic status. In order to cover all the social factors and describe them better, a new, purely theoretical contribution is then introduced: social capital. This is a more sophisticated version of social cohesion, social integration and social support. Finally, for the future, the interdisciplinary method is recommended for health surveillance in the workplace.

Riassunto
«Rischio cardiovascolare come paradigma delle conseguenze negative dello stress al lavoro: grande quantità di dati e grandi problemi». *I rapporti tra stress e coronaropatie risultano controversi. A riscontri positivi ne corrispondono altrettanti nulli e negativi. Una spiegazione di tale differenza può essere la capacità limitata dei questionari più utilizzati nella valutazione dello stress, di considerare tutti i fattori legati alla sua percezione. Infatti dal punto di visto clinico e sperimentale la relazione è evidente. Risultati più consistenti sono stati trovati tra malattie cardiovascolari e stato socioeconomico, interpretato come condizione di disadattamento legata a situazioni di stress. Per affrontare meglio la questione viene introdotto un nuovo contributo speculativo, di natura totalmente teorica: il capitale sociale. Questo è inteso come una versione più sofisticata della coesione, del supporto e della integrazione sociale. Per il futuro, si raccomanda interdisciplinarità nell'impostazione di sorveglianze sanitarie degli ambienti di lavoro.*

Introduction

The research on the relationship between occupational stress and cardiovascular disease has its roots in the physiology of adaptation mainly developed by Hans Selye (1907-1982) on the basis of Claude Bernard's homeostasis concept and of Walter Cannon's studies on the emergency role of adrenaline (*Bodily changes in pain, hunger, fear and rage,* 1915). Many other findings have been added

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over time. Selye (51) himself noted in 1976, that since his first letter to *Nature* forty years before on *A syndrome produced by diverse nocuous agents*, 110,000 papers were published. While preparing this presentation, I have found about 4,000 references in MEDLINE, 2001-2005, including the keyword *stress* in combination with *cardiovascular disease*, *coronary disease* and *hypertension*. Knowledge on biochemical pathways has been greatly expanded, as well as the availability of physiological measures. Biological effects of stress are related now not only to the activation of the autonomic nervous system and hypothalamic adrenal axis (29), but also to inflammatory (7), oxidative (44), coagulation (55) processes and gene environment interactions (18). On the contrary, the investigation on subjective perception has been restricted to a few instruments, among which the questionnaires derived from the models of Karasek (22) demand/control – and Siegrist (52) – effort/reward – are the more commonly used.

The disproportion between the apparent, wide biological awareness and the paucity (in the sense of "a few" and "a little") of psychological assessments depicts the problem of "stress and disease", particularly occupational stress and cardiovascular disease. The findings are controversial. In a recent and extensive 2004 review, the authors (6), who themselves are involved in occupational stress research, hence advocates of the relationship between stress and cardiovascular diseases, cannot but cite a number of negative or non significant results equal to the positive ones. Other negative results have been reported afterwards and in major studies (14, 15, 45). Our personal experience also shows positive and negative findings, obtained with exactly the same methods, albeit in different population samples (17). However, negative findings cannot abolish the positive ones, which "persist" and are repeatedly observed in the same and very distant research groups (19, 25, 43). It may be that the dissimilar characteristics of the samples make the differences in the results. It seems that the most widely used questionnaires are not able to collect all the factors which constitute and graduate stress perception; this impression is growing as the same instruments are used repeatedly.

On the other hand, clinical and experimental evidence of the influence of stress on the cardiovascular system and on the evolution of cardiovascular disease is a fact (4, 30, 50). Stress modifies heart rate, blood pressure and their metabolic correlates. Stress prolongs the recovery from a coronary event, can aggravate it or even bring about a heart attack. No guidelines on prevention or treatment of cardiovascular diseases ignore the counseling about the importance of controlling major tensions in life and work (9, 42). Intolerable emotions can be a cause of disability in a coronary patient (1, 41).

Unfortunately, the accurate observation which is possible in a clinical and experimental setting, is not possible in epidemiological field studies. In the chain which links occupational stress to cardiovascular disease – *occupational discomfort_ stress_ biological mediators_ risk factors_ disease* – each step is only an etiological fraction of the subsequent one. Too many variables can intervene altering the hypothesized causal passages and, actually, in field research results are not absent, but diverse; sometimes results are in one direction sometimes in another that may be the opposite (10).

More stable results on the relation of cardiovascular disease with psychosocial factors are reported for socio-economic status, or SES, usually defined by education, occupational level, neighborhood area or income, taken singularly or together (2, 8, 21, 28). Stress is not excluded by the definition of SES, because it may alternatively represent the synthetic or partial index of the adaptation difficulties, considered respectively as a whole or as a specific emotional hazard. In any case, the hypothesized biological mechanisms are the same mentioned above. Cardiovascular disease (CVD) appears to show a higher incidence and gravity in lower social classes, and the difference is claimed to increase in all western societies. Evidence for this relation has been derived from prevalence, prospective and retrospective cohort studies. A good review of the early works done on SES and CVD mortality can be found in Kaplan and Keil (20) with articles dating back to 1949. Now major studies on incidence are also available (in addition to the above references, see 38, 54). Higher incidence may simply mean that the "western" decrease in cardiovascular disease is less manifest as the social condition deteriorates. The phenomenon has been observed also in low incidence Mediterranean countries, where the opposite was true until a few decades ago (11, 16).

Recently, a strong debate has been initiated among epidemiologists on the connotation of social class and, in particular, of its bio-psychological counterparts. The concept of "social capital" has been introduced with the aim to better embrace and describe the factors which human existence is confronted with in societal organization and thus exposed to the unavoidable "wear and tear" of life.

A novel, theoretical contribution to the study of stress at work

The concept of social capital has long existed in economics, but it was only in 1996 that it made its appearance in public health (57). It was launched under the perspective of a more sophisticated version of social cohesion, social support, social integration and civic society (47, 48). The theory was then developed in more detail. In their paper, Szreter and Woolcock (56) identify three different views: the social support perspective, the inequality thesis and the political economy approach. The social support school believes that health outcomes are strongly connected to social relations and norms of reciprocity, as chronic and degenerative conditions decrease when there are good social networks. The second school of thought sees social capital issues as part of the psychosocial effects that widen the level of social economic inequalities (57, 36). Marmot, in particular, links this idea to the concept of stress seen as the absence or loss of autonomy over one's life course, recalling and expanding the *job strain* construct of Karasek. Finally, for the political economy approach, social capital is confined to access to material resources as these are the roots of inequalities in health and induce political and ideological decisions (13, 31).

Szreter and Woolcock introduce a new approach to try to unify the three assumptions. They differentiate social capital in the forms of *bonding*, *bridging* and *linking*. Bonding social capital refers to the relations of trust and cooperation between members of a network who see themselves as being similar. Bridging social capital refers to the relations of respect and mutuality between people who know they are not alike in social identity or socio-demographic sense. Finally, linking social capital refers to the norms of respect and networks between people interacting with explicit, formal power or authority. The social support perspective and the inequality thesis are compatible both with bonding and bridging, while the inequality thesis and the political economy approach are "unified" through linking

The Szreter and Woolcock contribution is considered very valuable as their attempt to reconcile all the different explanations provides a starting point for working on a common ground (24, 39). However, there are some issues that need to be resolved. First, it is necessary to decide if social capital should be interpreted as an individual or a collective property (46). Second, there is the need for measuring instruments which could distinguish between bonding, bridging and linking. Third, models integrating social structures and psychological exposures should also be introduced for better understanding of the determinants of morbidity and mortality. The discussion on how and whether to integrate stress theories to social capital develops from here. Fourth, there are still people like Putnam and Navarro (40, 47) who are not entirely convinced with Szeter and Woolcock's definition of social capital. Putnam states that health should not be considered an outcome of social capital. He claims that adding the category of linking social capital is not a valid, reliable, or substantively important feature. Indeed, even though, in principle, networks interacting through formal power are essential in any civic society, the distinction between "responsive" and "exploitative linking" should be made, as not all vertical networks have pro-social consequences.

So, the debate is on whether social circumstances should be understood and tackled to determine health outcomes. A big discussion, just on stress and CVD, was reported in the 2002 December issue of the *International Journal of Epidemiology*. Two of the contributors were Marmot and Beaglehole (5, 35). Marmot, on the basis of his long experience of stress studies on British civil servants (34), emphasized that healthy behaviours should be encouraged across the whole of society and that more attention should be paid to social environments, job design and the consequences of income inequality. Beaglehole, as a "pure" epidemiologist, claimed that, as traditional risk factors explain at least 75% of new cases of CHD, it would make more sense to identify and reduce them, thus increasing the proportion of people at low risk. In Beaglehole's opinion, acting on social factors would not produce much benefit as their contribution to population health is limited and unclear.

What is still really being discussed is whether social epidemiology, i.e. the science that studies the link between social environment and the development and distribution of disease in population, is a useful tool or not. This has obvious consequences also for occupational stress research.

Generally speaking, no one is truly denying the importance of sociology and psychology in the understanding of health phenomena, but the disagreement is more on how much "shopping in neighbouring fields without thorough subject matter knowledge" should be allowed (58): lack of good knowledge of both fields may only lead to statistical results without relevant meaning. Indeed epidemiology and psychology rely on very different backgrounds and so on very different methods and measures. The first discipline is based on experimental science and human biology, the second relies on socio-psychological theories.

Krieger (27) claims that ignoring the social determinants of social disparities in heath precludes adequate explanations for actual and changing population burdens of disease and death. Other authors (37, 53) also do not believe in the need of drawing boundaries around epidemiology to only include the biological side. These authors are very much in favour of social epidemiology as some of the greatest achievements in epidemiology have been possible thanks to the cooperation of other disciplines. For example, malaria distribution was studied thanks to entomology and ecology, the spread of HIV/AIDS with a detailed ethnology of human sexuality (23). Also, these authors believe that intellectual development can be achieved by different means, and it is not necessarily a specialization that determines correct knowledge.

Conclusion

It is acknowledged by most of the medical community that the social gaps – between the poor and the rich, the stressed and the adapted, the worker and the manager – in the very same society are a cause of health disparities. Such differences are observed especially in relation to cardiovascular disease: should we concentrate on social theories to reduce it "uniformly" or should we act directly on the risk factors? The answer is obvious and is "both" (3, 12, 33). But it is not a one man job. An interdisciplinary approach is obviously required.

The most important international health institutions have been fostering this kind of approach since the WHO, in 1946, defined health not only as the absence of disease, but as physical, psychological and social wellbeing. What needs to be avoided is the presumption to explain everything, i.e. the so called "umbrella theory". This ends up confounding the real results that have been objectively achieved.

Indeed the studies investigating social capital are really looking at the fact that, whatever we take social capital to mean, having "a lot" of it seems no doubt to be something positive. What we can do is to proceed by studying the influence on health of the lack or the shortage of social capital, i.e. low education, support, income, working conditions that cannot simply be characterised as someone's choice, and so on. As Kornhauser (26) said in 1965, "*The unsatisfactory mental health of the working people consists in no small measure of their dwarfed desires and deadened initiative, reduction of their goals and restriction of their efforts to a point where life is relatively empty and only half meaningful*".

Shopping too much in neighbouring fields without really knowing the other disciplines can lead to very serious errors of interpretation. Probably a thorough knowledge of sociology and psychology may not be essential, but a good enough knowledge of them is essential (32). This is a recognized exigency and a collaboration issue in modern clinical medicine. Occupational medicine should rediscover its clinical origin and method and apply it not only to individuals, but also to the investigation of groups. Stress is not a disease, but a symptom. Its relation with the disease is multifaceted in individuals as well in groups. It is the clinician who, by carefully observing the patient for enough time, can understand the true reason for the discomfort and the best therapy, which may be different for the same symptom. This process in the workplace is called *health surveillance*, and it is the most appropriate context in which the consideration of stress and disease is worthwhile through a progressive and endless approximation.

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La Medicina del Lavoro Med Lav 2006; *97*, 2: 278-279

Wednesday - June, 14 2006 - Semi Plenary

Work and cardiovascular disease

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Key words
Cardiocascular disease; hypertension; risk behaviour

In the US, cardiovascular disease (CVD) is the cause of 41% of all deaths. An estimated 250,000-350,000 people annually die suddenly of heart disease in the U.S. and an equal number lose their lives more slowly due to manifest CVD from which they have chronically suffered. By age 60, 60% of American workers will have developed hypertension a major risk factor for stroke and CVD. While morbidity and mortality have leveled off or declined slightly in the U.S. and Western Europe there have been dramatic increases in CVD morbidity and mortality over last 30 years in Eastern European countries as well as rising prevalence in many developing countries. "It has been projected that cardiovascular disease worldwide will climb from the second most common cause of death… in 1990, to first place, with more than 36 percent of all deaths in 2020" (Braunwald 1997, p. 1364).

The traditional medical approach to managing the CVD epidemic has focused on individual traits, especially genetic susceptibility and on risk behaviors (such as smoking, diet, sedentary lifestyle). The primary strategies – which have successfully reduced mortality but not prevalence or incidence - has been better management of atherogenic risk factors, use of medical treatments and technological advances, and research into the molecular biology of atherogenic and other cardiodegenerative processes.

The failure to curb the CVD pandemic results, in part, from the focus by modern medicine on treatment as opposed to primary prevention. Each of the "traditional risk" factors such as smoking, obesity, sedentary labor/physical inactivity, diabetes, elevated cholesterol/LDL and/or decreased HDL and hypertension has a strong material base related to modern societal development. We should think of the "traditional" risk factors as social constructs – each tied to unique social and historical developments in modern capitalism. Modern work organization – which refers to the work process and organizational practices that influence job design and work itself – plays an important role in the development of many of these risk factors. Work has changed dramatically over the course of the past 200 years. In particular, craftwork has been replaced by industrial processes. Skilled workers have been replaced by lower – skilled labor in new machine-based production. Taylorism reshaped the workplace with its emphasis on narrow performance and efficiency using the technique of the assembly line, at the expense of broader employee knowledge of the work process. White-collar work, through office automation, has also been shaped by principles of the assembly line. Globalization has extended and accelerated many additional changes.

Modern aspects of work place a burden on the human nervous system. On the one hand working

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and working conditions contribute to personal growth, well being and enhanced self esteem while on the other hand the same factors (under different conditions) or other working conditions can be detrimental not only to mental health and well being, but to physical health as well – blood pressure, back pain, diabetes, heart attacks and stroke – and death, so much so that scientists refer to some of these characteristics as 'hazards' of the 'psychological and social work environment' to which employees are 'exposed.' Changes in work have resulted in a new generation of "psychosocial stressors" such as job strain, effort-reward imbalance, and threat-avoidant-vigilant work. These exposures are so pervasive in the U.S. that workers at all levels (and all sectors) are experiencing significant stress at work; the National Institute for Occupational Safety and Health (NIOSH) reported in a 2002 survey that 60% of the U.S. working population reported feeling work stress.

Each of the traditional risk factors for CVD; lipids, smoking, obesity, diabetes, and hypertension have been shaped and influenced by the changes in modern work. Recent research findings on the role of work in contributing to the development and expression of each of these risk factors will be explicated. The analysis will clarify the role that inequalities of power and autonomy play in the development of CVD and makes clear that it is possible to design work that promotes both health and well-being and, in many cases, productivity as well.

La Medicina del Lavoro Med Lav 2006; *97*, 2: 280-287

Flexibility of working hours in the 24-hour society

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Key words
Shiftwork; social organization; working times

Summary
The 24-hour Society undergoes an ineluctable process towards a social organisation where time constraints are no more restricting human life. The borders between working and social times are no more fixed and rigidly determined, and the value of working time changes according to the different economic and social effects you may consider. Shift and night work, irregular and flexible working hours, together with new technologies, are the milestone of this epochal passage. What are the advantages and disadvantages for the individual, the companies, and the society? What is the cost/benefit ratio in terms of health and social well-being? Coping properly with this process means avoiding a passive acceptance of it with consequent maladjustments at both individual and social level, but adopting effective preventive and compensative strategies aimed at building up a more sustainable society. Flexible working times now appear to be one of the best ways to cope with the demands of the modern life, but there are different points of view about labour and temporal "flexibility" between employers and employees. For the former it means a prompt adaptation to market demands and technological innovations; for the latter it is a way to improve working and social life, by decreasing work constraints and increasing control and autonomy. Although it can be easily speculated that individual-based "flexibility" should improve health and well-being, and especially satisfaction, whereas company-based "flexibility" might interfere negatively, the effective consequences on health and well-being have still to be analysed properly.

Riassunto
«La flessibilità degli orari di lavoro nelle Società delle 24 ore». *La "Società delle 24 ore" appare oggigiorno un processo ineluttabile verso un'organizzazione sociale dove le costrizioni temporali non sono più una limitazione per le attività dell'uomo. Tempi sociali e di lavoro non sono più fissati rigidamente, e il loro valore cambia in relazione ai diversi effetti di carattere economico e sociale vengano considerati. Il lavoro a turni e notturno, gli orari di lavoro irregolari e flessibili, associati alle nuove tecnologie, forniscono un supporto basilare a questo cambiamento epocale. Ma quali sono i vantaggi e gli svantaggi per l'individuo, l'impresa e la società? Qual è il rapporto costi/benefici in termini di salute e benessere sociale? Affrontare in modo appropriato tale processo significa evitare di subirlo passivamente, con conseguenze negative in termini di disadattamento individuale e sociale, e invece mettere in atto efficaci strategie preventive e compensative verso una società più sostenibile. Gli orari di lavoro flessibili sembrano essere uno dei modi migliori per far fronte alle richieste della società moderna, ma vi sono punti di vista diversi sulla "flessibilità" tra datori di lavoro e lavoratori. Per i primi essa significa un pronto adattamento alla domanda di mercato e alle innovazioni tecnologiche, per i secondi uno strumento di miglioramento delle condizioni di vita e di lavoro, in grado di attenuare le costrizioni e aumentare l'autonomia. Quantunque si possa ragionevolmente ipotizzare che una flessibilità "orientata all'individuo" abbia effetti positivi, mentre una flessibilità "orientata all'impresa" possa interferire negativamente, le effettive conseguenze sulla salute e sul benessere delle persone devono ancora essere analizzate compiutamente.*

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Introduction

At present, time is the main unit of measurement for human activities: space is very often measured by time (e.g. travelling time) and new technologies made possible to break the link between work place and working times (e.g. telework), the value of which changes according to the different economic and social consequences they have at different periods of the workers' life. Time has become a strategic issue and we are more and more accustomed to using it in several and different ways: full-time, part-time, just-in-time, day time, night time, flex-time, time pressure, are some of the most common labels of our everyday working life.

The borders between working and leisure times are no more fixed and rigidly determined by the normal diurnal working day. Waking hours are not only extended to evening and night hours as well as to week-end days, but hours of duty have become more variable. Obviously, all that should be aimed at contributing to improve the quality of human life (more goods and services, higher salaries, better leisure activities, etc.) in a society that never stops ("24-hour Society") and requires continuous adjustments to its development and organisation (13, 16, 18). Working times are one of the main factors involved in such "adjustments" and their various arrangements together with new technologies are the milestones of this epochal transition to the post-industrial Society. The main problem is whether the workers are able to cope with these changes and with new forms of social and work organisation, by having advantages and avoiding drawbacks (4). Flexible working times have been advocated for some time and now appear to be one of the best ways to cope with the changing demands of the modern working life, but what do we know about their effective influence on health and well-being?

Forms of "labour flexibility" and interests in flexible arrangements of working hours

There are several approaches and models to define "labour flexibility", depending on the kind of work, personal and social criteria and perspectives you may consider. As pointed out by Goudswaard and De Nanteuil (8), "flexibility emerges as a heterogeneous concept, mixing two series of variables: quantitative/qualitative and external/internal, with consequent several possible combinations between these variables", i.e. "numerical", "geographical", "temporal" and "functional" flexibility. They are strictly linked to each other, and their impact on working conditions, health and well-being is influenced more from their interactions rather than as a direct effect of a single aspect.

The increasing interest on Flexible Working Times in recent years reflects broader societal reasons, involving social development, economic efficiency and individual behaviours. These are connected, on one hand, to policies concerning globalization of labour market, economic and productive strategies, as well as employment policies; on the other hand, to a progressive transfer of attention from the quantitative to the qualitative aspects of work and social activities, among which working times represent the most important interrelated factor (i.e. the reduction of weekly working hours which is now shifting to the search and implementation of new forms of flexible arrangements of working time).

Moreover, the general ageing of the population, the increasing immigration of people from eastern to western and from southern to northern countries, the massive entry of women into the labour market, the increasing number of one or two person households are some of the main aspects of this epochal passage, in which the arrangement and interaction of working and social times acquire an overwhelming importance, taking into account that working and non-working (leisure, social, family) times are interrelated both on the chronometric (i.e. duration of duty periods and length of free-time) as well as on the chronologic (i.e. position and distribution of the different periods) dimension.

"Flexibility of working times" has many meanings and interpretations: for instance, there are different points of view between employers and employees. The former are keener to see it in terms of prompt adaptation of production systems to fluctuations of market demands and technological innovations, thus leading to a higher exploitation and diversification of operating hours. On the other hand, employees consider it an important tool to improve "work-life balance", by decreasing work constraints, increasing the possibility of employment, and gaining more autonomy over their own affairs. The society is interested in flexible working hours as well, as many advantages can derive from a more articulated arrangement of social activities and services (e.g. reduce unemployment and social disparities, fulfil client's convenience, support more vulnerable groups, improve retirement policies).

"Company based flexibility" meets the needs of employers, i.e. changing operational timetables, varying customer and service times. Strategies of company-controlled flexibility include, for instance, overtime, shift and night work, week-end and seasonal work, adding/cancelling/splitting and extending/shortening of shifts.

"Individual based flexibility" meets the changing needs of employees according to varying family and social contexts and phases of life (i.e. ageing, study, family, health), providing more autonomy regarding starting and ending times as well as breaks, days off and vacations.

One of the questions with negotiating flexible work hours is the problem of discretion or autonomy of both parties. Flexibility has to do with making decision about work hours and adapting them to both company's and worker's demands. Since neither form relying completely on the discretion of one of the partners involved seems to be acceptable from a societal perspective, the main problem is how and who is in control of the work hours, to which amount and whether there is a fair share of interests so that employers and the employees are able to negotiate working hours, based on an equal discretional power, able to properly balance time restrictions with time autonomy. Shift work, for example, enables the company to extend operating hours, the workers to increase wages, as well the Society to improve public utilities. However, shift and night work may severely interfere with workers' health and well-being, unless appropriate countermeasures are taken both in terms of reduced working hours, ergonomic shift schedules and support to worker's coping strategies (10, 12).

WAYS AND METHODS SUITABLE FOR INCREASING COMPANY AND INDIVIDUAL FLEXIBILITY OF WORKING HOURS

The search for ways and methods suitable for increasing the flexibility of the working systems, particularly of working times, can include several different interventions both in short- and long-term periods according to the temporal scales that one may consider (table 1). The type of interventions depends on the prevailing factors that at different times influence political choices in work and social organization.

In the short-term, one may expect that work hours may be altered for limited periods in terms of increased or decreased hours worked per day or week and/or changed position of work hours (for example, adding a night shift to a two-shift operation), in order to cope with increasing temporal (seasonal, peak hours, just-in-time production) demands for goods and services, as well as to reduce production costs.

In the long-run, the interventions are linked to more complex planning or adjustment of professional career, and to adaptations of working life to living and social conditions (i.e. temporary interruptions or reductions for education or maternity and child care, early or delayed retirement).

Looking at the data of the 3rd EU Survey on Working Conditions, carried out in 2000 in 15 European countries (17), we can see that the so-called "normal" or "standard" working hours represent the exception rather than the rule. In fact, if we do not consider persons working more than 40 hours per week, and more than 10 hours per day, on shifts, at night, on Saturday and Sunday, and at part-time, we find that people working the traditional "nine-to-five workday" week are now less than one fourth of the whole population (table 2). Significant differences can be seen according to: a) way of employment, where it is worth noting that only 8% of self-employed workers work on "normal" day work; b) gender, where overtime for men and part-time work for women make the largest differences; c) country, being the patterns widely influenced by different economic, cultural, political and social backgrounds (figure 1).

Table 1 - *Possible working time arrangements of working hours (WH) according to different temporal scales and type of intervention*

Intervention	Period			
	Day	Week	Year	Life
Increase of WH with higher salary	Overtime	Overtime	Loss of infra-week days-off	Delayed retirement
Re-arrangement of the same amount of WH	Splits shifts; different start and end of duty periods; on call work	Compressed work week; FWH with weekly/monthly recovery; variable shifts	Staggered holidays; seasonal work; bank of hours; autonomous work hours	Flex start/end of working life; long-term bank of hours; periods of recoverable interruptions
Reduction of WH at the same level of salary	<8-hour shifts ("6x6")	Short week; very short week	Increase of holidays; bank of paid leaves	Early retirement; planned stops by accumulating paid leaves
Reduction of WH with reduced salary	"Horizontal" part-time	"Vertical" part-time	Seasonal work; job-sharing	Reversible transfer from full- to part-time work; unpaid leave; smooth retirement
Reduction of WH with transfer of costs to the community	Solidarity contracts	Wage Supplement Fund; Solidarity contracts	Temporary Wage Supplement Fund	Early retirement

Table 2 - *Prevalence (%) of people working on different working hours*

	All	Employed	Self-Employed	Women	Men
Total sample	100	100	100	100	100
no more than 40 hours per week	77	84	44	86	70
+ no more than 10 hours per day	58	64	26	70	48
+ no night work	52	57	24	65	41
+ no Sunday work	45	50	20	54	37
+ no shift work	41	45	45	50	33
+ no part-time work	31	34	15	31	31
+ no Saturday work	24	27	8	24	24

In the United States, the data of the May 2004 Current Population Survey (21) show that over 27 million full-time wage and salary workers have flexible work schedules that allow them to vary the time they begin or end work. Flexible schedules are more common among men than women, among white workers than black or Hispanic or Latino workers. Among the major occupational groups, flexible schedules are more common among management, professional and related occupations, and among sales and office workers. In contrast, far less construction, maintenance, production, transportation, and material moving workers have such flexibility.

Thus, working hours appear to have changed quite extensively in the last decades, and the wide range of patterns adopted represent how many possibilities there are for adjustment of working times to work demands and personal needs.

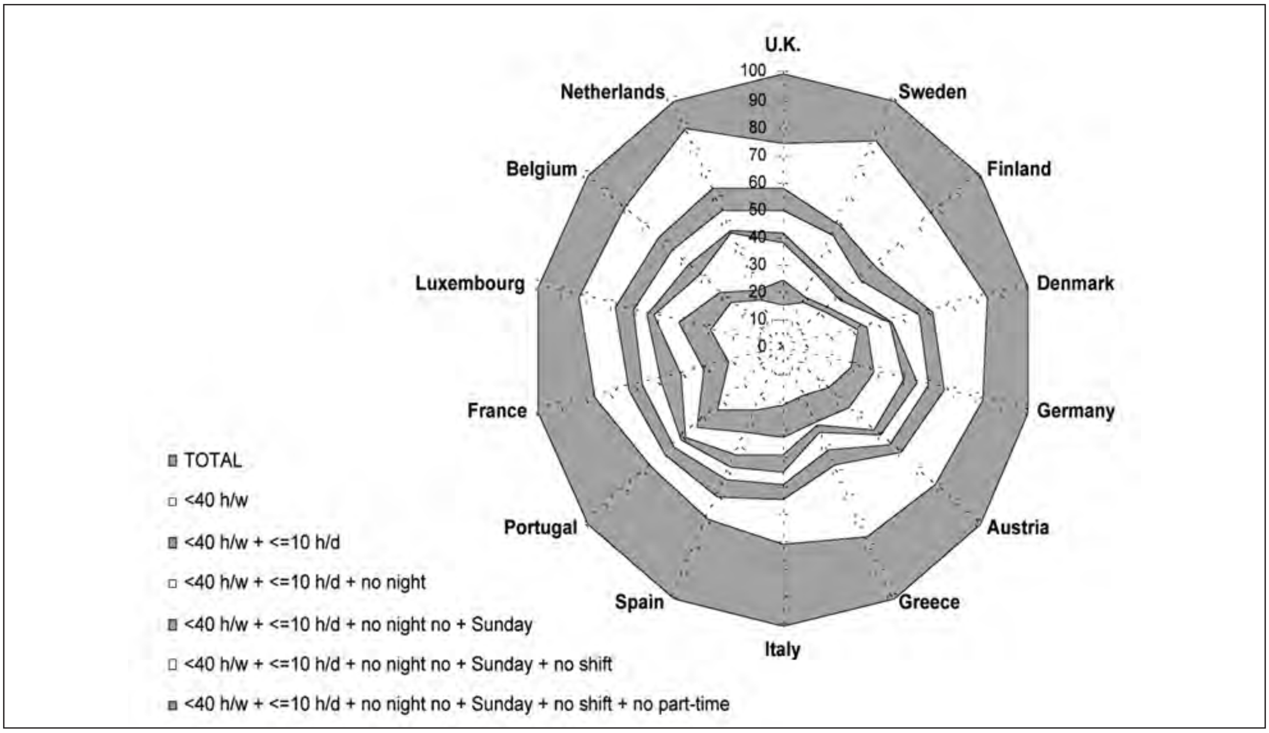

Figure 1 - Prevalence of people engaged in different working hour patterns in 15 EU countries in 2000 (3rd EU Survey on Working Conditions)

What problems for health and well-being?

Clearly, flexible work hours may result in changes in total working time, work shift duration, amount of night work, and greater variability in work hour patterns, which may have effects on performance efficiency, health, family and social life. Although it can be easily speculated that, in general, "individual-based flexibility" should improve health and well-being, and especially satisfaction, whereas "company-based flexibility" might interfere negatively, the effective consequences on health and well-being have still to be analysed properly, taking into account both subjective and objective criteria and outcomes, and differentiating different forms of flexible working hours.

As for health, for example, we have some epidemiological evidence on the deleterious effects of night and shift work on fatigue, sleep disturbances, accident risk, cardiovascular and gastrointestinal diseases, as well as on family and social life (1, 11). But it is also evident that such effects can be strongly influenced by many intervening factors related to several aspects pertaining to different domains, dealing with personal characteristics and coping strategies, as well as with family, social and working conditions (5). The result of their interactions depends not only on the specific load of each factor, but also on their temporal occurrence and duration in the worker's life. Similar effects could thus be expected from increases or changed patterns of hours of work and non-work hours (19, 20). Particular problems can arise in case of seasonal work, week-end work or compressed work weeks (i.e. 12-hour shifts), where the "compensation" for the accumulation of long work hours and excessive stress and fatigue is postponed in the long run, or simply replaced by monetary reward.

Flexible work hours, if resulting in irregular work hours, may also contribute to the risk of social impairment. Persons engaged in "non-standard" working hours can frequently be "out of phase" with society and can face greater difficulties in their social lives, since most social activities are still arranged according to the normal day-oriented rhythms of the general population. This can lead to some "social marginalisation", particularly when it refers to groups of persons requiring regular contacts (e.g. sports and religious events, political and social groups). "Irregular" work hours may also interfere with the co-ordination of family timetables according to family composition (i.e. number and age of children, cohabiting persons), personal duties (i.e. school, housework), and availability of public facilities (i.e. shop hours and transports). "Time pressure" is a constant condition among those who have a high family burden (e.g. women with small children), and this can have a negative influence on marital relationships, parental roles and children's education and socialization (3, 15).

On the other hand, flexible work hours can permit a more tailored use of daytime hours to comply with particular needs or preferences (i.e. access to public services, to study, moonlighting, hobbies) or in case of persons who give a higher priority to family and domestic commitments than to personal leisure.

Many other factors concerning individual characteristics can interact and influence the effect of "irregular" work hours. One of the most important refers to ageing, which may cause greater difficulties in coping due to reduced psycho-physical fitness, decreased restorative properties of sleep, and proneness to internal desynchronisation of circadian rhythms. In particular, too variable rest patterns, long work shifts and short recovery periods do not agree with ageing (7, 9). On the other hand, flexible arrangements of working hours on a life span basis (e.g. bank of hours, part-time work) may be of interest for both parties to ensure that the work force is available for longer periods of planning and workload is more tolerable (i.e. delayed and/or smooth retirement).

SOME EVIDENCE FROM AN EUROPEAN SURVEY

Using of the dataset of the 3rd European Survey on Working Conditions (17), we recently tried to evaluate possible relations between different "flexible" working hours and health. We compared two forms of "flexible working hours", the first more subjected to company control and decision, and based on having or not to work the same number of hours every day, the same number of days every week, and/or at fixed starting and finishing times; the second one more related to individual discretion and autonomy, based on possibility of taking a break at one's wish, being free to decide when to take holidays or days off, and/or able to influence one's working hours (6).

In general, the individually-oriented flexibility was associated to better health conditions than the company-based one. Among 15 health outcomes taken into consideration, "individual flexibility" appeared to have a positive influence on almost all, while "company flexibility" showed some influence only on few of them (table 3). Moreover, lack of individual flexibility proved to be the most significant factor associated to job dis-satisfaction and with working hours not fitting well with family and social commitments; it was also significantly associated to the feeling of not being able to do the same job when 60 year old. On the other hand, less variable arrangements of working hours were significantly associated with better integration with family and social commitments and being able to do the same job when 60 years old. Furthermore,

Table 3 - *Prevalence (%) of health troubles in relation to company or individual based "flexibility" of working hours*

	Company based Flexibility		Individual based Flexibility	
	Variable	Fixed	Flexible	Rigid
Health and safety at risk	32.1*	25.2	23.1*	32.6
Backache	35.1*	28.6	25.9*	36.6
Stress	34.8*	22.9	26.5*	31.8
Overall fatigue	25.8*	20.3	19.5*	28.1
Headaches	15.8*	12.7	12.1*	18.4
Irritabilità	11.9*	7.0	7.5*	12.5
Sleeping problems	11.5*	5.3	6.0*	9.6
Anxiety	9.5*	5.4	6.6*	8.7
Skin problems	7.5*	6.0	5.2*	7.7
Injury	7.8	6.0	4.7*	8.0
Stomach-ache	6.3*	3.1	3.6*	5.8
Allergies	4.8*	3.8	3.3*	5.1
Respiratory difficulties	4.1	3.9	3.1*	4.7
Heart diseases	2.0	0.8	1.1	1.3

* $p<.01$ at χ^2 test

by examining their interaction with other twelve intervening factors, it turned out that low individual control and high company driven variability of work hours are both consistently associated with poor health and well-being, while the opposite situation has positive effects, i.e. on sleeping troubles and stress (figure 2).

These findings were also confirmed by the six case-studies carried out in different countries that showed that the majority of the workers in the European Union have some forms of individual or company-based "flexibility" in working hours, mainly in agriculture, transportation, information technology, education and health sectors. However, overtime is still the most frequent form of company-based flexibility; overtime and week-end work have negative effects on stress, sleep, social and mental well being, as well as with the person's opinion on the ability to remain in the work force until the age of retirement. On the other hand, individual flexibility alleviates some negative effects of the company-based flexibility on subjective health, safety and social well being; however, it has been noted that that also some forms of too flexible working hours may be detrimental (2, 14).

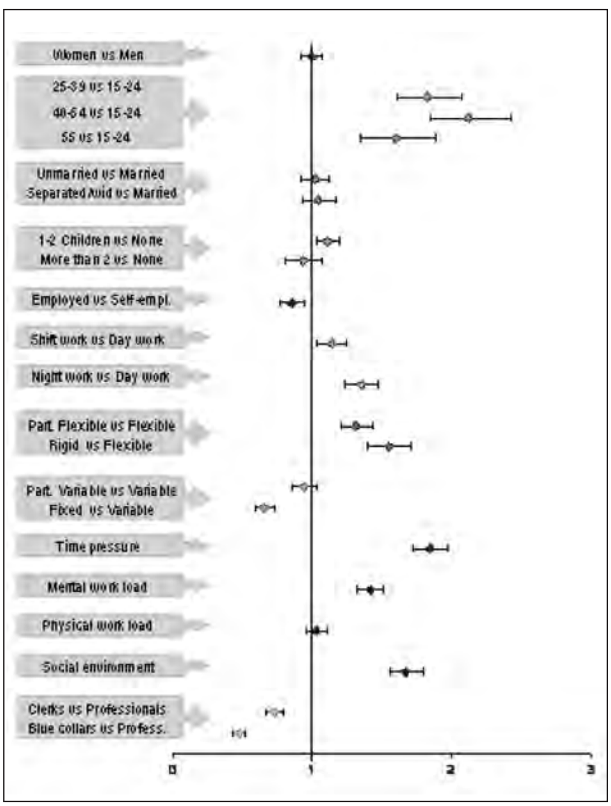

Figure 2 - Mutually adjusted Odds Ratio (95% C.I.) for perceived stress at work

Conclusions

The effects of "Flexible working hours" on health and well being need a careful attention, starting with a general consensus on a valid definition at international level, and focusing their evaluation more on human centred outcomes on health and well-being rather than on economic issues. It is also necessary to focus better on age/gender and "flexibility", taking into account the increasing feminisation and ageing of the work force, and to develop guidelines on non-impairing or positive arrangements of flexible working hours according to ergonomic principles: that has to be done throughout participatory planning and by publishing "best practice" examples, showing good integration of working and non working hours, thus improving working conditions and adding social value to the quality of life.

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La Medicina del Lavoro Med Lav 2006; *97*, 2: 288-294

Occupational Health and general practice: from opportunities lost to opportunities capitalised?

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Key words
Occupational health; chronic diseases; general practice

Summary

Background and aim: *Western populations are in the middle of the epidemiological transition of chronic diseases. Care of patients with chronic disease is directed at optimising life expectancy and quality of life. Daily and social functioning, including paid work are part of the treatment objectives. Yet, advice for and support in work related coping with chronic diseases, and collaboration with occupational health are not – yet – part of routine curative medical care procedures. This is also the case in general practice, where most patients with chronic conditions are treated. This 'blind spot' signals a generic lost opportunity in optimizing the care of patients with chronic disease. This paper analyses from empirical data the importance of integrating work-related advice and support in general practice and explores potential evidence of the benefits this provides for patients: the opportunities that can be capitalised through better interaction between occupational physicians (OP) and general practitioners (GP).* **Methods:** *The paper is based on a review of three sources: (i) Epidemiology of chronic diseases: the Nijmegen Continuous Morbidity Registration; (ii) The relevant guidelines of the Dutch College of General Practitioners; (iii) Studies of work-related implications of asthma and COPD management of GPs of the Nijmegen centre of Evidence-Based Practice.* **Results:** *Chronic diseases like cardiovascular disease, diabetes mellitus, COPD and asthma dominate general practice and lead annually to a large number of consultations. Although a majority of patients are 65 years or older – in particular for the first three diseases – GPs also care for a substantial number of under-65 years old. General practice guidelines for these disorders advocate care directed at normal functioning but do not systematically address functioning in the working place. Analysis of work-related functioning in case of chronic respiratory diseases, however, highlight that work-related factors and circumstances play an important role in patients' coping strategies. Patients tend to ignore negative effects of their workplace on their physical condition and as a consequence suffer undue limitations. Despite these work related risks, COPD patients who were in paid employement perceived higher quality of life than COPD patients who were disabled for work, but had similar disease severity (airway obstruction). Interestingly, a programme of patients' self-management of asthma resulted, in comparison to GP-supervised usual care in a substantial and lasting reduction of asthma related absence from work and other social-daily activities.* **Conclusions and discussion:** *All consultations with employees with a chronic (respiratory) disease can be*

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considered as opportunities to supervise work-related implications of the disease. Patients value their ability to work but frequently apply inefficient coping through ignoring the implications of their circumstances for their disease. A more efficient coping can probably be achieved through a more active involvement of patients in managing their own disease. Guidelines – like the Dutch College of General Practitioners'– have developed into a sophisticated and generally respected system of guidance of patient care. Explicit emphasis of management in relation to the work place may present a logical opportunity to capitalise on.

Riassunto

«Salute occupazionale e medicina di base: da un'occasione persa ad una sfruttata?». *Le popolazioni occidentali si trovano al centro di una transizione epidemiologica verso le malattie croniche. La cura dei pazienti cronici è orientata ad ottimizzarne l'aspettativa e la qualità di vita. La funzionalità quotidiana e sociale, incluso il lavoro salariato, costituisce uno degli obiettivi della cura. Tuttavia, l'offerta di raccomandazioni e sostegno alle capacità di coping sul lavoro destinate ai soggetti affetti da malattia cronica e la collaborazione con la medicina del lavoro, non sono ancora entrati a far parte delle procedure routinarie di cura medica. Questo accade anche al livello della medicina di base, dove viene curata la maggior parte dei pazienti cronici. Questo punto debole corrisponde ad un'occasione mancata di ottimizzare la cura dei pazienti affetti da malattia cronica. Questo articolo analizza, sulla base di dati empirici, l'importanza di integrare raccomandazioni e sostegno sul lavoro al livello della medicina di base, esaminando le prove scientifiche relative ai benefici di questa integrazione per i pazienti, ossia alla possibilità di capitalizzare le occasioni di cura grazie una migliore integrazione tra medici del lavoro e medici di base. Questo contributo si basa su un'analisi condotta su tre fonti: (i) epidemiologia della malattie croniche attraverso lo strumento Njmegen Continuous Morbidity Registration; (ii) le specifiche linee guida sviluppate dal Collegio Danese dei Medici di base; (iii) studi condotti sulle implicazioni lavoro-correlate della gestione dell'asma e del BPCO da parte dei medici di base del Centro di Pratica basata sull'evidenza di Nijmegen. Malattie croniche come i disturbi cardiovascolari, il diabete mellito, il BPCO e l'asma sono prevalenti nella medicina di base e conducono ogni anno ad un numero rilevante di consultazioni. Sebbene la maggioranza dei pazienti – soprattutto per quanto riguarda le prime tre malattie – sia di età pari o superiore ai 65 anni, i medici di base si prendono cura anche di un numero sostanziale di persone sotto i 65 anni. Le linee guida di medicina di base relative a queste malattie consigliano l'impiego di una tipologia di cura diretta a sostenere il normale funzionamento ma non si rivolgono in maniera sistematica alla funzionalità sul posto di lavoro. Le analisi condotte sulla funzionalità lavorativa in soggetti affetti da malattie respiratorie croniche, evidenziano tuttavia quanto i fattori e il contesto lavorativi giochino un ruolo importante nella formazione delle capacità di coping del paziente. I pazienti tendono ad ignorare gli effetti negativi prodotti dal lavoro sulle proprie condizioni fisiche, subendo in questo modo limitazioni funzionali imposte. Nonostante la presenza di questi rischi lavorativi, a parità di gravità della malattia (ostruzione delle vie aeree) i pazienti affetti da BPCO in attività percepiscono una qualità della vita superiore rispetto a pazienti affetti da BPCO con disabilità lavorativa. È interessante notare che, rispetto alle cure standard condotte sotto la supervisione del medico di base, l'implementazione di un programma orientato all'autogestione dell'asma ha condotto ad una riduzione sostanziale e a lungo termine delle assenze asma-correlate sia dal lavoro che da altre attività legate alla vita sociale quotidiana. Tutti le consultazioni effettuate con lavoratori affetti da malattia cronica (di tipo respiratorio) possono essere ritenute un'occasione di monitoraggio delle implicazioni lavorative della malattia stessa. I pazienti considerano preziosa la propria loro capacità lavorativa ma frequentemente applicano strategie di coping inefficaci nel momento in cui ignorano le implicazioni che il loro contesto di lavoro determina in relazione alla propria malattia. E' possibile ottenere strategie di coping più efficaci attraverso un coinvolgimento più attivo dei pazienti nell'autogestione della propria malattia. Le linee guida – come quelle sviluppate dal Collegio Danese dei Medici di base – si sono evolute in un sistema di conduzione della cura al paziente sofisticato e generalmente ben applicato. L'enfasi esplicita posta sulla gestione della malattia da parte del paziente in relazione al proprio lavoro può costituire un'occasione logica da capitalizzare.*

Introduction

The epidemiological transition of chronic diseases western societies are currently witnessing makes that an increasing part of the populations are living with chronic illness (22, 31, 32). Characteristic is the ongoing management, directed at minimising signs/symptoms, preventing complications and optimising life expectancy and quality of life (7). Professional medical care is shifting its role from *prescribing* of treatment for the patient to *supporting* and *coaching* patients in applying treatment to the needs and demands of their personal life circumstances (14). Self-management programmes emphasise the importance of ongoing modification and adaptation of treatment, as individuals' living conditions fluctuate and change.

Most patients with chronic conditions are treated by general practitioners (GP), in primary care (15) and there are guidelines available for diagnosis and treatment of most common chronic diseases in the specific primary care setting (13). The importance of preserving daily and social functioning is acknowledged as an important outcome of care.

'Work' is in principle an important part of the daily living activities of patients with chronic illness who are below retirement age: adapting to work demands may have negative implications for their chronic disease and its treatment and the opposite, adapting the working conditions to the demands of the employee with a chronic disease may just have positive effects. Yet, advice for and support in work-related coping with chronic diseases is not common in routine curative medical care (2, 4, 9, 10). And there is also little collaboration with Occupational Physician (OP) (8, 11). This 'blind spot' signals a lost opportunity in the care of patients with chronic disease (5, 19).

This paper analyses the importance of integrating work-related advice and support in general practice and the potential benefits this may provide for patients: the opportunities that can be capitalised through better interaction between OPs and GPs. It is based on a secondary analysis of empirical data from general practice. Chronic respiratory diseases (asthma and COPD) serve as a case study.

Methods

The study set-out to bring together three aspects of work-related care for patients with chronic disease in general practice by analysing three different data sets.

First, general practice epidemiology of chronic diseases was reviewed with particular emphasis of patients of pre-retirement age. This provided information of the clinical importance of systematic work-related advice in general practice care. Incidence (new number of cases/1,000 during a year) and prevalence (total number of cases/1,000 during a year) were calculated for (i) all patients; and (ii) for all patients younger than 65 year. These data were taken from the Nijmegen Continuous Morbidity Registration (CMR) (29, 28). The CMR was founded in 1971 in four general practices (population of approximately 12,000 people) to collect all episodes of morbidity presented to the GP, including diagnoses made by specialists after referral, and cause of death. The quality and consistency of recording is safeguarded through the use of diagnostic criteria (27) and regular meetings of the participating GPs. Practice assistants check the completeness of recording and their transfer to the central database. The database is a key factor of the Nijmegen general practice research program of longitudinal research of patients with chronic disease.

Secondly, the guidelines of the Dutch College of General Practitioners (13) for the most common chronic diseases were analysed for specific work-related recommendations. The Dutch College guidelines are evidence-based recommendations for the diagnosis, treatment and management of diseases frequently encountered in general practice. An expert panel reviews the literature with special attention for the external validity for the general practice setting. Recommendations are made upon best available evidence, and when for important clinical decisions no evidence is available, consensus statements are drawn. The expert panel's recommendations are peer reviewed before authorised. Upon authorisation the guideline is published on the College's website (13) and its scientific journal. Analysis was directed at the version available in February 2006.

A third source were three Nijmegen studies of management of asthma and COPD in general practice that looked at work-related implications (6, 16-18, 21, 24, 25).

1. Studies analysing cross-sectionally the relation between respiratory health status (chronic respiratory symptoms, pulmonary function), employment status and sick leave from work (6, 16). This also included an exploration of patients' work related adaptations, due to (changes in) their respiratory health status.

2. An analysis using the cohort of a ten years randomized controlled prospective screening study (1, 25, 17). The original study was directed at the effectiveness of early intervention of chronic respiratory signs/symptoms and was based on a screening of the practice population of 10 general practices (1, 25). At baseline-, 5-, and 10-year assessments subjects underwent lung function measurements, and completed the modified Dutch version of the Medical Research Council questionnaire (26). At the 10-year assessment a questionnaire inquired the level of education, smoking status, and chronic morbidity as well as current employment status, working hours, work adjustments due to respiratory complaints, and socio-economic limitations. Socio-economic limitations due to health complaints were operationalized as: 1) the number of days during the past 12 months that subjects had been limited in their non-vocational activities (i.e., household chores, leisure activities, sports), 2) a formal work disability status in accordance with the Netherlands' Disability Act (NDA) (23), and 3) sick leave from work during the past 12 month. When subjects were not currently employed at the time of the 10-year assessment, sick leave from work was recorded for the last 12 months of their most recent job in the preceding year. The 5-year respiratory health status was analysed to predict the socio-economic limitations 5 and 10 years later (22). A study exploring the effects of a 2-year randomised controlled clinical trial on guided self-management of asthma in general practice on days with respiratory-related socio-economic limitations and the role of patients' attitude and self-efficacy levels (18, 21, 24) was reported. Hundred sixty one adult patients with stable asthma from 19 general practices were randomly allocated to guided self management or to usual care. Participants reported weekly their signs/symptoms and the number of days with respiratory-related socio-economic limitations. Attitude and self-efficacy levels were assessed at baseline, after 6 months and at the end of follow-up. The risk on days with respiratory-related socio-economic limitations was estimated in a multivariate logistic regression model. The correlations between the number of days with respiratory-related socio-economic limitations during follow-up and baseline attitude- and self-efficacy levels were analysed, and the effect of GSM on attitude and self-efficacy were examined.

RESULTS

Table 1 lists the most frequent chronic diseases in general practice. High incidence and prevalence rates were found for obesity, cardiovascular disease, diabetes mellitus, COPD and asthma, indicating a high level of GP involvement in diagnosis and follow-up treatment and a large number of consultations on an annual basis. Although most patients were 65 years or older, GP care included a substantial number of under-65 years old, for whom salaried work can be expected to be part of their daily life. For asthma, a majority of patients were younger than 65 years.

Dutch College of General Practitioners' guidelines (13) were available for most of conditions in table 1 – marked in italic. In addition, the guidelines of low back pain, depression and reumatoid arthitis were analysed. Most guidelines advocated care directed at normal functioning but only the guidelines on asthma, deafness, depression and low back pain explicitly mentioned 'work': in the asthma guideline it was recommended to consult with the OP in case of worsening of asthma control due to work circumstances and the guideline 'deafness' adviced consultation of an OP in case work circumstances had caused hearing damage. In case of depression the guideline adviced continuation of work activities, whenever possible. The guideline on low back pain urged exploration of work cir-

Table 1 - *Prevalence of chronic diseases in general practice 1998-2003 (17, 18)*

Disease	Prevalence total population	65-74 y.	45-64 y.	25-44 y.
Chronic nervous compl.	143	190	199	159
Varicose veins	60	196	88	28
Obesity	47	106	84	35
Hypertension	42	170	84	8
Deafness	33	118	34	7
COPD	31	107	41	10
Hyperlipemia	26	95	61	7
Asthma	23	7	16	23
Chr. Isch. Heart disease	22	103	29	1
Myocardial infarction	18	82	26	2
Psoriasis	15	39	23	12

In *italics* diseases with a Dutch College of General Practitioners'Guideline

cumstances in relation to symptoms and recommended an active life style.

Analysis of work related functioning in case of chronic respiratory diseases, however, highlighted that work-related factors and circumstances played an important role in patients' coping strategies (6, 16). Patients tend to ignore negative effects of their workplace on their physical condition and as a consequence suffer undue limitations. Their actual work status was related to their chronic respiratory symptoms, but not to their pulmonary function. This was confirmed in a longitudinal analysis: respiratory symptoms predicted sick leave from work five years later (OR=1.8; 95%CI=1.1-2.9), and also seemed to increase the risk for work disability and non-vocational activity limitations (17). Pulmonary function (FEV_1-measurements) did not add to the predictive value for socio-economic limitations, in addition to respiratory symptoms assessment. In another analysis it was found that COPD patients who did paid work perceived higher quality of life than COPD patients who were disabled for work (CRQ scores 0.52 point difference, p<0.001) (16). No significant differences in lung function or in most common co-morbidity in COPD were observed between these subgroups. Guided self-management of asthma resulted, in comparison to GP-supervised treatment in a substantial and lasting reduction of days with respiratory-related socio-economic limitations (OR=0.49) – even though the majority of patients (66%) did not report any days with respiratory-related socio-economic limitations during the 2-years study period. In the intervention group higher baseline levels for attitude and self-efficacy were significantly correlated with less days with respiratory-related socio-economic limitations during follow-up: (r=-0.534, p=0.033) and (r=-0.622, p=0.010), respectively. Under usual care no correlations were found. A positive effect of guided self-management on attitude was shown, and there were indications that it also improved patients' self-efficacy, however the latter did not reach the level for statistical significance (18).

Discussion

The high prevalence found in general practice of chronic diseases with a great impact on society underlines the leading role of GPs in the community in providing care for patients with chronic illness. This results in a large number of consultations over a longer period of time. Although chronic diseases concern in particular the over-65 years old, a substantial minority is younger and can be expected to be employed in paid work. In a health survey among employees of a Dutch University more than a fifth reported to suffer from one or more chronic diseases (20). For asthma, the chronic disease per example in the under-65 years old, the interaction with work related conditions is highly relevant. A recent WHO study reports that worldwide risk factors were responsible for 11% of asthma, 13% of COPD and even 37% of back pain (30). Consultations with the group of under-65 years old chronic patients can be considered as opportunities to supervise work-related implications of the disease.

Patients with chronic disease value their ability to work, but it is obvious that there are regularly circumstances where 'disease' and 'work' interact negatively. This requires adaptation – of treatment and/or of the work demands – and this highlights the need to include work-related aspects of functioning in the management of chronic diseases. Our findings in patients with chronic respiratory diseases were comparable to a study in rheumatoid arthritis (3). Adaptation is for employees with chronic disease learning experience (12) but our studies found that ineffective self-directed adaptations were a contributing factor to sick leave (6). The importance of medical professional involvement is underlined by the finding that patients' self-prescribed adaptations are mainly based on ignoring the implications of their work circumstances for their disease and result in inefficient coping. Although this is based on patients' apparent desire to remain active in their work, it may result in (prolonged) sickness leave due to being over-burdened. However, the involvement of GPs in work-related counselling of their patients with chronic diseases is low and the guidance of care for chronic diseases in general practice only incidentally addresses this issue. It has been stressed that workers visit their GP more frequently and often more early than the OP. However, GPs ask in less than half to a quarter of consultations after occupational factors, working conditions or conflicts at work.

It is important to keep in mind that most patients with asthma or COPD in our studies had an unrestricted work participation and sick leave was found in only a minority. For those with sick leave, perceived (respiratory) symptoms determined their ability to work, and even predict their future sick leave from work, work disability and non-vocational activity limitations.

The more 'objective' marker of chronic respiratory disease, pulmonary function, on the other hand had no additional value for predicting these future socio-economic limitations (17).

Adaptation can help patients to remain active in their working situation. This implies adequate mangement of limitations, communicating with collegues about the disorder, not trying to hide the disease and its sequelae, saving energy for leisure activities and for social life activities, and timely recognition of the need to take sick leave when the disease exacerbates. GP's can support their patients in many aspects of this adaptation process.

The importance of patients' perceived health status should be related to the experience of the asthma self-management study (18). The majority of the asthma patients in this study had no days of sickness during the two years of the study. This reflects the relatively healthy state of the patients with asthma that were involved. At the same time, it meant that the 'room for improvement' though the asthma self-management plan was limited. The fact that guided asthma self-management did still result in a statistically significant further reduction, compared to the usual GP-supervised treatment, of respiratory-related absence from work and other socio-economic activities may be an indication of the power of self-management of chronic illness. Self-efficacy and attitude did co-determine this outcome, but at the same time guided self-management modified patients' self-efficacy and attitudes. This is in all probability the crucial difference with unguided self-management that patients with asthma and COPD reported doing in coping with the demands of work. Self-management is seen as the management of chronic diseases and more and more the Dutch College of General Practitioners' guidelines make recommendations accordingly. These guidelines have developed into a sophisticated and generally respected system of evidence-based medicine. But advice with regards to work is presented in only a minority of the guidelines – in particular in health problems with a peak prevalence before the age of 65 years (low back pain, asthma), and in an unsystematic way. Currently, a project screening – and when possible modifying – relevant guidelines on 'work relatedness' is in progress. Part of the problem, however, is the lack of research – evidence – to base recommendations on. In the absence of more research common sense consensus may be a way out of the blind spot, in order to improve the quality of primary care of those patients, who are at the same time employees/workers.

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La Medicina del Lavoro Med Lav 2006; *97*, 2: 295-302

The occupational physician and chemical disasters: old problem, new threats

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Key words
Chemical disasters; occupational physicians

Summary
Chemical disasters continue to occur, in spite of significant progress in process engineering, industrial hygiene practices, and improved enforcement of health and safety legislation. In addition to the ever-present risk of unintentional incidents, recent geopolitical events have raised the specter of chemical terrorism. Terrorists or even disgruntled employees may exploit lapses in chemical plant security and ready access to large quantities commodity chemicals, capable of causing great harm to the population if suddenly and unexpectedly released. Occupational physicians, who are uniquely equipped to understand the health hazards associated with industrial chemicals should be involved in prevention of, planning for, and response to chemical disasters. Measures for improving preparedness include training and collaboration, not only with plant health and safety personnel but also with public safety and health care providers, through drills and assessment of needs and capacities. Occupational physicians should be aware that communications and other systems often fail in disasters, requiring multiple alternatives. Likewise, occupational health specialists should be prepared to deal with mass casualties, including psychological casualties which may be difficult to distinguish from those of organic etiology. Chemical disaster preparedness is an urgent and demanding responsibility for occupational physicians everywhere.

Riassunto
«Il medico del lavoro e le catastrofi chimiche». *Le catastrofi chimiche continuano a verificarsi, nonostante siano stati fatti progressi significativi nei cicli produttivi, nella pratica dell'igiene industriale e siano state rese più severe le norme di sicurezza ed a tutela della salute. In aggiunta al rischio sempre presente di incidenti, i recenti eventi geopolitici hanno prospettato all'orizzonte il rischio del terrorismo chimico. I terroristi o i lavoratori talora insoddisfatti, possono sfruttare le carenze di sicurezza nelle industrie chimiche e quindi aver accesso ad una grande quantità e varietà di prodotti chimici, in grado di causare un grave danno alla popolazione se rilasciati improvvisamente e inaspettatamente nell'ambiente di vita. I medici del lavoro, possiedono un bagaglio culturale di nozioni specifiche che permettono loro di comprendere i rischi per la salute che possono derivare dalle sostanze chimiche di uso industriale dovrebbero essere coinvolti nella prevenzione, programmazione di piani d'azione per le catastrofi chimiche. Le strategie per promuovere la gestione di tali eventi prevedono programmi di formazione e collaborazione non solo con chi nella fabbrica si occupa di salute e sicurezza, ma anche con chi all'esterno deve assicurare queste garanzie al*

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pubblico. E questo obiettivo può essere raggiunto mediante addestramenti e la valutazione dei bisogni e delle capacità. I medici del lavoro devono essere consapevoli del fatto che i sistemi di comunicazione ed altri metodi spesso si collassano in corso di disastri, e pertanto è necessario prevedere più strategie d'intervento. Inoltre gli specialisti in medicina del lavoro dovrebbero essere in grado di fronteggiare le patologie di massa, compresi i danni psicologici che spesso sono difficilmente distinguibili dai disturbi organici. L'affronto delle catastrofi chimiche è una responsabilità urgente ed impegnativa che il medico del lavoro deve gestire.

Introduction

Some 30 years have passed since the chemical disaster in Seveso, Italy and more than 20 years since that of Bhopal, India. In spite of this, inventories of the economic and human consequences of these tragic failures continue to be published today. (7, 32) Notwithstanding, while social scientists and health care researchers continue to write about these events, as with all tragedies, vigilance wanes over time, increasing the likelihood of a recurrence. In the years following Seveso and Bhopal, government and industry took enormous steps to improve prevention of chemical incidents, honing their skills in risk assessment and devoting substantial resources to emergency response. While most developed countries and many countries in development might be described today as reasonably well prepared to deal with industrial incidents, there is still work to be done even in the area of "conventional" chemical emergencies.

During this same 20 to 30 years, new threats have slowly but steadily begun to rear their ugly heads. Those threats are chemical sabotage and terrorism. While the approach to these unconventional threats is based on the same principles as the approach to conventional chemical threats, there are qualitative and quantitative differences that must be considered. They will be addressed here.

Finally, the recent Asian tsunami and Hurricane Katrina in North America have reminded us all of the great capacity of nature to destroy lives and disrupt our daily routines. Fortunately, the impact, in terms of chemically-induced ecological damage appears to have been less than anticipated in both cases , although it may yet be too early to come to any broad conclusions (1). These and other recent natural disasters (3, 34) should serve as a reminder to industry for the need for even greater physical security measures.

Many will insist that "others" are responsible for planning and response to these chemical emergencies – engineers, safety specialists, industrial hygienists, security analysts and public officials. While the contributions of these latter professionals are indispensable to this process, the responsibility for the health and safety of workers and of the community surrounding the incident site falls squarely on the backs of physicians. Physicians, and in particular occupational physicians, have much to offer in the planning and implementation of chemical emergency response plans and should be at the table when they are forged and revised (24).

Epidemiology of chemical disasters

Process failures

Bhopal represents the worst of technical failures resulting in chemical disaster. The ultimate cause of this disaster is still debated today, but it is clear that multiple failures occurred at the level of engineering controls, containment plans, and in warning of the public and community preparedness for such an event. While no conventional chemical incident has since approached the magnitude of Bhopal, significant incidents continue to occur from time to time, both in fixed facilities (AZF in Toulouse, France (10); BP Chemicals in Houston, TX (5) and in transportation (chlorine rail car derailment in South Carolina (29)). These incidents resulted in far few deaths than seen in Bhopal and less ecological damage than Seveso, but have nonetheless caused great disruption in the lives of those working in the plants and neighbors of these facilities and along transportation routes.

Sabotage and terrorism

Industrial sabotage by employees is fortunately rare but a worrisome entity. In recent years, union workers have threatened a number of times to harm the environment and local communities through the intentional release of chemicals into the air or groundwater if salary and other concessions were not afforded by management. Examples include the Cellatex and Moulinex incidents in France (13). In the Cellatex incident, 5000 liters of sulfuric acid were released into a creek feeding the Meuse river.

Chemical industrial terrorism is, to date, equally rare, but the potential for attacks on chemical plants and other facilities using or producing chemicals is substantial and appears to be growing. News media have proven themselves capable of entering chemical plants and placing make-believe "bombs" on chemical tanks with virtually no impedance. The recent attack by militants on the largest refinery in Saudi Arabia (19) underscores the fact that terrorists understand the potential for death and destruction on a major scale should get past the security of our factories. Were it not for multiple layers of defense (armed guards, two layers of security gates) the attackers would have likely succeeded in causing an enormous explosion. The diversion of airplanes loaded with fuel to attack the World Trade Center and the ramming of the S.S. Cole by a small boat laden with explosives have demonstrated the awesome power associated with "low tech" attacks. Clearly, there is little need to undertake the steps to fabricate chemical weapons like sarin or mustard when widely available and potentially deadly "TICs and TIMs" (toxic industrial chemicals and toxic industrial materials) can be exploited to create widespread fear and havoc (31).

Natural disasters

The impact of natural disasters on industrial facilities has recently been reviewed by Young. (34)Hurricanes, landslides, earthquakes, fires, and floods have been associated with chemical releases, and in some cases human health effects.

Prevention and preparedness

Risk assessment

Conventional risk assessment, using a combination of hazard assessment and estimation of probability of a critical incident, remains an important part of the prevention and preparation for chemical emergencies. Unfortunately, the potential for intentional attacks on chemical facilities has rendered the traditional approach insufficient. Worst case scenarios, involving the simultaneous precipitous release of multiple chemicals must be considered in the risk assessment process. Such a process has recently been implemented in the US(21). It has been criticized as being unrealistic, because the process assumes not only instantaneous release, but that physical containment measures likewise fail. Whether or not such events are viewed as realistic, it seems prudent to consider the possibility of catastrophes at this scale and to model the responses, even if ultimately government decides not to hold the facilities to a standard of preparation sufficient to respond to a disaster of this proportion. Nor can risk assessment stop at the company fence. Occupational physicians planning for chemical disasters need to consider not only the chemicals stored in their own plants, but those stored in adjacent and nearby facilities in the planning process and to work with their counterparts in those facilities to prepare for eventualities which respect neither fence lines nor geographic borders.

Preparedness assessment

If risk assessment must be carried out considering worst case scenarios, assessments of preparedness should be approached likewise. Rather than throwing up our hands to say we could never prepare for disasters on the scale of Bhopal, we must in fact prepare for them continuously, hoping that they never happen. The expenditures for such preparedness are obviously substantial and will no doubt be weighed against "more pressing" demands elsewhere. Nonetheless, every occupational health budget should include provisions for strengthening disaster response capabilities, even if improvements must be done on a gradual basis.

False assumptions

The chemical emergency plans of many facilities rely heavily on outside (often local governmental) response to assist in fire suppression, spill mitigation, as well as for decontamination and treatment of the injured. Prior to the Asian tsunami and Hurricane Katrina, many facilities assumed that assistance from government (local, regional, and national) would be quickly provided if needed. These events have served to show us that in devastating circumstances, we may not be able to depend on outside assistance. Current plans in facilities in developing countries often make assumptions of non-assistance because local government emergency response capacity at baseline is insufficient. Developed countries may learn from the autonomous emergency plans of these facilities. Furthermore, these recent events highlighted the insufficiency of disaster plans of health care facilities in the communities. The chemical plant that assumes that the local hospital will relieve it of responsibility for the treatment of injuries and illness may be sadly disappointed.

Communications

In disasters of all kinds, failure of communication is the rule. For example, during Hurricane Katrina in the US, fixed and cellular telephone services, radio communications between police, fire, and emergency medical services and most public television and radio service were knocked out early in the storm. Essentially the only remaining radio communications during the first few days after the storm were satellite radios of a private ambulance service. The combination of that single atypical source of radio communication and of national television media that arrived shortly thereafter seemingly provided the only working link between disaster-torn New Orleans and the rest of the US. Every disaster plan should be re-evaluated in this light. The occupational physician should be concerned with available means of contacting employees in general (warning) and key employees (other plant physicians, nurses, emergency medical technicians) under widely varying circumstances. In addition to such "internal" communications (which may, in fact, require calling outside the plant for employee assistance), the occupational physician should be keenly concerned about external communication with the poison control center (23), fire and rescue personnel, local hospitals, and emergency planning officials, not only to call for outside assistance, but to be able to provide toxicological and medical treatment information for the community. Exploitation of every means of communication, from the most sophisticated (satellite, internet) to the most basic (human messengers) must be evaluated and prioritized (14).

Personal protection

Disaster plans must include provisions for a stay of several days in the plant, should critical community infrastructure be destroyed. Essential basic requirements for food, shelter, sleeping and bathing facilities must be considered. Many plans now suggest that occupational health specialists carry a duffle bag in their vehicles with enough survival supplies to last for a week. Likewise, consideration should be given to the need for personal protective equipment by health care personnel, who may be unable to evacuate the facility and who may be involved in employee decontamination (15, 25).

Decontamination

Plans for decontamination (18) of employees should consider worst case scenarios, including terrorism and massive release of corrosive or toxic chemicals. There may be a need for multiple sites within the physical plant for mass decontamination, taking into account potential physical damage to plant structures, meteorological conditions, and nearby chemical stocks. In addition to decontamination of employees, advice for decontamination of members of the public should be ready. A line of communication established between occupational health specialists and emergency care providers must exist before the emergency occurs! Otherwise, precious time may be wasted "decontaminating" a patient who does not need it at the expense of delayed treatment of injuries or cardiorespiratory problems. Conversely, health care facilities and workers may be put at risk by secondary contamination due to inadequate decontamination at the incident site.

Emergency medical equipment and antidotes

The need for large quantities of specific supplies must be anticipated, again giving consideration to worst case scenarios and the need to carry out continuing care for several days. Adequate supplies of oxygen, intravenous solutions, antibiotics, emergency medications and antidotes must be assured. Assuming that local hospitals have sufficient antidotes would be ill advised (20). A plan for exchange of supplies with the manufacturer's representative or with local hospitals may need to be instituted to insure that expiration dates are not exceeded due to lack of routine use of these supplies within the plant. Careful consideration should be given to alternate sites for storage of equipment, in the event the onsite occupational clinic is damaged or deemed uninhabitable. Air handling and ventilation installations should be evaluated for the risk of entraining contaminated air (27).

Training

It is difficult to devote the time to training for the disaster that none of us hopes will come. It is human nature to believe "it won't happen here." We know, however, that continuous evaluation and training are essential to an adequate response in times of crisis. Shortly before the sarin release in the Tokyo subway, prehospital health care professionals had drilled for such an event and hospitals had adequate antidote supplies to care for many victims. Preparation paid off dearly during this heinous event of chemical terrorism. While hundreds of victims required evaluation and treatment, there were only a handful of deaths and relative order in the response to an overwhelming incident. Without adequate training, the outcomes might have been very different. Okumura has recently reported on the shortcomings of the response to this attack (28).

Numerous training courses have been devised to better prepare health care professionals to deal with chemical emergencies. One such course is the Advanced Hazmat Life Support Course (www.ahls.org), which is now offered around the world. This course promotes a generic, consistent approach to chemical emergencies, based on use of "toxidromes" (toxic syndrome complexes) rather than dependence on immediate identification of the chemical at cause, which is not always possible.

Exercises

The bookend to training is the exercise. Without practice, a plan is little more than a stack of paper. Exercises can be simple, such as morning conferences in which occupational health personnel are given a scenario and asked to verbally respond. More intensive table top exercises may involve the entire facility. The ultimate test is the community emergency response drill, involving outside agencies with transport of "victims" to the hospital for treatment. Some companies tend to avoid such "events," fearing that they will worry neighbors about the risk of a chemical incident. However, if placed in proper context, through deliberate communication with the news media, these drills can promote a positive public image. More importantly, they provide an opportunity for occupational physicians and other plant safety personnel to interface with local emergency medical services and with community physicians, to share critically important knowledge that may not exist in the community, and to instill a sense of cooperation rather than blame, should a real incident subsequently arise.

Collaboration

In-depth understanding of chemical risks is the exception among most physicians and public officials. The occupational physician can play a vital role in emergency planning at the community level. While structures vary from one country to another, there are frequently local emergency planning committees that assist with, or are responsible for, chemical disaster plan development and implementation. Often, these groups depend on voluntary assistance of experts from the community. Occupational physicians should take an active role in these committees in order to assure the most adapted response to the chemical emergency.

Emergency response

The proof, of course, is in the pudding. When a chemical disaster occurs, our ability to respond quickly and deliberately will depend on our preparation for the disaster. The response may be inadequate in spite of our best efforts, due to the overwhelming and in some cases unpredictable nature of these events. The greater our preparation and consideration of the 'impossible' occurring, the better our response will be. Occupational physicians and their employers are likely to be judged as much for their preparedness for chemical disasters as for the ultimate outcomes.

Triage

With each new disaster, we learn new lessons regarding the limitations of disaster triage. Numerous systems (2, 26) have been devised in recent years to improve triage and the occupational physician is well advised to be familiar with these, and particularly with the system used by local emergency medical services. Work remains to be done on these systems, as most are based on predictive prognostic criteria for traumatic injuries, with less thought given to chemical injuries. Nonetheless, disaster triage should be in the armamentarium of the occupational health provider.

Decontamination

The planning for decontamination facilities has already been mentioned. The need for early and copious decontamination after exposure to irritant and corrosive compounds, as well as to well-absorbed toxicants is well known to most occupational physicians. It should be anticipated that well-meaning emergency medical services personnel may insist on 'decontaminating' the victim of a gaseous exposure where little or no skin contamination is likely to be present. The occupational physician will need to use judgment and good communication skills in such scenarios. In no case should the victim's care be compromised by decontamination procedures, unless the victim truly poses a risk of life threatening secondary contamination to the rescuer. At the same time, decontamination as a precautionary measure should not be discouraged if it does not unduly delay definitive medical care.

Emergency exposure guidelines

While the evaluation of the environment is generally the purview of others, the occupational physician may be called on for advice regarding the need for evacuation of citizens outside the plant, based on a measured concentration of an air contaminant. Thus, occupational physicians should be familiar with emergency exposure guidelines designed for the general public, rather than for healthy workers. Numerous guidelines are under development, including emergency response planning guidelines (ERPGs)(16), acute exposure guidelines (AEGLs) (22), Acute Exposure Toxicity Thresholds (AETLs) (33), and others. These guidelines take into account the most susceptible in the population (elderly, those with respiratory diseases, etc.) and anticipate relative short (1-3 hour) exposures.

Mass casualties

The management of mass casualties is generally relegated to emergency physicians and trauma surgeons. The role of the occupational physician in the management of mass casualties is two-fold. He or she must be prepared to deal with the immediate life threats of multiple casualties in the workplace until help arrives. Furthermore, the occupational physician should be intimately familiar with the health effects associated with the chemicals in his or her workplace. Without the advice and assistance of the occupational physician, the emergency physician may be completely dependent on the information in a material safety data sheet, which is generally inadequate to this task.

Mass psychogenic illness

Chemical disasters spawn pathology in populations far in excess of what might be expected by the exposure plume. Mass psychogenic or sociogenic illness may occur after a chemical release (4). The psychological response may depend on many factors, including antecedent warnings about chemical terrorism, familiarity with the chemical involved and its warning properties, and perhaps most important, the type and adequacy of information received in the first hours after a release. Informed, early risk communication is critical to avoiding panic in populations. If the media is allowed to provide uninformed judgments about the nature of risk, untoward psychological reactions may be expected. The occupational physician may not be the ideal person to convey the risks, as there may be suspicion on the part of the public that the involved company is attempting to downplay the risk. On the other hand, the occupational physician can and should communicate quickly with public health officials, public information officers, and emergency physicians, who are likely to be called on as spokespersons. Collegial information exchange is generally appreciated and may avoid hyperbole and its consequences.

Recovery

Return to normalcy after a chemical emergency is often a slow and painful process. Loss of life or health, employment, and material possessions may leave durable emotional scars. (9, 30)Employees may fear returning to work, distrust may be high. The occupational physician must assure that crisis management, medical, and rehabilitation teams are available to deal with the psychological and long-term medical needs of employees involved in a chemical disaster. Such support is vital not only to the employee's wellbeing, but to the restoration and maintenance of a healthy working environment.

Conclusion

In summary, the occupational physician, while often not considered a key player in chemical disaster management, should in fact be at the table in every discussion of emergency preparedness for such events. The occupational physician is the ideal and logical interface between the plant and the community in matters involving health care of workers and those potentially exposed beyond the plant gates. It is incumbent on occupational physicians to become more involved with risk assessment and disaster planning, training and exercises. Only through such involvement can we assure the optimal response to the health needs of our coworkers and neighbors in the event of a chemical emergency.

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Med Lav 2006; *97*, 2: 303-311

Low-cost risk reduction strategy for small workplaces: how can we spread good practices?

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Key words

Good practices; SME; health risk

Summary

Recent advances in health risk reduction approaches are examined based on inter-country networking experiences. A noteworthy progress is the wider application of low-cost improvements to risk reduction particularly in small enterprises and agriculture in both industrially developing and developed countries. This is helped by the readiness of managers and workers to implement these improvements despite many constraints. Typical improvements include mobile racks, simple workstation changes, screening hazards, better welfare facilities and teamwork arrangements. In view of the complex circumstances of work-related health risks, it is important to know whether a low-cost strategy can advance risk reduction practices effectively and what support measures are necessary. It is confirmed that the strategy can overcome related constraints through its advantages. Main advantages lie in (a) the facilitation of improved practices in multiple technical areas, (b) the strengthening of realistic stepwise risk reduction, and (c) the enhanced multiplier effects through training of local trainers. Action-oriented risk assessment tools, such as action checklists and low-cost improvement guides, can encourage risk-reducing measures adjusted to each local situation. It is suggested to spread the low-cost risk reduction strategy for improving small workplaces in diversified settings with the support of these locally tailored tools.

Riassunto

«Strategia a basso costo per la riduzione del rischio nei piccoli luoghi di lavoro: come è possibile diffondere buone pratiche?». *In questo contributo, i recenti progressi nell'approccio alla riduzione del rischio per la salute vengono valutati sulla base di esperienze di rete inter-nazione. Un notevole progresso si è avuto con la diffusa applicazione in paesi sia sviluppati che in via di sviluppo di interventi migliorativi a basso costo, tesi alla riduzione del rischio specialmente nelle piccole aziende e in agricoltura. Questo processo è sostenuto da manager e lavoratori disponibili ad implementare gli interventi migliorativi nonostante le molte costrittività presenti. Interventi tipici comprendono l'introduzione di scaffalature mobili, semplici cambiamenti della postazione di lavoro, screening dei rischi, miglioramenti a livello dei servizi per il benessere dei lavoratori e sviluppo del lavoro di gruppo. Data la complessità delle circostanze in cui si possono verificare i rischi per la salute lavoro-correlati, è importante sapere se una strategia a basso costo possa efficacemente sostenere l'avanzamento delle pratiche di riduzione del rischio e quali misure di sostegno siano necessarie. Dal lavoro svolto è risultato come i vantaggi insiti nella strategia adottata siano in grado di superare le costrittività presenti. I principali vantaggi sono: a) la facilitazione di pratiche migliorative in molteplici aree tecniche; b) il consolidamento di interventi graduali di riduzione del rischio; c) il benefico effetto moltiplicativo legato alla formazione di trainer locali. Gli strumenti di valutazione del rischio orientati all'azione, come lo sviluppo di checklist di azioni e guide per interventi migliorativi a basso costo, possono incoraggiare l'implementazione di misure per la riduzione del rischio adattate alle esigenze delle singole realtà locali. Suggeriamo di diffondere questa strategia di riduzione del rischio a basso costo al fine di migliorare le condizioni operative dei piccoli luoghi di lavoro in contesti diversificati, attraverso l'ausilio di questi strumenti adattati alle realtà locali.*

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Introduction

The use of low-cost improvements is increasing in reducing workplace risks. Numerous reports indicate that low-cost improvements can motivate people to undertake immediate improvements in various aspects of working conditions (1, 8, 12, 14, 20). There are an increasing number of reports that show the spreading impact of low-cost improvements in managing risks particularly in small workplaces in industrially developing countries (5, 7, 18, 19, 21, 22).

This trend is linked with the renewed interest in comprehensive risk management at the workplace. This is represented by the international move towards upgrading occupational safety and health management systems in line with the ILO guidelines known as ILO-OSH 2001 (8, 14). Low-cost improvements are gaining importance as one of key factors for involving small enterprises in this move (3, 4). Awareness is growing that many low-cost improvements are applied as a means of facilitating simple action-oriented risk assessment procedures. Examples are found in reducing musculoskeletal and stress-induced disorders and other work-related risks (2, 11, 13, 16).

On the other hand, there are obviously limitations in widely applying low-cost improvements in managing diversifying risks at the workplace (14, 17). There are complex factors involved in the control of these work-related risks. The readily applicable character of low-cost improvements may hamper the needed broad scope for the often sophisticated control measures. The merits and limitations of low-cost solutions in dealing with the complex problems of work-related risks should be carefully examined.

Despite these constraints, there is a strong need for developing a low-cost risk reduction strategy suited to different local situations particularly for small workplaces. In exploring the spread use of this strategy, it is useful to examine the common features of low-cost risk-reducing measures in relation to the following three questions: (a) how we can apply a low-cost strategy in dealing with complex workplace risks; (b) to what extent we can actually reduce these risks through focusing on low-cost improvements; and (c) what support measures are necessary for facilitating the advantageous use of the low-cost strategy. These three aspects are discussed in this paper.

Materials

Recent advances in health risk reduction approaches emphasizing the use of low-cost improvements in small workplaces are reviewed based on our inter-country networking experiences. These approaches have been undertaken in participatory action-oriented training programs in different settings. Positive experiences are gained in small and medium-sized enterprises, construction sites, home workplaces and agricultural farms. The methods and achievements of the programs reported at a jointly operated website (http://www.sin-asia.org) are examined.

The reviewed programs cover (a) action training courses applying the WISE (Work improvement in small enterprises) methodology (5) in the Philippines, Thailand and Vietnam; (b) similar training activities combined with risk management for small enterprises, construction sites and home workers including those in Japan, Cambodia, Laos, Malaysia, Thailand and Vietnam (6, 8); (c) training workshops for farmers applying participatory training methods known as WIND (Work improvement in Neighbourhood Development) methods (10) in Thailand, the Philippines and Vietnam; and (d) training activities applying POSITIVE (Participation-oriented safety improvement by trade union initiative) methods developed jointly with national trade union centres and the Japan International Labour Foundation (9) in Bangladesh, China, Mongolia, Nepal, Pakistan, the Philippines, Thailand and Vietnam. Links to websites reporting these programs are found at the above-mentioned website. Main features of these programs are reported by Kogi (14), Zalk (23) and Khai et al (10).

The features and roles of low-cost improvements applied in these programs are discussed. Attention is drawn to the efficacy of stepwise risk reduction procedures in addressing complex workplace conditions and the multiplier effects of the participatory approaches generally taken. On the basis of this discussion, necessary support measures for facilitating the effective use of the strategy are then discussed.

Results and discussion

Building local initiative for responding to diversifying needs

All the programs reviewed are aimed at immediate implementation of priority measures meeting local needs. These programs commonly focus on low-cost improvements. These low-cost improvements are found to have real impacts on improving safety, health and well-being of workers in small enterprises, construction sites, home workplaces and agriculture. This is obviously due to the general readiness of managers and workers to implement these improvements in spite of the many constraints of these workplaces. It is confirmed that this focus on low-cost improvements is meaningful in both industrially developing and developed countries.

The types of low-cost improvements achieved have some distinct features. They are selected so as to meet the local needs of managers and workers through immediate changes at the workplace. Main areas of low-cost improvements applied in the programs cover various aspects of conditions of work load and working environment. They include the following:

a. work interface redesign: easy-to-operate interfaces, work space arrangements;

b. improving physical environment: lighting, ventilation, isolating hazard sources;

c. muscle load reduction: improved materials handling, better workstations;

d. accident prevention: machine guarding, safe work practices, preventing errors;

e. work organization and schedules: teamwork, autonomous work, work-rest regimes;

f. reduction of stress at work: coordinated work assignments, social support.

The first question about how we can apply a low-cost strategy to complex workplace risks may be answered by examining the way low-cost solutions can deal with the wide-ranging problems related to actual risks. Two apparent responses of the reviewed programs attract our attention. The first response is to use simple improvements for initiating preventive action despite the various constraints of the particular work setting. This is because the focus on low-cost improvements has the merit of facilitating the initiative building in difficult local situations. The second response is to keep a broad scope in selecting appropriate improvements relating to existing complex risks. In particular, the multifaceted scope adopted in proposing necessary improvements may help people identify multiple measures that can contribute to reducing the existing risks.

The multifaceted aspects of low-cost improvements used in the reviewed programs are summarized in table 1. In looking for practicable improvements, attention is usually drawn to a range of locally available, easy-to-implement options and the promotion of consensus building for immediate implementation.

Table 1 - *Multifaceted aspects of low-cost workplace improvements for immediate implementation meeting local needs*

Practicable improvements	Action-oriented procedures	Workable low-cost concept
Locally available good practices	Collect and present good examples locally achieved	- Simple, practical ideas - Visible benefits at work
Easy-to-implement options addressing various risks	Examine many low-cost ideas that can reduce local risks	- Locally feasible proposals - Covering multiple areas
Consensus building leading to immediate implementation	Use local materials and skills through group work	- Voluntarily selected ideas - Rapid implementation

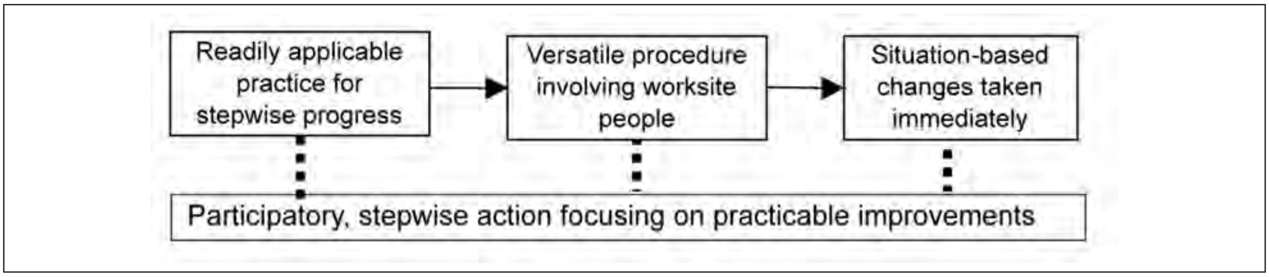


Figure 1 - Common features in the application of low-cost improvements within the framework of occupational safety and health management in both large and small undertakings

Both these responses have positive impacts on the wider application of low-cost improvements in improving occupational safety and health conditions. This is seen in figure 1 illustrating the common features characterizing the use of these improvements. Three features must be mentioned that are incorporated in all the programs reviewed. It is clear that approaches focusing on these improvements rely on a stepwise progress. Further, other features, such as versatile procedures and the emphasis on situation-based changes may facilitate the stepwise application of these improvements. As a result, the characteristic stepwise action emphasizing practicable improvements in multiple areas is conducive to addressing the complex nature of workplace risks.

We may confirm that the facilitation of readily practicable practices in multiple technical areas is beneficial for building local initiative in responding to diversifying needs of any workplace. The strategy relying on low-cost improvements is found to help build this local initiative. The strategy is considered generally applicable to small workplaces where the focus on practicable improvements in multiple areas is particularly advantageous.

Risk-reducing effects of focusing on low-cost improvements

The second question about the risk-reducing effects of low-cost improvements may be looked at by examining the way these improvements are actually implemented. As many of these improvements relate to basic principles of occupational hygiene and ergonomics, a combination of these improvements may lead to effective reduction of existing risks.

Table 2 summarizes the costs and types of improvements implemented by a WISE course in Thailand in small enterprises and a WIND workshop in Vietnam in farm households. It is reported that the costs of improvements achieved by the participatory action-oriented programs are generally low. About one-third of the improvements could be achieved at zero cost in either occasion. Another one-third could be done at less than US$ 20 in the WISE course and at less than US$ 10 in the WIND workshop. It is striking that in both these cases, zero-cost and low-cost improvements are found in all the areas listed in the table. Many such improvements are achievable not only in materials handling and welfare facilities but also in workstation redesign and physical environment.

Many of these improvements are considered to have risk-reducing effects as indicated by their typical examples mentioned in the table. They apply the basic principles of occupational hygiene and ergonomics, such as safer materials handling, less stressful work operations, better work environment and enhanced refreshing effects.

These effects are well illustrated by the examples reported from the reviewed programs, as shown in figure 2. The effect of each individual improvement relates to the reduction of certain aspects of existing risks. Nevertheless, this effect tends to be sustainable as most such improvements relate to changes in equipment and facilities. These types of low-cost improvements are found widely applicable in different settings, as clearly noted from the examples shown.

Table 2 - *Costs of low-cost improvements done by participatory action training and contributing to risk reduction*

	Materials handling	Workstation design	Physical environment	Welfare facilities
Results of a WISE course in Thailand				
Zero cost	4	4	10	4
Less than US$20	1	6	9	7
US$20 or more	4	1	6	7
Results of a WIND workshop in Vietnam				
Zero cost	9	10	3	6
Less than US$10	11	13	8	5
US$10 or more	4	-	14	5
Typical examples of low-cost improvements	- Multi-shelves - Mobile racks - Lifting devices - Places for tools - Safe grips	- Easy access - Elbow-level job - Fixtures - Coded displays - Buffer stock	- Relocated lights - Machine guards - Isolated hazards - Spot exhausts - Self-paced work	- Drinking water - Washing facility - Clean toilets - Protective gears - Resting corners

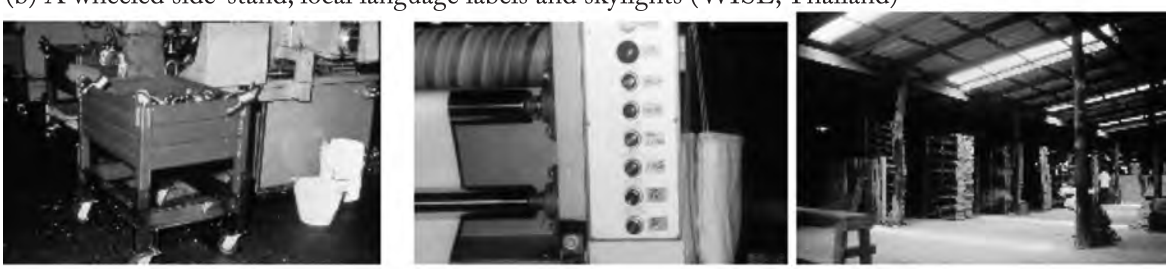
The typical risk-reducing effects of commonly applicable low-cost improvements are listed in table 3. Their risk-reducing effects are real for the types of workplace risks listed. The effects may be

Table 3 - *Typical risk-reducing effects of low-cost improvements. The combined use of these improvements is found to mutually strengthen preventive effects*

Risks addressed	Examples of modifications	Risk-reducing effects
Transportation injuries	- Marked transport route - Internal traffic signs/mirrors	Less frequent injuries Less collisions
Machine-based injuries	- Putting guards/fences - Covers/ramps to danger spots - Two-hand controls/interlocks	Reduced contact dangers Less dangerous falls No accidental contacts
Musculoskeletal strains	- Labeled multi-level shelves - Hand-made mobile racks - Elbow-level work on platforms - Better seats in standing/sitting	Reduced handling loads Less handling injuries Less low-back pains Reduced postural strains
Repetitive/excess strains	- Easily reached containers - Jigs for repeated operations - Refreshing resting corners	Reduced muscle strains Reduced static loads Recovery from fatigue
Operation errors	- Labels and rearranged controls - Colour-coded switches	Reduced mistakes Correct emergent actions
Poor lighting/ventilation	- Skylights - Relocated lights - Increased natural ventilation - Heat barriers	Consistent brightness Safer productive work Cooler workspace Preventing heat stress
Noise, dust, chemicals	- Isolating hazard sources - Signs at areas for wearing PPE - Mobile local exhausts	Reduced exposures Regular use of PPE Reduced inhalation
Infection/poor sanitation	- Washing facilities/lockers - Safe needle handling procedure	Routine sanitation Reduced needle sticks
Stress-induced disorders	- Brief meetings/open notices - Fostering supportive climate	Coordinated teamwork Less psychosocial stress

(a) Labels for switches, adjusted work height and machine guards (WISE, Vietnam)

(b) A wheeled side-stand, local language labels and skylights (WISE, Thailand)



(c) Elbow-level work, machine guards and storing pesticide containers (WIND)

(d) A safety belt (WISCON), lights with a fan and a heat barrier (WISH, Thailand)

(e) A gravity chute, a resting corner and separate waste containers (POSITIVE)

Figure 2 - Low-cost improvements achieved by participatory programs in different settings

relatively limited in individual circumstances, but the stepwise nature of all these improvements and their initiative building functions as already discussed. We should also note that these effects have significant impacts when they are combined as is the case in all these programs.

Support measures for facilitating the use of the low-cost strategy

All the reviewed programs demonstrate the active role of support measures provided through a network of trainers in participatory application of low-cost improvements. Common support measures include the development of locally adjusted training toolkits, training of local trainers who train local people in different workplace situations and the exchange of positive experiences gained in similar local conditions.

The main elements of such a network involving core and local trainers are shown in figure 3. Core trainers are involved in the development of training toolkits and the training of local trainers who train managers, workers or farmers at local sites. The developed toolkits commonly comprise photographs of local good practices, action checklists, improvement manuals and trainers' guides. Low-cost improvement databases also assist the trainers. Action checklists are representative of these toolkits and usually adjusted to each local situation by listing locally practicable low-cost improvements. These checklists are suited to guide local people in identifying improvements that are effective in risk-reduction. All the toolkits are used to facilitate group work for action.

The consistent focus on the low-cost strategy has an obvious advantage of increasing the impact of the network of trainers. The toolkits incorporating low-cost ideas in action forms can help trainees adopt them relatively easily. Trainees can also easily feedback to the trainers the results of their improvements done by using their own skills. This interactive merits of the network should be fully utilized.

From risk reduction points of view, the multiplier effect of the training network appears to be particularly important. As shown in figure 4, the steps for making low-cost improvements may well correspond to actual risk reduction steps, as exemplified by the process of checklist application. This process is done by identifying locally achievable types of improvements shown in the checklists listing such improvements. This represents the risk management steps of reviewing good practices and implementing priority risk control measures. Trainers can play a key role in linking the checklist application with appropriate risk-reducing ideas. The recent developments of occupational safety and health management systems can thus be reflected in the low-cost risk reduction strategy. This has

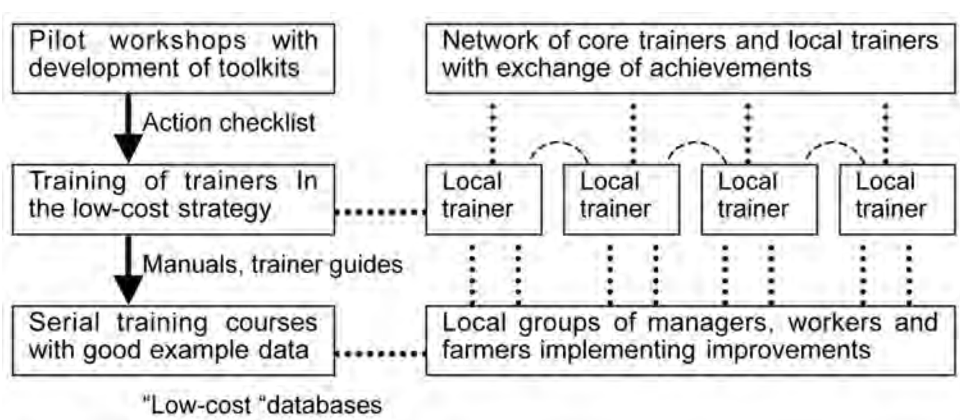


Figure 3 - The training network of core and local trainers suitable for training of local people implementing low-cost improvements according to the low-cost risk reduction strategy (applicable to WISE, WIND and POSITIVE activities)

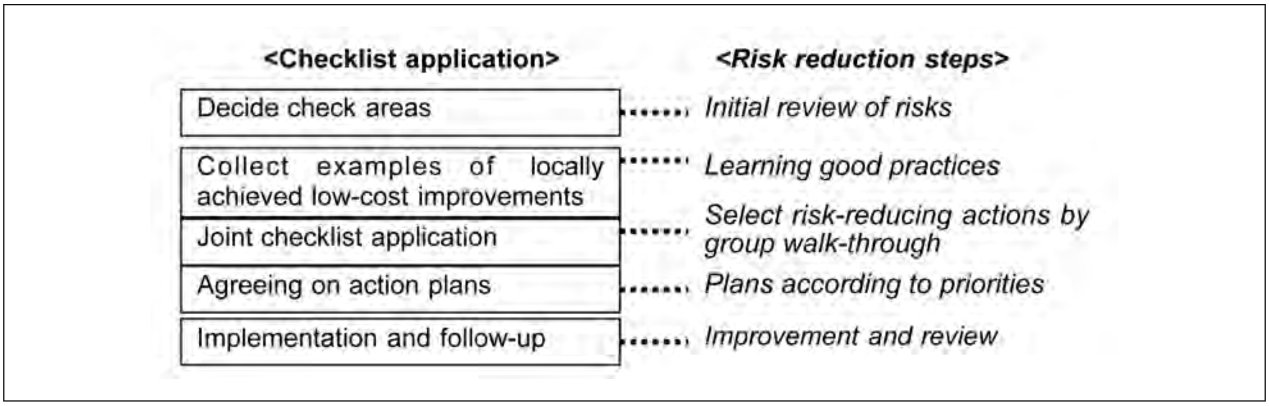


Figure 4 - Low-cost improvement procedures by means of an action checklist comprising locally practicable low-cost ideas in multiple areas

been proven by the experiences in our inter-country networking activities.

The coordinated development of trainers' networks is therefore found essential in the low-cost strategy. We need to support these networks by emphasizing the use of the strategy as part of the overall effort to strengthen comprehensive occupational safety and health management systems. The accompanying multiplier effects is the key for the effective use of the strategy in different settings including small enterprises and agriculture.

CONCLUSIONS

The spreading use of low-cost workplace improvements is characterized by voluntary initiative of local people for immediate action. This is confirmed by ongoing programs in our inter-country networking of participatory action-oriented training activities for small workplaces and agriculture. The focus on low-cost improvements can effectively contribute to risk reduction at the workplace. This low-cost risk reduction strategy can be effective by (a) looking into locally practicable ideas in multiple technical areas, (b) stepwise application of risk-reducing improvements and (c) relying on multiplier effects through a network of trained trainers. As we all know, the strategy should be pursued as part of the comprehensive risk management effort.

It is suggested to adopt a low-cost risk reduction strategy in this direction in various work settings in both industrially developing and developed countries. The strategy is found particularly useful in building local initiative in small and micro enterprises and in agriculture. Direct support should be provided by developing action-oriented toolkits incorporating low-cost ideas for realistic risk reduction. Positive experiences being gained in participatory programs in different countries can accelerate the spread application of the low-cost strategy despite constraints in various small-scale workplaces.

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La Medicina del Lavoro

Med Lav 2006; *97*, 2: 313-321

The contribution of occupational risks to the global burden of disease: summary and next steps*

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Key words

Occupational risk; global burden of disease

Summary

Background: *The Comparative Risk Assessment (CRA) project of the World Health Organization (WHO) assessed worldwide mortality and morbidity in the year 2000 resulting from exposures to selected occupational hazards. This article summarizes findings of the WHO CRA project, presents the estimates of the International Labor Organization (ILO) for total deaths due to workplace risks, and calls for action.* **Objectives:** *Global burden estimates and counts of deaths assist ministers and other decision and policy makers to make informed decisions and to take action regarding risk reduction.* **Methods:** *The WHO CRA methodology combined the proportions of the population exposed to five occupational hazards (excluding numerous risks due to inadequate global data) with relative risk measures to estimate attributable fractions of the selected health outcomes for both morbidity and mortality. ILO estimates of total numbers of global work-related injury deaths apply national fatality rates to employment data for the particular country; for disease deaths ILO uses an attributable risk approach.* **Results:** *In 2000, the selected occupational risk factors were responsible worldwide for 37% of back pain, 16% of hearing loss, 13% of chronic obstructive pulmonary disease (COPD), 11% of asthma, 8% of injuries, 9% of lung cancer and 2% of leukemia, and about 100% of pneumoconioses and mesothelioma. These selected risks at work resulted in the loss of about 24 million years of healthy life and caused 850,000 deaths worldwide, about 40% of the ILO estimate of 2.2 million total deaths.* **Conclusions:** *These global and regional analyses have identified areas where specific preventive actions are required.*

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** The views expressed in this article are those of the authors and do not necessarily reflect the position of the World Health Organization .*
This article includes content from eight articles and the editorial, prepared by the authors of this report, that are included in a Special Issue of the American Journal of Industrial Medicine entitled "Contribution of Occupational Risks to the Global Burden of Disease" AJIM Volume 48, Issue 6, Pages 395-541 (December, 2005).
Some of this information was also published by the World Health Organization in Ezzati M, Lopez AD, Rodgers A, Murray CJL, editors. Comparative Quantification of Health Risks: Global and Regional Burden of Disease Attributable to Selected Major Risk Factors. Geneva: World Health Organization, 2005.

Riassunto

«Il contributo dei rischi professionali al "Global Burden of Disease": riepilogo e prossimi obiettivi». *Il progetto Valutazione Comparativa dei Rischi (Comparative Risk Assessment) della Organizzazione Mondiale della Sanità ha valutato la mortalità e la morbilità mondiale nell'anno 2000 derivanti da specifici rischi professionali. Questo articolo, che riassume i risultati del progetto WHO CRA, presenta le stime della Organizzazione Internazionale del Lavoro sull'incidenza dei rischi presenti nei luoghi di lavoro e sul totale delle morti e invita all'azione. Le stime e il conteggio delle morti aiutano i ministri e altri uomini politici a compiere scelte informate e ad agire sulla riduzione dei rischi. Il metodo WHO CRA correla la proporzione di popolazione esposta a cinque rischi professionali (escludendone numerosi a causa di dati inadeguati) con la relativa misura del rischio per stimare la frazione di rischio attribuibile per ciascuno degli indicatori scelti (mortalità e morbilità). La stima dell'ILO sul numero globale delle morti dovute a infortuni professionali applica i tassi di mortalità nazionali per ciascun paese ai dati sull'occupazione; per le morti per malattia l'ILO usa un approccio di tipo rischio attribuibile. Nel 2000 i rischi professionali selezionati rendevano conto in tutto il mondo del 37% delle lombalgie, del 16% delle perdite di udito, del 13% delle broncopneumopatie croniche ostruttive, 11% dei casi di asma, 8% degli infortuni, 9% dei tumori del polmone e del 2% delle leucemie e circa il 100% delle pneumocoiosi e dei mesoteliomi. Questi specifici rischi professionali sono responsabili della perdita di circa 24 milioni di anni di buona salute e hanno causato 850000 morti in tutto il mondo, circa il 40% dei 2,2 milioni di morti totali stimati dall'ILO. Queste analisi condotte su scala globale e regionale, hanno identificato le aree dove sono necessarie azioni preventive specifiche.*

Introduction

Estimates of health burden at a population level, whether using a state, national or global focus, have several important potential benefits. They attract the attention of policy makers and the community by showing the size of the problem. They also provide guidance to policy makers on how to expend limited resources by identifying the major disorders and the exposures resulting in the largest burden, so that appropriate interventions can be put in place to reduce injury and illness.

Over the last decade some significant research has focused on estimating the global burden of ill health due to various health disorders and due to specific exposures (10, 19, 20, 21, 29, 30). This work has included analyses of exposures and outcomes related to work activity. Recent additions to this important topic include a Special Issue of the American Journal of Industrial Medicine (AJIM) entitled *Contribution of Occupational Risks to the Global Burden of Disease* (11) that amplifies for an occupational health readership the work prepared for the Comparative Risk Assessment (CRA) project of the World Health Organization (2, 3, 10). The International Labor Organization has published new updated estimates of numbers of global occupational accidents and work-related diseases in its *Introductory Report: Decent Work – Safe Work* for the 17th World Congress on Safety and Health at Work (15). *Global estimates of occupational accidents* are analyzed in detail by Hamalainen et al (2006) (12).

The international organizations responsible to the member states of the United Nations (UN) on global occupational health and safety are the World Health Organization (WHO), which primarily relates to National Ministries of Health, and the International Labor Organization (ILO), which relates primarily to National Ministries of Labor as well as to representatives of Employers and of Labor. Traditionally ILO and WHO issue independent estimates of burden related to work activity (15, 10). The editorial in the AJIM Special Issue by occupational health leaders in WHO and ILO brings a desired unity of opinion to the occupational health community (9).

This article summarizes some of the information published in the 2005 Special Issue of the American Journal of Medicine devoted to the *Contribution of Occupational Risk Factors to the Global Burden of Disease* (11), provides the methodology and the findings, and places the WHO results in context with estimates of the ILO of total annual fatalities due to occupational risks.

Methods

Global burden of disease

A "burden of disease" study estimates the gaps between current population health and a normative goal for population health, for a comprehensive set of disease and injury causes, and for major risk factors. The World Health Organization's ongoing Global Burden of Disease (GBD) project provides comprehensive, consistent, and regularly updated estimates of mortality and morbidity for more than 135 causes of disease and injury (33). WHO conducted a Comparative Risk Assessment (CRA) using global data for the year 2000 and a common methodology to estimate the contribution to the health outcomes due to exposures to 26 risk factors grouped in seven major categories of risk factors: childhood and maternal under-nutrition, other diet-related risk factors and physical inactivity, sexual and reproductive health, addictive substances, environmental risks, selected occupational risks, and other risks to health (10). The CRA used a consistent methodology throughout the project so that the impacts of these risk factors could be compared, thus improving the evidence base on distribution and costs of diseases and injuries by risk factor. The purpose was to support rational health policy decisions worldwide to develop interventions to reduce risks. All estimates were stratified by age, gender, and WHO subregions, thus providing regional results for the 191 Member States of WHO that are located in six geographical regions (Africa, Americas, Europe, Eastern Mediterranean, Southeast Asia, and Western Pacific).

Comparative risk assessment

Various measures have been developed to quantify population health, but the most useful for the GBD studies is the disability-adjusted life year (DALY). This is a summary measure, which calculates the years lost from an ideal lifespan due to both morbidity and premature mortality. The DALY thus represents the gap between the current situation, and an ideal situation where everyone achieves standard life expectancy (82.5 years for women, 80 years for men) in perfect health (25, 26).

The heart of CRA was determining the number of DALYs and deaths attributable to the various risk factors, in a manner that allows comparisons to be made. This determination is based on attributable fractions, i.e., the proportion of the incidence of a given health outcome in a given population that is identified as due to a given exposure (25, 26). Attributable fractions of a health outcome were calculated from estimates of the proportion of a population exposed to a risk factor, combined with relative risks of disease or death due to the health outcome resulting from that exposure. The total number of deaths and/or DALYs attributable to the given exposure was determined by multiplying the attributable fraction by the number of deaths and/or DALYs estimated by WHO for the relevant health outcome in the Global Burden of Disease analysis.

WHO comparative risk assessment for selected occupational risk factors

The methodology by which the WHO CRA methodology was used to assess the contribution of occupational risk factors to the global burden of occupational disease and injury is described in Nelson et al, 2005a (22). The stringent requirements of the CRA permitted CRA analysis of only five selected occupational risk factors for which there were adequate global data: occupational carcinogens (6), airborne particulates (7), noise (23), and ergonomic stressors (27) and risks for injuries (3). Also included in the AJIM Special Issue is a separate analysis of Hepatitis B, Hepatitis C and HIV/AIDS infections in Health Care Workers due to needlesticks (26).

Excluded exposures and outcomes

The criteria for inclusion of *risk factors* in the CRA study were: adequate exposure information for all regions, and the applicability of health outcome data to all regions of the globe. Inclusion of a *health outcome* required that it be in the WHO GBD database of diseases and injuries (10). These strict criteria precluded CRA analysis of many occupational risks, including: some respiratory diseases; some infectious diseases; less widespread cancers and carcinogens; musculoskeletal disorders other than low back pain; intentional injuries in the workplace; commuting injuries; organ and systemic diseases resulting from occupational exposure to solvents, pesticides and heavy metals; maternal and perinatal conditions resulting from occupational exposures; skin disorders; coronary heart disease and other outcomes associated with work-related stress. Child labor could not be included due to the lack of consistent national definitions for the youngest ages included in the labor force, as well as lack of exposure and relative risk information on children.

Estimating exposed populations and risks for the selected occupational hazards

The general methodology is described in Nelson, 2005a (22), with details specific to the occupational risk factors provided in the separate papers in the AJIM Special Issue (11). Risk measures (relative risks or mortality rates) for the health outcomes resulting from exposure to the risk factors were determined primarily from studies published in peer-reviewed journals. Adjustments were made, as appropriate, to account for differences in levels of exposure, exposure duration, age, sex, and subregion.

The exposed-worker populations were estimated using an approach based on the International Standard Industrial Classification of All Economic Activities (ISIC), an economic classification system of the United Nations (UN) that organizes all economic activities by economic sectors and relevant sub-groupings (31). The ISIC system is used almost universally by national and international statistical services to categorize economic activity, and therefore allows global comparisons. The ILO has developed economically active population (EAP) estimates by applying economic activity rates (EAR), by sex and age group (greater than age 15) to the population estimates and projections of the UN (14). The EAP provides the most comprehensive global accounting of persons who may be exposed to occupational risks as it includes people in paid employment, the self-employed, and people who work to produce goods and services for their own household consumption, both in the formal and informal sectors. For the WHO Comparative Risk Assessment, the EAP was further divided into nine economic subsectors (where people work) and seven occupational categories (what type of work people do), based upon country-level data for 31 countries (13, 22).

Methodology of the ILO

The ILO regularly updates its estimates of regional and global numbers of occupational injury deaths as new data become available. The estimate is obtained by applying national fatal injury rates for each country to the total employed labor force for that country. Where rates are not available for a country, rates from “similar or comparable” countries are applied. For estimates of total occupational disease deaths, ILO uses an attributable risk approach. Attributable fractions are taken form the Finnish study by Nurminen and Karjalainen (2001) (24), with some minor modifications to take account of particular conditions and regions. These fractions are applied to overall disease death estimates by age and sex in the WHO Global Burden of Disease database (8).

Results

The WHO Comparative Risk Assessment data provide detailed, yet still incomplete, results for the global problem of occupational health risks. In total, the selected occupational risk factors accounted for 850,000 deaths per year, and for almost 24 million disability-adjusted life years lost (DALYs). Figure 1 illustrates the attributable fractions for the selected occupational risk factors.

The WHO CRA analysis found that occupational injuries result in about 312,000 deaths per year for the world’s 2.7 billion workers (3). As in the industrialized world, high injury fatality rates in the developing world are clustered in certain sectors, including agriculture, construction, and

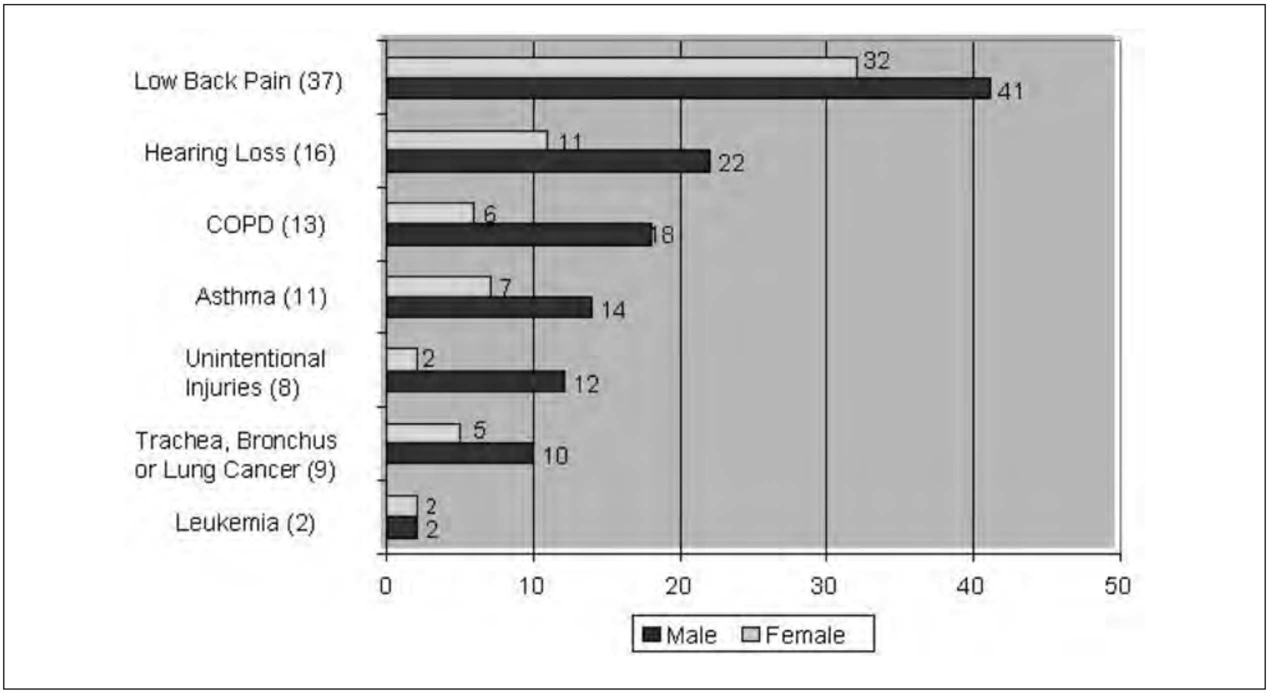

Figure 1 - Attributable fraction of global disease and injury due to occupational risk factors (the attributable fraction for the each of the pneumoconioses (silicosis, asbestosis and coal workers' pneumoconiosis) and for mesothelioma is assumed to be 100%, since virtually all exposure occurs in an occupational setting). Source: Adapted from (2)

mining. Occupational injuries accounted for more than 10 million DALYs and 8 percent of unintentional injuries worldwide. ILO estimated 335,000 deaths from occupational accidents in 1996 (29) and 350,000 in 1998 (12). The somewhat different methods give similar results, all of which noted by the authors to be underestimates of the true number.

The second occupational risk factor was exposure to workplace lung carcinogens (such as asbestos, diesel exhaust, and silica) and leukemogens (such as benzene, ionizing radiation, and ethylene oxide). The WHO CRA analysis found that occupational exposures account for about 9 percent of all cancers of the lung, trachea, and bronchus and about 2 percent of all leukemias. Overall, about 102,000 deaths were due to these two occupational cancers and about 1 million DALYs. An additional 43000 deaths and 563,000 DALYs were estimated for malignant mesothelioma, caused by asbestos. (6).

Estimates of the global burden of chronic nonmalignant lung disease demonstrate the significant contribution of occupational exposures. There were an estimated 386,000 deaths (asthma: 38,000; COPD: 318,000; pneumoconioses: 30,000) and nearly 6.6 million DALYS (asthma: 1,621,000; COPD: 3,733,000, pneumoconioses: 1,288,000) due to exposure to occupational airborne particulates. Occupational exposures accounted for about 13 percent of all chronic obstructive pulmonary disease (COPD) and about 11 percent of asthma. For the pneumoconioses (silicosis, asbestosis and coal workers' pneumoconiosis), the attributable fraction was assumed to be 100%, since virtually all exposure occurs in an occupational setting. (7).

The remaining selected occupational risk factors have in common the fact that they do not directly produce premature mortality but do result in substantial disability. This feature differentiates these conditions from the others analyzed in the study. The CRA analysis found that 37 percent of all back pain worldwide is attributable to work, resulting in an estimated 0.8 million DALYs, significant loss of time from work, and high economic loss (27). Additionally, worldwide, 16 percent of all hearing loss was attributable to workplace exposures, resulting in 4.2 million DALYs (23).

Because of the critical role played by health care workers everywhere, a special risk analysis independent of the CRA methodology was made of Hepatitis B, Hepatitis C, and HIV infections among health care workers due to contaminated sharps, such as syringe needles, scalpels, and broken glass. This analysis illustrates the general problem of high risks existing in the small worker population having exposure. Among the 35 million health workers worldwide there were 3 million percutaneous exposures to bloodborne pathogens in 2000. This is equivalent to between 0.1 and 4.7 sharps injuries per year per health worker, varying by subregion. The analysis found that about 40% of Hepatitis B and 40% of Hepatitis C present in health care workers were due to sharps injuries, with wide regional variation. Between 1 percent and 12 percent of HIV/AIDS infections in health care workers was due to sharps injuries in different subregions, with an overall estimate of 4.4% (26) (figure 2).

In summary, the selected occupational risk factors included in the WHO Comparative Risk Assessment were responsible for about 850,000 deaths worldwide in 2000 and caused workers who developed outcomes related to these occupational risk factors to lose about 24 million years of healthy life. Injuries, hearing loss, and COPD together accounted for about 80 percent of years of healthy life lost. Just three of the selected occupational risk factors (carcinogens, airborne particles and injuries) accounted for the 850,000 deaths. These deaths constitute less than 40% of the total 2.2 million occupational disease and injury deaths estimated by ILO to have occurred in 2000 (15).

Discussion

The AJIM Special Issue examines the role of burden estimates in global health and safety, notes the issues and general principles associated with developing such estimates, and puts the WHO

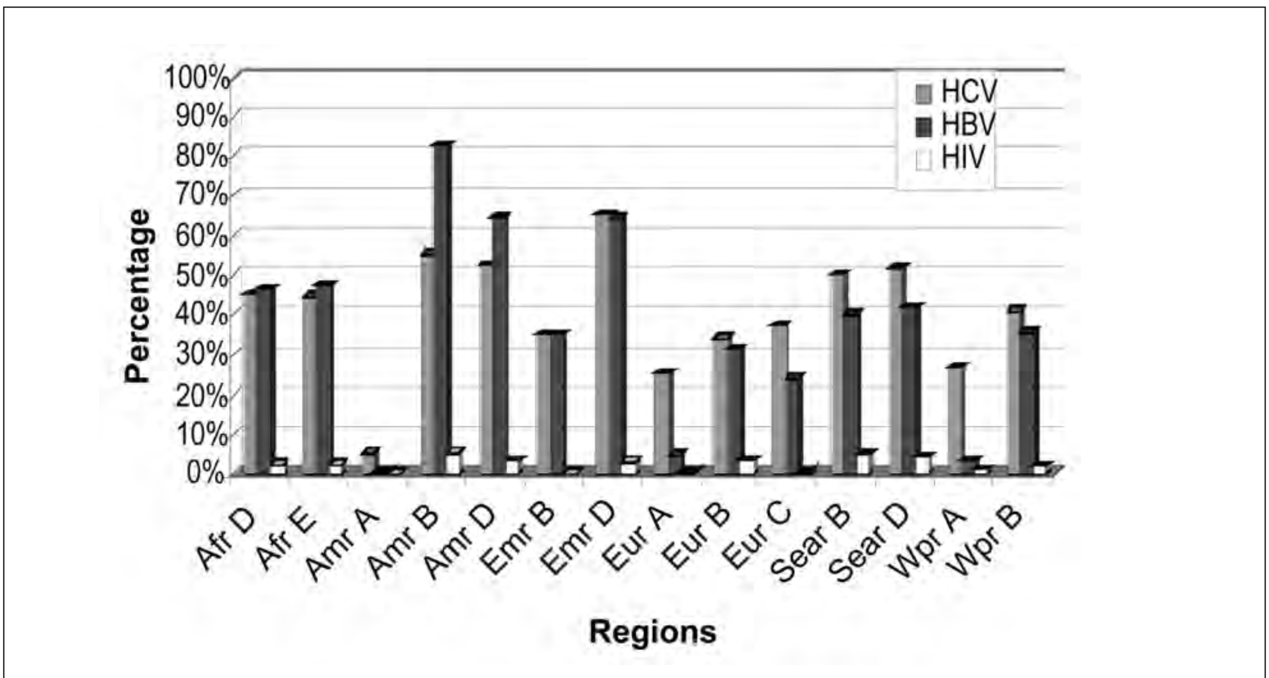

Figure 2 - Attributable fraction of HCV, HBV, and HIV infections in health care workers due to injuries with contaminated Sharps. Source: (32)
HCV: Hepatitis C Virus; HBV: Hepatitis B Virus; HIV: Human Immunodeficiency Virus; Afr: Africa; Amr: America; Emr: Eastern Mediterranean; Eur: Europe; Sear: South-East Asia; Wpr: Western Pacific

CRA estimates into context with ILO independent estimates.

The WHO Comparative Risk Assessment has accounted for only about 850,000 of the more than 2.2 million deaths estimated by ILO to occur each year due to occupational illness and injury (15). This is primarily because deaths due to a wide range of occupational exposures could not be included in the CRA study due to the strict requirements for global data. It is important to note that the consequences of grave underreporting in existing systems and the dearth of high quality record-keeping systems in the developing nations lead to substantial undercounting by both the ILO and WHO. Additionally, the absence of adequate data particularly in developing countries requires that all global estimates utilize extrapolation from developed country data. Despite the data deficiencies, however, the global analyses provide important insights into the immense global burden of disease and injury due to occupational risk factors.

Next steps

Improve data collection

One of the important limitations for carrying out the global burden studies, and also national burden studies in terms of occupation, is the lack of reliable data, particularly in developing countries. Clearly, it is important for countries to improve national statistics describing traditional exposures and health outcomes. Challenges exist for the scientific community to develop methods and criteria for newer etiologically relevant physical and psychosocial exposures and outcomes. Only then can countries develop such databases using standardized methods and criteria.

However, it is critical, particularly in situations with scarce resources, to find the right balance between "perfect data" and "enough data to act". It should be noted that 2.2 million deaths per year place annual occupational fatalities higher than deaths due to tuberculosis (1,644,000) and almost double the deaths from malaria (1,124,000) that were reported in the 2002 WHO World Health Report (32). The analyses reported here and by others provide more than adequate evidence to act to reduce workplace risks.

Improve methodologies

Future analyses need to use different approaches in order to "triangulate" results, hopefully leading to confidence regarding which estimate is closer to the true burden. Improvements in injury estimates are likely to come from more country-specific outcome data; clearer delineation of the type of cases included (particularly by excluding disease cases, separately identifying commuting cases, including homicide cases, and deciding whether to include or exclude suicide cases); better estimates of the true population at risk by including child workers and workers in the informal sector; and inclusion of bystanders. Improvements in disease estimates will probably arise from the use of better country or region-specific exposure data, allowing more appropriate attributable risks to be used, and improved relative risk estimates for cardiovascular, malignant, respiratory, and communicable diseases.

It should also be noted that as a basis for decision-making and policy setting, information on global burden, whether measured by deaths or DALYs, needs to be complemented by additional information, in particular on the cost-effectiveness of various interventions. This information is required if preventive activity is to be targeted as appropriately as possible, although information on the number of deaths makes an important contribution to awareness raising, monitoring, and to initial prioritization of resources. The AJIM Special Issue includes 3 articles illustrating how cost-effectiveness studies could be done (16-18)

Calculate national and regional burden

In order to assist ministers and other policy makers, as well as scientists in the countries, WHO has made available guidance for performing national and local assessments of disease and injury burden due to the selected occupational risk factors. Documents illustrating how to assess the national and local burden of disease from work-related noise, occupational carcinogens, and occupational particulate exposure are available free of charge at http://www.who.int/quantifying_ehimpacts/publications/en/ (1, 4, 5, 25, 28).

Introduce workplace interventions to reduce risks

Strategies for controlling injury and occupational disease, developed by industrial hygienists and others over many decades in industrial countries, are fully applicable in developing countries. The strategies include a hierarchy of controls in decreasing order or preference: substitution of major hazards for less hazardous materials or processes; application of engineering controls to separate workers from hazards that remain; use of administrative controls to minimize contact uncontrollable by engineering; and, as the last line of defense, the use of personal protective equipment such as respirators and protective garments. What differs in developing country situations is the context in which the controls must be applied.

An example of an approach supported by WHO and ILO to use knowledge about exposure to provide simplified guidance to immediately control the hazards is "control banding", re-named as the Occupational Risk Management Toolbox (see http://www.ilo.org/public/english/protection/safework/ctrl_banding/index.htm). The approach of, for example, a Chemical Toolkit is to provide practical risk assessment and management approaches that can be applied across the board by employers and workers.

The WHO Global Network of about 70 Collaborating Centers in Occupational Health fosters such projects, which can be seen in the new 2006-2010 Work Plan of the Collaborating Centers at www.who.int/oeh.

Solutions exist to address risks experienced by health care workers from contaminated sharps, as illustrated in figure 2, in the countries and regions that have engaged in serious prevention efforts. Proper needle handling and waste management, substitutions for sharps, Hepatitis B virus (HBV) immunization, post-exposure prophylaxis, training, and legislative measures have been successful. Beyond the personal and workplace consequences, the potentially devastating societal impact of loss of this critical worker group can be anticipated if prevention measures are not ensured in the developing countries where the proportion of health care workers in the population is already small. This situation is so critical that the topic this year for the April 7, 2006 WHO World Health Day is Health Workers (See http://www.who.int/world-health-day/2006/en/.)

Conclusion

The magnitude of the occupational health burden in the world is overwhelming, and the causes and mechanisms behind it are multiple and complex. The magnitude calls for an integrated, coordinated, and strategic response. Particularly the health and labor sectors, together with the social partners (workers and employers), but also non-governmental organizations (NGOs), training institutions, and local governments play key roles in addressing the occupational health and safety issues. Commitment from all partners to improve occupational health and safety for all workers, is essential to translate economic progress to sustainable human development.

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La Medicina del Lavoro

Med Lav 2006; 97, 2: 322-323

Toxicogenomics and environmental diseases: the search for biomarkers predictive of adverse effects

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Key words

Biomarkers; toxicogenomics; environmental diseases

The mission of the National Center for Toxicogenomics of the National Institute of Environmental Health Sciences of the U.S. National Institutes of Health is to utilize genomic approaches to investigate environmental effects on the etiology and progression of injury and disease processes. Thus a key goal is to design and conduct seminal studies that provide definition to and stimulate development of the field of toxicogenomics, integrating global "omics" approaches into conventional studies of toxicity and disease processes. Toxicogenomics, as defined by the NCT, combines genetics, genome-wide mRNA expression analysis (transcriptomics), cell and tissue-wide protein expression analysis (proteomics), and metabolite profiling (metabonomics) with conventional biology, physiology, pathophysiology and toxicology in an effort to understand adverse affects of gene-environment interactions on human health. Core to the NCT research strategy is the concept of phenotypic anchoring in which studies are designed to relate specific alterations in gene expression to specific adverse effects of environmental stresses defined by conventional parameters of toxicity and pathology such as clinical chemistry, histopathology, etc. To accomplish this task, studies have been designed that utilize a variety of agents that elicit a similar adverse response at a variety of doses and a variety of times of treatment that would elicit the full range of biological responses to those agents. In addition, attempts have been made to incorporate exposures to related but non-adverse agents when possible and to analyze biological responses in additional tissues that do not seem to suffer the same adverse effect (non-target tissue). When analysis of the experimental results implicates a critical role of a particular biological process or a critical role of a particular gene in the response, additional experiments are designed to test those hypotheses concerning their roles. Studies therefore are designed both to gain insight into mechanisms of injury and disease initiation and progression, and to establish signatures of adverse effects, linking gene expression alterations to specific parameters of well-defined indices of injury and disease to develop putative biomarkers. One aspect of this is to develop biomarkers that are reflective of incipient injury or disease before the culmination of severe injury or disease in order to develop true "predictive toxicology" through the use of toxicogenomics. Our strategy to accomplish this is to build a compendium of signatures linked to environmentally important patho-biological endpoints. In order to learn more about processes involved in acute liver injury and to investigate the true power of genomics to provide insight into mechanisms of injury as well

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as to provide profiles of processes of injury, we selected a single agent to focus our research efforts initially. Acetaminophen (APAP) was selected as an appropriate model hepatotoxicant due to the well-defined adverse phenotypic endpoints in the liver following toxic exposures, the similarities in metabolism between rodent and human and the relevance of exposure to humans. Studies were designed to test several hypotheses including whether genomic analyses of the liver could reveal indicators of incipient injury before that injury was manifested in such a severe manner as to be detected by traditional indices of liver injury. We were able to demonstrate that gene expression analysis can yield signatures of incipient toxicity after exposure to sub-toxic doses of the toxicant of interest (Heinloth et al, Toxicol Sci 2004; *80*: 193ff). In this manner, the NCT program is striving to integrate conventional biology, genetics, pathology and toxicology with emerging "omics" technologies in order to develop useful insights and potential biomarkers to aid in improving human health.

La Medicina del Lavoro Med Lav 2006; *97*, 2: 324-331

Guidance values for the biomonitoring of occupational exposure. State of the art

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Key words
Biological monitoring; guidance value; speciation

Summary
Biomonitoring was developed for the assessment of the health risks from exposure to chemicals at work, and the approaches and concepts of biomonitoring are derived from such exposures. At present, biomonitoring is increasingly used also to assess exposure from the environment. Biomonitoring and assessment of external exposure are complementing activities, where the exposure assessments are much more widely applied, especially when the number of chemicals concerned is considered; environmental analysis also offers the distinct advantage of speciation analysis - which is very poorly developed for biomonitoring. Biomonitoring on the other hand provides information on exposure from all sources, and via all absorption routes, and considers also accumulation of the chemical in the body. Biomonitoring using exposure biomarkers thus consider interindividual differences in the absorption, while use of effect biomarkers ideally also considers interindividual differences in sensitivity. Few effect biomarkers, however, have been validated. The major challenges of biomonitoring are the development of monitoring methods, which are inexpensive enough to be applied at a frequency that makes possible meaningful biomonitoring of chemicals with a short half-time; development of exposure biomarker guidance values specific to individual species of different metals; expansion of the repertoire of validated effect biomarkers; and validation and application to effect monitoring of the omic technologies. Another major challenge is a reconsideration of the basis of biomonitoring action limits to reflect the change in the work place: Biomonitoring should be adapted to assist in the generation of a healthy workplace, which is capable of attracting workers, and assist them to perform their work effectively – rather than just to guarantee absence of serious health effects.

Riassunto
«Valori guida per il monitoraggio biologico dell'esposizione ad agenti chimici negli ambienti di lavoro. Stato dell'arte.». *Il monitoraggio biologico è stato sviluppato per la valutazione dei rischi per la salute causati dall'esposizione ad agenti chimici negli ambienti di lavoro, e gli approcci e i concetti del monitoraggio biologico derivano da queste esposizioni. Attualmente, il monitoraggio biologico viene utilizzato sempre di più anche per valutare le esposizioni derivanti dall'ambiente. Il monitoraggio biologico e la valutazione di esposizioni ambientali sono attività complementari, dove le valutazioni dell'esposizione sono applicate in maniera più ampia, specialmente quando si considera un numero di agenti chimici di interesse. L'analisi ambientale inoltre offre il preciso vantaggio di analisi di speciazione, che è scarsamente sviluppata per il monitoraggio biologico. Il monitoraggio biologico d'altra parte, fornisce informazioni sull'esposizione di tutte le fonti, su tutte le vie di assorbimento, e tiene anche conto anche del-*

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l'accumulo dell'agente chimico nel corpo. Inoltre, il monitoraggio biologico, attraverso gli indicatori di esposizione, considera le differenze interindividuali nell'assorbimento, mentre l'utilizzo di indicatori di effetto idealmente permette di considerare la variabilità individuale di sensibilità. Anche se pochi sono gli indicatori di effetto validati. Le sfide principali del monitoraggio biologico sono (i) lo sviluppo di metodi di controllo che siano sufficientemente economici da essere applicati con una frequenza tale da rendere possibile un monitoraggio efficace di agenti chimici con un breve tempo di dimezzamento; (ii) lo sviluppo di valori guida di indicatore di esposizione specifico per le singole specie di metalli differenti; (iii) l'ampliamento del repertorio di indicatori di effetto validati; e (iv) la validazione e l'applicazione al monitoraggio degli effetti delle tecnologie "omiche". Un'altra importante sfida è la riconsiderazione delle basi dei limiti di azione del monitoraggio biologico nel riflettere i cambiamenti negli ambienti di lavoro. Il monitoraggio biologico deve essere adatto al fine di aiutare la creazione di un posto di lavoro sano, che sia capace di attrarre i lavoratori, di favorirli nello svolgere il loro lavoro in maniera efficace, piuttosto che garantire solo l'assenza di seri danni alla loro salute.

Introduction

The first paper on biomonitoring - on the use of the analysis of lead in urine in exposed workers as means of diagnosing lead-induced industrial disease - was published in 1927 (6). We thus approach the 80th anniversary of biomonitoring. Biomonitoring has its origins and widest area of application in the assessment of exposure to chemicals at work, but it has made important contributions also to the assessment of health hazards from environmental exposure, and at present an extensive programme on environmental biomonitoring is in progress in the US (http://www.cdc.gov/exposurereport/) and another is planned in Europe (http://www.euro.who.int/eehc/implementation/20051017_1). Widely publicized results of analyses of environmental chemicals in the blood and urine of populations have raised concerns, when the interpretation and limitations of the results have not been clear (http://today.reuters.com/News/CrisesArticle.aspx?storyId=L05670176).

In risk assessment of metal exposures, indicators of effects and indicators of exposure have been considered in several consensus documents, published since the 1970:s by the Scientific Committee on the Toxicology of Metals of the International Commission of Occupational Health (ICOH) (7, 9, 21, 22). Authoritative reviews on different aspects of biological monitoring, including analytical methods, reference values, and guidance values, have been published by IPCS, WHO and others (1, 4, 10, 11, 13-15, 23, 24). The term "Biological Monitoring" (synonym Biomonitoring) has been used for a long time and more widely during the last two decades (8, 9) to describe exposure and internal dose of metals by measurements in biological samples such as blood and urine and other human tissues and fluids.

A *biomarker* is an indicator signalling an event or condition in a biological system or sample, giving a measure of exposure, effect or susceptibility (17).

A *Biomarker of exposure* relates exposure to a xenobiotic (*i.e.*, a metal or metal compound) to the levels of this substance or its metabolite, or of the product of an interaction between the substance and some target molecule or cell that can be measured in a compartment within an organism (13, 17).

A *biomarker of effect* is a biomarker that, depending on its magnitude, can be recognised as associated with an established or possible health impairment or disease (13, 17).

There are some examples of useful *biomarkers of early (critical) effects*. One such example is the detection of early damage to the kidney tubules by cadmium using urinary levels of low molecular weight proteins such as beta-2-microglobulin, protein HC and the enzyme N-acetylglucosaminidase.

Interpretation of biomonitoring results

A prerequisite of a meaningful interpretation of biomonitoring results is an accurate chemical analysis. Although analytical techniques have developed dramatically in the last few years, the analytical quality still is of major concern, and an efficient external quality control such as those provided by e.g. the German Society for Occupational and Environmental Medicine, Erlangen, Germany (http://www.g-equas.de/), Finnish Institute of Occupational Health (http://www.ttl.fi/search/MsmGo.exe?grab_id=149&page_id=11534848&query=quality+assurance&hiword=assurance+quality+), United Kingdom National External Quality Assessment Service (http://www.ukneqas.org.uk/anage/overview.htm), Robens Institute of Industrial and Environmental Health, Guildford, UK (http://www.surrey.ac.uk/SBMS/eqas/index.html) and Toxicology Centre, Québec, Canada (http://www.ctq.qc.ca/ctqintre.html), should be a part of all biological monitoring programmes.

A feature that distinguishes biomonitoring of chemicals from e.g. clinical chemistry analyses, is the dependence of the concentration of the chemical of the kinetics and exposure pattern: At work, the exposure is at most for a period of 8 hours daily, and very often is limited to only short periods of time within the working hours. Some chemicals or their metabolites have a very short half time in the body, especially in blood, and thus the concentration drops very rapidly immediately after the exposure – and the concentration measured may reflect more the time lapse between exposure and sample collection than the actual original concentration while the exposure takes place. This will lead to badly distorted assessment of the exposure – and of the risk involved, and even to the conclusion that there is no exposure when in fact there was exposure but by the time the sample was collected all chemical has disappeared from the blood. While the excretion in the urine functions as a buffer and the problem thus is not equally conspicuous, all biomonitoring requires knowledge of the timing of the sample collection, and of the kinetics of the analyte measured in that matrix.

Biomarkers of exposure may be used to identify exposed individuals or groups, quantify the exposure, assess the health risks, or to assist in diagnosis of (environmental or) occupational disease. The first two depend on a comparison of the results with reference values, the latter two to a comparison to biomonitoring action limits.

Identification of exposed people

For the identification of the exposed, the analytical results are compared to the reference interval for the element in the matrix studied. Reference intervals are derived from reference values observed in a reference population, usually as the 95 the percentile – meaning that 1 out of 20 non-exposed will give a result outside the reference range. As the reference values are different in different geographic locations (mainly because of variation in exposure via the diet), reliable identification of exposure crucially depends on reference values determined in the area of analysis, and is up-to-date. There is considerable variation among countries depending on a combination of geological factors, dietary habits and anthropogenic exposures that may affect a whole country (18). Examples are mercury levels in blood and hair which are much dependent on the fish consumption in the population studied (19, 20). Cadmium levels are higher in Japan than in other countries, probably due to a low level contamination of rice which originates from a combination of geological factors and mobilisation of Cd into the environment by human activities (12). Year-by -year fluctuations in selenium levels have been recorded in the Finnish population related to the wide distribution of selenium-rich imported wheat some years when the local crops were insufficient (5). While dietary exposure to the chemical is the main component of the reference values, factors such as smoking also have to be considered: reference values of cadmium in blood and urine, and also of benzene /its metabolites, or toluene in blood, are different for smokers. The main obstacle for biomonitoring of platinum is the platinum derived from dental prostheses, which overshadows any occupational or environmental exposure.

As discussed above false negative results will be obtained if the timing of the specimen collection is not appropriate.

A biomarker level above the reference limit does not tell anything of a possible health hazard – it simply means that the individual has been exposed to a greater extent than the reference population.

Reference values are intended to identify exposed individuals; if biomarker concentrations are available for several members of a group, a more appropriate assessment of the exposure situation of the group is obtained from a statistical comparison of the exposed group and the reference population.

Quantitation of exposure

In occupational settings, quantitation of exposure usually refers to a comparison of the amount absorbed in the body at an exposure equivalent to the occupational exposure limit rather than to the derivation of a dose *e.g.* in mg/kg body weight. The situation is quite complicated in environmental biological monitoring, there is not similar point of reference, and the assessment of the dose is done by modelling; data required for the modelling is only available for few chemicals.

Quantitation of exposure relies on knowledge on the relationship between the exposure, usually measured the time-weighted average concentration of the chemical in the air, and the concentration at a specified time, of the biomarker in the blood or urine - or in rare cases, other biological media.

The robustness of different biomarkers as quantitative indicators of exposure varies: for some, such as mandelic/phenylglyoxiclic acid in urine in exposure to styrene, thiothiazolidine carboxylic acid in urine en exposure to carbon disulphide, or chromium in urine in manual metal arc welding, or methylmercury in blood or hair in dietary exposure, the relationship is well known, and several studies give similar results. On the other hand, while for some chemicals individual studies show a relationship between exposure and the biomarker level, individual studies give different results – such as dimethylformamide, hexane, or cobalt. For some further chemicals, only very limited database is available and thus there is a major uncertainty – such as benzene or toluene in blood or urine, or the arsenic metabolites in exposure to arsenic trioxide.

As discussed above, consideration of the kinetics and appropriate timing of specimen collection are prerequisites of accurate exposure assessment. If the half-time is shorter than say 6 hours, it may be impossible to do any quantitative biomonitoring. Concentration in the urine is related to the time-weighted average concentration in blood (or actually to the free concentration in plasma). Thus for elements with a short half-time in the blood, it may be kinetically advantageous to analyse the urine rather than blood

For many chemicals, the disappearance from the blood exhibits several consecutive half-times, and thus by an appropriate sampling strategy, an idea of exposure over different time periods may be obtained: e.g., concentration of chromium in the urine of manual metal arc welders on Friday afternoon reflects mainly exposure over that day, that in a Monday morning urine specimen, exposure over the preceding week (3).

Quantitation of exposure in itself does not give an indication or prediction of adverse health effects. However, for several chemicals, follow-up studies among exposed worker populations – in which the level of exposure is known – allow assessment of the risk. If in addition. The relationship between the biomarker levels and the exposure is known, an indirect estimation of health risks may be achieved from biomonitoring data; this is the case for e.g. styrene, carbon disulphide, and dimethylformamide.

One of the areas where biomonitoring has traditionally been considered as best justified is the assessment of exposure of chemicals that are mainly absorbed through the skin, as traditional industrial hygiene measurements are not very informative. However, biomonitoring also has problems in this area: although it may measure the exposure very well, the result does not automatically render itself to interpretation, the question being, what does this result represent in terms of absorbed amount (or health risk). The answers must be sought from experimental exposure studies, comparisons between exposure exclusively via inhalation, and via the dermal route – but especially for very toxic, or carcinogenic chemicals, such experiments may not be possible to carry out. An important step forward, originally proposed by the British Health and Safety Executive, was to use levels observed in work places with good hygiene ad the basis for determining, what is an acceptable biomonitoring result in these situations: they set the biomonitoring action limit to a level achieved in 90% of the #good work places.

Assessment of health risk

Assessment of health risk of health risk from biomonitoring may be achieved if the relationship between the effects and the biomarker concentrations is known. This is the case for lead in blood, cadmium in blood and urine, methylmercury in blood and hair, and inorganic mercury in urine, and to a more limited extent, for arsenic in urine, carbon monoxide in blood, and fluoride in urine. For these elements, epidemiological studies area available, which have studied the relationship between the biomarker level and long-term health effects. In fact, for methylmercury, cadmium, and lead, the risk assessment is primarily based on biomonitoring. Such studies are difficult to carry out, and often the study results are not very consistent.

For some chemicals (styrene, carbon disulfide), an assessment of health risks may also be obtained indirectly from the relationship between health effects and external exposure (concentrations in the air) and that between the biomarker concentration and the concentration in the inhaled air.

Biomonitoring in clinical diagnosis

Chemically-induced adverse health effects or diseases usually are not different from the same disease induced by other causes, and thus a causal diagnosis, "etiognosis" depends on the clinical picture plus history of exposure considered sufficient to cause the disease. In the assessment of the history of exposure, biomonitoring when available is probably the best means as it provides direct information of the exposure of the individual.

Biomarkers of exposure and industrial hygiene measurements

Biomonitoring most widely applied in occupational health, and thus has a similar objective as industrial hygiene measurements, assessment of exposure through measurement of the concentration in the air. While it is clear that for most chemicals, industrial hygiene measurements are the best and often the only way of assessing exposure, the two approaches complement each other as their scope and performance are not identical.

Air is a homogeneous and relatively simple matrix, and therefore, sample preparation is often simple and straightforward, and analytical methods relatively easy. When the air-borne concentration of the chemical is low, the amount of air collected on the filter may be increased, and thus the sensitivity of the analysis improved. As air measurements also have a long tradition, established methods exist for the large majority of industrial chemicals. For several elements, fractionation and speciation analysis methods are available and thus important qualitative information on the exposure may be gained from such analyses.

On the other hand, concentrations of chemicals in workplace air are seldom stable but fluctuate with time and are different in different locations. The amount of a chemical that reaches the alveolar region of the respiratory tract is directly related to the volume of respiration and thus to the work load. Exposure peaks often coincide with increased workloads caused by e.g., the malfunctioning of a closed process. Several chemicals are absorbed also via the dermal route and the absorption via the skin is generally not related to the concentration in the air. Even when the exposure takes place mainly by inhalation, the bulk of the actual absorption may be via the gastrointestinal tract (notably aerosols with particle sizes too large to lead to deposition in the alveolar region). Personal working habits vary, and individuals may absorb different amounts of chemicals in apparently similar conditions. Protection afforded by personal protection devices varies depending on the user and on the condition of the device. Furthermore, biomarker, in contrast to industrial hygiene measurements, reflects the accumulation of the chemical in the body. Biomarkers of exposure, which reflect all this variation in exposure - and at the same time, exposure from all sources - are thus closer than industrial hygiene measurement to the toxicologically important concentration of the chemical at the target site (1).

Biomarkers of exposure do not consider inter [or intra]-individual differences in the toxicodynamics of the chemical - which are covered in an ideal case of effect biomarkers. Biomarkers do not differentiate between sources of exposure and in order to decrease the risk from the chemical, it may be necessary to consider (and analyse) separately, from where the exposure is derived, from work or from e.g. hobbies, or environment.

Biomarkers of exposure reflect the amount of the chemical in the systemic circulation and models have been developed to predict concentrations in other compartments in the body. However, a major obstacle in the interpretation of biomonitoring data involves concentration and effects at the site of entry, such as the lungs after exposure to particulates containing metals: concentrations in the urine or even blood of nickel tell little of the concentrations or the health risks in the lungs after exposure to soluble or insoluble nickel. Similarly, irritation - a mainly concentration-related effect - is not easily assessed from exposure biomonitoring data.

Biomarkers of effect

Biomarkers of effect have the intrinsic advantage that they may take into account differences in individual sensitivity to the chemical. Thus e.g. in exposure to cadmium, assessment of low-molecular weight protein sin urine may be used to identify individuals who are exceptionally sensitive, i.e., develop adverse health effects at levels of exposure, at which individuals with normal sensitivity remain healthy. However, cadmium and its renal effects are practically the only case, where such an advantage can be achieved; no other biomarker of effect has been truly validated as a predictor of health effects, although a large variety of biomarkers of effect have been described for neurotoxicity, lung toxicity, and genotoxicity (2, 4).

Speciation in biomonitoring

With few exceptions, routine biomonitoring is dependent on the analysis of the total content of an element as the biomarker, rather than a speciation analysis. For some elements, this simplistic approach is well sufficient; this is notably the case when the key effect of the element on the health is systemic and the relationship between the total element concentration and the effect is known. Thus most of the time in occupational exposure, a reliable prediction of long-term health effects may be made from (total) lead in blood, (total) mercury in blood or urine, and total cadmium in blood or urine. However, in exposure to tetraethyl lead, or in exposure to methylmercury from diet, these analyses may be very much misleading. This error may be even more marked, when there is concomitant exposure to different species of the same metal. The toxicity, including mutagenicity and carcinogenicity of several metals is very much dependent on the identity of the elemental species - or e.g. the oxidation state, inorganic vs. organic compounds of the same element. To overcome these problems, speciation analysis is an important aspect in biomonitoring now and in the future. Speciation in biomonitoring may be approached with three different strategies: analysis of specific element species (as of now, practically limited to arsenic), fractionation by chemical analytical means to organic vs. inorganic species (mercury, lead in blood mainly), or application tot he analysis of information on the differences in the distribution of different species o f an element (mercury in plasma, blood cells, urine; chromium in erythrocytes / plasma (15).

Even when the total concentration of an element is measured, exposure indices of the individual species to which the population is exposed should be developed and used, when appropriate (15).

Future trends

The major challenges of biomonitoring include the development of monitoring methods, which are inexpensive enough to be applied at a frequency that makes possible meaningful biomonitoring of chemicals with a short half-time; development of exposure biomarker guidance values specific to individual species of different metals; expansion of the repertoire of validated effect biomarkers; and validation and application to effect monitoring of the omic technologies.

A further major challenge is a reconsideration of the basis of biomonitoring action limits: Until today, they have been derived from consideration of serious health effects. With the demographic development in industrialized countries, and looming or already prevailing shortage of work force, there is an increasing pressure to generate workplaces that are able to attract people, and chemical exposures thus must be kept low enough to guarantee not only health but also work environment that stimulates the work force to high productivity. Work place attractivity thus has to be tailored in to the biomonitoring action limits – and such a paradigm does note exist today.

As of today, biomonitoring action limits (like their model, industrial hygiene guidance values) have been mostly developed as point estimates of the highest concentration likely not to induce serious health effects. Thus the approach is quite different from the modern risk assessment practices, where a no-effect level is first developed, than the uncertainty of the assessment is considered, and the final figure of acceptable concentration is developed through the application of an uncertainty factor. Therefore, the biomonitoring action limits/workplace air standards differ from the guidance given to the general publication often much more than what would be expected from the difference between the two populations (working population vs. general population including children and sensitive individuals).

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La Medicina del Lavoro

Med Lav 2006; *97*, 2: 332-338

Behavioral toxicology: from historical background to future trends

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Key words

Behavioral toxicology; neurotoxins; central nervous system

Summary

In the 1960's and 70's some investigators started to use behavioral tests in toxicology, realizing that classical toxicological methods were inadequate to describe the negative effects on workers health caused by workplace neurotoxic exposures. Among the first publications were those of Helena Hänninen, who reported on exposure to CS_2 (24, 22). In clinical examinations, these workers presented severe functional changes to the central nervous system (CNS), although there were no observable signs of frank brain damage. In experimental studies of effects from acute exposures to various chemicals, methods from classical toxicology were definitely not useful. Such investigations were performed with exposure to carbon monoxide and to different solvents. Studies were carried out in the US, Sweden, and Germany, and reported by Richard Stewart (53), Francesco Gamberale (15, 16), and Gerhard Winneke (63). Rapid development followed. Scientists active in behavioral toxicology gathered at various meetings, and in 1982 an international symposium dedicated solely to the use and development of behavioral testing techniques in toxicology was organized by Renato Gilioli. He then used the Scientific Committee of Neurotoxicology and Psychophysiology of the International Commission on Occupational Health as a platform for a series of triennal symposia. The 9th meeting was held in Korea 2005, and the 10th will be organized in Costa Rica 2008. By providing a basis for the exchange of scientific knowledge and ideas, these symposia have been successful in further advancing the development and application of behavioral techniques in toxicology. This history is presented in some more detail, and a few possibilities for further development of the area will be discussed.

Riassunto

«Tossicologia comportamentale: dal background storico ai futuri sviluppi». *Negli anni '60 e '70 del secolo scorso alcuni ricercatori iniziarono ad utilizzare test comportamentali in tossicologia, dopo aver constatato che i metodi tossicologici classici erano inadeguati a descrivere gli effetti negativi causati da esposizioni professionali a neurotossici sulla salute dei lavoratori. Le prime pubblicazioni furono quelle di Helena Hanninen, che descrisse esposizioni a CS2. I lavoratori esaminati presentavano alterazioni importanti del sistema nervoso centrale, sebbene non si osservassero franchi segni di danno cerebrale. In studi sperimentali sugli effetti provocati da esposizioni acute a varie sostanze chimiche, i test della tossicologia classica risultarono del tutto inutili. Con i test neurocomportamentali si studiarono gli effetti dell' esposizione al carbonio monossido ed a differenti solventi. Gli studi furono compiuti negli Stati Uniti, Svezia, Germania da Richard Stewart, Francesco Gamberane e Gerhard Winneke. Seguirono rapidi progressi. Ricercatori che si occupavano di tossicologia comportamentale organizzarono vari incontri, e nel 1982 un*

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simposio internazionale dedicato esclusivamente allo sviluppo delle tecniche per testare il comportamento in tossicologia fu organizzato da Renato Gilioli. Egli successivamente grazie al Comitato Scientifico di Neurotossicologia e psicofisiologia della Commissione Internazionale di Medicina del Lavoro organizzò una serie di simposi a cadenza triennale. Il nono meeting si è tenuto in Korea nel 2005, Il decimo sarà in Costa Rica nel 2008. I simposi, fornendo le basi per lo scambio di conoscenze scientifiche e idee, si sono dimostrati molto utili per permettere ulteriori avanzamenti nello sviluppo e nell'applicazione delle tecniche comportamentali in tossicologia.

Introduction

In the 1960's, it was obvious to many that classical toxicological criteria, including obvious cellular damage, could not effectively detect and describe the impact on the central nervous system (CNS) from chemical exposures in the work environment. This lack of documentation of health effects in practice meant that prevention was not possible. In Scandinavia, effects from exposure to various solvents were widely debated (27), and they were perceived by many workers and trade union representatives as a major threat to health and well-being.

These insights led to the application of behavioral methods in the efforts to document the influence from chemical exposures on the working population. Effects on the nervous system were described in clinical studies on workers exposed to carbon disulphide in viscose rayon published by Helena Hänninen in Finland (22, 23). Experimental studies with acute human exposure to several different solvents were published in the US by Richard D. Stewart and colleagues (53, 54). In Sweden, a long series of experimental studies on human solvent exposure was performed by Irma Åstrand and Francesco Gamberale, studying both the physiological and psychological effects of acute exposure to many different compounds (5, 6). Similarly, studies of acute exposure to some chlorinated solvents and to carbon monoxide were reported from Germany by Gerhard Winneke and colleagues (63, 64).

Important meetings and conferences

The rapid development of behavioral research and behavioral test methods was reflected in a number of meetings and conferences dedicated to these issues. The first meeting dedicated solely to behavioral toxicology was the Behavioral Toxicology Workshop, that was held at the University of Rochester's Department of Radiation Biology and Biophysics, in June 1972 (60). A year later, i.e. in June 1973, the Behavioral Toxicology Workshop for Early Detection of Occupational Hazards, was organized by the US Department of Health, Education, & Welfare in Cincinnati. The book containing the proceedings was published the following year (65).

A symposium on Neurobehavioral Methods in Occupational Health was organized by the universities of Milan and Bari, in collaboration with the Johns Hopkins University in Baltimore, USA. The symposium was held in Como and Milan, Italy, on June 23-26 in 1982, and the proceedings were published the following year (19). This symposium was the start of a series of triennial symposia, organized by the Scientific Committee on Neurotoxicology and Psychophysiology of the International Commission on Occupational Health. See table 1 for a listing of these symposia, their venues and proceedings.

The World Health Organization (WHO) sponsored a meeting organized at NIOSH, Cincinnati, USA in 1983, with the aim to establish a consensus on a test battery, to be applied in studies of workplace exposures. This meeting in due course resulted in the publication of a book, describing the background for and the administration of the "WHO-Neurobehavioral core test battery" (WHO-NCTB) (38).

Test methods

The test methods applied in behavioral toxicology were inspired by tests from several different research areas, such as behavioral pharmacology, clin-

Table 1 - *The International Symposia on Neurobehavioral Methods and Effects in Occupational and Environmental Health*

#	Venue	Year	Proceedings
1	Milan, Italy	1982	(19)
2	Copenhagen, Denmark	1985	(21)
3	Washington DC, USA	1988	(37)
4	Tokyo, Japan	1991	(4)
5	Cairo, Egypt	1994	(1)
6	Shanghai, China	1997	(36)
7	Stockholm, Sweden	1999	(34)
8	Brescia, Italy	2002	(42, 43)
9	Gyeongju, Korea	2005	
10	Costa Rica	2008	

ical psychology and general experimental psychology. For the clinical studies traditional clinical methods, such as e.g. the WAIS scale developed by Wechsler and colleagues (59), were used. Similar methods, e.g. the test battery used at the Finnish Institute of Occupational Health (25) and the Swedish TUFF battery (14), were applied in most epidemiological studies comparing different worker groups. Numerous other test and batteries have been used in research on the neurotoxic effects from various environmental exposures. A major effort at the standardization of tests was sponsored by the WHO, when they organized the meeting in Cincinnati mentioned above. This meeting resulted in a recommended test battery, the WHO-NCTB, which is to be used in epidemiological studies (38).

In the experimental studies other tests, often borrowing test paradigms from experimental psychology and behavioral pharmacology, were generally applied. Since in these studies there was no need to compare test results with any norms, there was a rapid development of methods more sensitive than the clinical ones. The development was also driven by the fact that the organic solvents that were studied first and foremost had narcosis effects, i.e. affected the wakefulness and concentration of the exposed subjects.

A significant trend for more than two decades has been the computerization of test methods. The Swedish Performance Evaluation System (SPES) was developed in the early 1980's from tests that were used in earlier experiments, and primarily intended for use in experimental studies of acute solvent exposure (3, 29). Later on the SPES was further developed and enlarged, and of applied in numerous epidemiological studies of different groups workers (32, 33).

Several other computerized test batteries have been developed over the years, but according to Anger (2) "…the greatest impact in this field during the 1980s and 1990s was the development of computerized testing and specifically the 'neurobehavioral evaluation system' (NES)", i.e. the test battery created by Richard Letz and his colleagues (7, 39-41). Over the years other computerized batteries that have been developed, e.g. the Performance and Information Processing System (PIPS) (61), the Milan Automated Neurobehavioral System (MANS) (10), the Behavioral Evaluation for Epidemiology Studies (BEES) (12), and the Neurobehavioral Testing System (NEUTEST) (8). This list is by no means exhaustive, but available space does not allow us to do justice to all who have made serious efforts to develop computerized test batteries. More comprehensive reviews have been provided by many others (2, 39, 44, 62).

However, the highest potential of the recently developed computerized test batteries has probably the Behavioral Assessment and Research System (BARS), which is continuously developed by Kent Anger and his colleagues at the Oregon Health & Science University (2). One drawback with the BARS is the fact that it was developed for Macintosh computers, which imposes some restrictions to the distribution, but this is one of the few test batteries where development is continuing. Special attention is being paid to the development of efficient ways of implementing instructions, and, not the least important, a lot of energy is put into the process of developing tests for use with children (49-51).

In addition to various performance tests, symptom questionnaires and rating scales have often been used as a complement to performance testing in behavioral toxicology. Well known examples are the short Q16 developed in Sweden (26, 45) to screen for symptoms related to solvent exposures, and the European collaborative effort EURO-

QUEST (9, 19), which is a more comprehensive survey comprising a total of 83 questions in ten different dimensions.

Some methods to study different physiological functions have also been applied within behavioral toxicology. Electrophysiological measures like EEG and evoked potentials have been studied (46, 55, 58), and different aspects of vision, e.g. contrast sensitivity and color discrimination (18, 20, 30; 55), have frequently been tested when searching for effects from chemical exposures.

Future trends

Modern and very sensitive test methods imply new problems in deciding which effects are adverse of those observed, i.e. which effects should affect exposure limits. In studies of workplace exposures it is an open question which of the measured effects are considered normal. Most people would for example expect some fatigue to be experienced by the end of a day at work. However, feeling exhausted following every working day would not be accepted as normal by most people in industrialized countries. Therefore, some definition of an adverse effect is desirable when using behavioral toxicology data for risk assessment. However, science cannot help us in this, since the definition of adversity is not a scientific issue. Adversity must be defined on ethical grounds, and is thus an issue for the society in total, not primarily for the scientists. Still, I'm convinced that whatever definition of the concept of adversity is chosen, behavioral toxicology will continue to contribute to the study of environmental exposures, and thus to the risk assessment and risk reduction made possible by such studies.

One fact that slows down the development of behavioral toxicology is that different researchers and laboratories develop new tests and batteries, instead of applying well validated existing tests. This is to some extent inevitable, since every single study is unique, and granting agencies tend to prioritize innovative thinking. Still, the accumulation of knowledge would benefit from some coordinated approach to test selection. In 1992, together with the developer of the NES battery Richard Letz, we recommended the application of three simple, well validated tests (34) for use in every study of effects from exposure to neurotoxic chemicals in the environment. Unfortunately this recommendation did not have much impact as yet, and it may well be that the idea is premature.

Other ways of promoting behavioral toxicology are, e.g. to improve exposure assessments, to perform more longitudinal studies, and to perform meta-analyses of already published data. In general, exposure assessments have improved in recent years, and better methods for estimation of past exposures in epidemiological studies have been developed.

Calls for longitudinal studies and/or the application of behavioral techniques for surveillance of industrial workers have oftentimes been made (17, 28, 31, 44). Such applications, providing data from several measurement occasions, would greatly increase the impact of the results from behavioral studies. Still, longitudinal studies are very expensive to run, and have other important drawbacks and limitations. Thus, they are sparse, in spite of the fact that they are badly needed.

Several meta-analyses of neurotoxic impact from environmental agents have been published in recent years (47, 48, 52). Meta-analyses are one way to accelerate the accumulation of knowledge, although there are many inherent difficulties in these analyses. Some of these difficulties would be much overcome by the use of some identical tests applied in similar ways over different studies.

Two reviews on the use of behavioral data in the establishment of occupational exposure limits (OELs) during the last decade (11, 13) have indicated that sensory irritation is presented as the critical effect for OELs in about 40% of the instances where limits have been established. This may be one reason for a further trend in modern behavioral toxicology, which is the performance of more detailed studies into the psychology and physiology of sensory irritation. See e.g. reviews by van Thriel and colleagues (56, 57). These efforts will in the long run contribute to a better scientific documentation of the effects that constitute the basis for the establishment of many OELs.

Conclusions

Behavioral toxicology has contributed to the establishment of exposure limits in many countries, both for the work environment and the environment in general. The continuous development of measurement methods, statistical evaluations and study design will ensure that the quality of the behavioral data is high, that the data base for risk assessments thus is further improved, and that the inferences from this data base are well founded.

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La Medicina del Lavoro

Med Lav 2006; *97*, 2: 339-347

Thursday - June, 15 2006 - Semi Plenary

Framework for considering genetics in the workplace[1]

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Key words

Genetics; workplace; ethics

Summary

There has been a proliferation of genetic information in the last 25 years resulting in a spectrum of existing and potential uses in the workplace. These uses of have different issues and implications which may be more clearly considered in a framework that identifies three distinct uses (research, practice, and regulation/litigation) for inherited genetic factors and acquired genetic effects. Inherited genetic factors pertain to the characteristics of the genes, and acquired genetic effects to the impact on genes and chromosomes of environmental and constitutional factors. Critical in assessing the issues involving genetics in the workplace is attention on the rights of workers, validity and clinical utility of genetic information, cost pressures on employers, and societal implications. Genetic information may provide mechanistic and diagnostic insight into occupational diseases and allow for targeting high-risk groups, improving risk assessments, and providing early indicators of risk. However, these benefits are more likely to be realized and problems avoided when the different uses are considered in a framework that distinguishes them by type and content. The application of such a framework makes it easier to assess whether there is a sufficient evidence base and worker safeguards in place for any particular use of genetic information.

Riassunto

«*Schema per considerare la genetica nel posto di lavoro*». *L'espansione delle informazioni genetiche durante gli ultimi 25 anni risulta in un'ampia gamma di utilizzi esistenti e potenziali nel posto di lavoro. Questi possono avere diversi problemi e implicazioni, che possono essere considerati più chiaramente in un schema che identifica tre distinti usi (ricerca, pratica e attività di regolamentazione) per fattori genetici ereditari ed effetti genetici acquisiti. I fattori genetici ereditati appartengono a caratteristiche dei geni, e gli effetti genetici acquisiti all'impatto di fattori ambientali e costituzionali sui geni e sui cromosomi. Un fattore critico nel valutare i problemi che coinvolgono la genetica sul luogo di lavoro è l'attenzione ai diritti dei lavoratori, alla validità e all'utilità clinica dell'informazione genetica, il costo che grava sui datori di lavoro, e le implicazioni sociali. L'informazione genetica può contribuire alla comprensione del meccanismo d'azione e alla diagnosi delle malattie occupazionali e permettere di individuare i gruppi ad alto rischio, migliorando la valutazione del rischio e fornendo indicatori di rischio precoci. Comunque si è più vicini a ottenere questi benefici evitando i problemi quando i diversi usi sono inquadrati in una cornice metodologica che li distingua per tipo e contenuto. L'applicazione di questa cornice metodologica rende più facile stabilire se ci sia una base di evidenza sufficiente ed una salvaguardia del lavoratore per ogni particolare uso dell'informazione genetica.*

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[1] The finding and conclusions in this report are those of the author and do not necessarily represent the views of the National Institute for Occupational Safety and Health

Introduction

Genetics has become a core discipline in medicine. That is, that etiology, mechanism, pathogenesis, treatment, and prognosis of disease are influenced by the action of somatic or germ cell genes (22). It is now common to consider genetic components of disease in general medical research and practice (12). It has long been known that there is a range of variability in human response to occupational hazards particularly chemical hazards. Genetic factors contribute to the variability and consequently may be useful to consider in research and control of hazards (27). The growing knowledge about the role of genetic factors provides the promise of sensitive, early-warning indicators of exposure or risk and the characteristics on which to base workplace interventions (11, 29). Most of these promises are yet to be realized. In fact, while genetic information about disease is inherently important, whether it will mean much to pursue genetic factors in the ultimate understanding and control of occupational disease is yet to be demonstrated.

In this paper, genetics related to the workplace will be considered in three categories of use: research, practice, and regulation/litigation (table 1). All of the uses of genetic information in the workplace can be viewed through these three categories. To further explore these categories, they will be considered in terms of inherited genetic factors and acquired genetic factors. This is a common classification scheme for genetic risks. Inherited genetic effects pertain to germ and somatic cell DNA transmitted through meiosis or mitosis. Acquired genetic effects involve modification of genetic material over time and can include genetic damage or genetic expression as a result of workplace and environmental exposures. Either type of genetic information, when it is measured in a biological specimen, can be considered a genetic biomarker (6). However, the line between inherited genetic factors and acquired genetic damage and effects can be blurry in some areas, particularly those related to gene expression status such as transcriptomics, proteomics, toxicogenomics, and metabolomics. The definition of genetic information includes not only the results of genetic tests, but also information about genetic factors in medical records.

Inherited genetic factors-research

Genetic factors are likely to be responsible for some differential distribution of diseases among workers that cannot be accounted for by differ-

Table 1 - *Uses of genetic information in the workplace*

	Types of genetic information	
Uses	Inherited genetic factors	Acquired genetic effects
Research	Gene-environment interactions Mechanistic insight Population characterization Predictive value	Effects of exposure Linkage to disease Early warning Mechanistic insight
Practice	Disease diagnosis Preventive services Genetic screening Risk management	Genetic monitoring Intervention evaluation Risk profiling
Regulation/litigation	Risk assessment Workers' compensation Tort litigation Standard setting	Risk assessment/management Pre-market testing Workers' compensation Tort litigation Standard setting

ences in exposures and lifestyle. (27). It is clearly accepted that practically no disease is determined solely by either genes or environment. In the early history of occupational epidemiology, genetic influences were considered only in terms of confounding by race and sex. Today as many occupational exposures are being controlled to lower levels, the importance of genetic factors as sources of variability in risk estimates is increasing. This is not to imply that occupational etiologies will be replaced with genetic etiologies, rather that genetic factors, which might confound exposure-disease associations, are being included as relevant variables in study designs and analyses.

New technologies and approaches now allow researchers to focus more on studies of gene-environment interactions which aim to describe how genetic and environmental occupational factors jointly influence the risk of developing disease (20). The study of gene-environment interactions (3) allows for better estimates of population-attributable risk of genetic and occupational factors, (1) strengthens associations between occupational risk factors and disease, (2) provides insight into mechanisms of action, and (4) provides new opportunities for intervention and prevention (20).

Technological developments, such as DNA and gene microarrays, and automated work stations capable of extracting, amplifying, hybridizing, and detecting DNA sequences will present a number of benefits and issues in studying genetic and environmental variables (11). The benefits include the ability to study large numbers of genes, practically the entire human genome, in one study or experiment and to have access to data banks containing further information on genomic DNA. The primary attendant issue with this technology includes heightened difficulties in analyzing and interpreting such large amounts of data (13).

The underlying rationale of most research involving genetic and occupational risk factors is the extent to which the genetic factors may modify the exposure-effect relationship. That is, will the risk of disease attributable to an occupational exposure be decreased, unchanged, or increased among individuals with a particular genetic characteristic? For the most part, this may be because the gene in question codes for an enzyme or receptor involved in the activation, metabolism, or detoxification of the occupational exposure. This genetic factor generally may not be a risk for disease without the exposure. In contrast, some genes may be risk factors for the same disease that the occupational exposure is and, thus, the two may be additive (43). In addition, there may be variation in genetically coded repair capabilities for mutations or damages.

Ultimately, the focus of occupational genetic research should be conditioned by criteria for the importance of the research to answer questions with workplace relevance. As Millikan (24) noted: "If epidemiologists only direct their efforts toward a comprehensive search for the genetic underpinnings of every discrete health outcome and ignore environmental exposures and attributable risks, they will miss opportunities to prevent disease."

For research on the role of genetics in occupational disease to be useful and informative, the validity of the genetic information needs to be assessed or confirmed. Validity can pertain to the assay used to evaluate genetic polymorphisms and also to the population characteristics that influence the prevalence and distribution of a polymorphism. It is only when the underlying validity questions have been assessed that a genetic assay can be used effectively to study occupational exposure-disease associations. Genetic research that focuses only on one or a few genes may be overly simplistic (39). There are many genes that might affect risk given an exposure. Ultimately, the research needed regarding genes or gene expression will need to take a systems biology approach (41). Such an approach requires much investment and experimentation. However, with the emergence of technologies to enable collection of comprehensive genomic data sets it may be possible obtain system level understanding (23).

Safeguarding rights of participants in research

A broad spectrum of opinion exists about what obtaining informed consent entails and when it is achieved (19, 33-35). Some believe that for genetic data (biomarkers) whose meaning is not known at the time of the study, a subject or worker in an occupational study cannot give truly informed consent (33). This implies a much higher standard of interpretation for genetic biomarker information than for other information routinely obtained by questionnaires, environmental monitoring, or record linkage. Until there is determination of predictive value and course in the natural history, such genetic biomarkers are clearly only research variables with no clinical meaning, and participants should be made aware of this. The extent to which a biomarker has been validated (i.e., quantitatively linked to risk of disease at the group or individual level) should be clearly described to potential research participants. With regard to informing participants of risks, general practice has been to identify only medical risks; however, it has been argued that truly informed consent should include reference to non-medical risks that might affect participants. For example, a study subject may be informed that they carry a genetic mutation that puts them at increased risk of subsequently developing cancer given a particular exposure. In the extreme case, the mere acknowledgment on an employment or insurance application that they have had a biological or "genetic test" may result in denial of employment or insurance. Participants in occupational genetic studies consent to provide the specimens and corollary demographic and risk factor information and, hence, cooperate in the specified research. The participant generally does not consent or imply consent to distribution of the data in a way that identifies him or her individually to any other parties, such as employers, unions, insurers, credit agencies, lawyers, family members, public health agencies, etc. (34).

Interpreting and communicating the results of occupational genetic research

Three issues merit consideration in the interpretation and communication of the results of genetic research. These include the realization that: 1) epidemiologic results are group risks and not individual risks; 2) a statistically significant genetic factor may not be biologically significant; and 3) the results of many small studies of genetic polymorphisms have not been replicated (38). Aware of these issues, a Centers for Disease Control and Prevention (CDC) multidisciplinary group (8) using expert opinion, as well as Federal regulation, the National Bioethics Advisory Commission's report on research involving human biological materials (26), and the relevant literature suggested that participants not be told of information that has no direct clinical relevance. However, occupational studies differ from population-based studies in the sampling frame used and the types of intervention available. In occupational settings "clinical relevance" could be defined as whether participants could take reasonable preventive or medical action based on the results. In the workplace, these reasonable actions could include various engineering, administrative, or behavioral controls (46). Clearly, where valid risks to workers are found in studies, notification is warranted.

Inherited genetic factors-practice

Prevention and diagnosis

Genetic tests have been shown to be useful for various nonoccupational diseases in terms of disease diagnosis and individual risk assessment and provision of preventive services (10, 16). Thus they are becoming a part of general medical practice. The extent to which they will impinge on practice related to the workplace and workers is not known. Whether such approaches will be useful for occupational disease also is not known. If genetic tests are to be useful in occupational health there will need to be a process of evidence based integration of data for the development of guidelines for disease prevention and health services such as been suggested for general clinical and public health practice (http://www.cdc.gov/genomics/gtesting/egapp.htm)

In the future, the practice of occupational medicine may occur against the backdrop of individualized or personal medicine. At the least this may involve the need to consider an individual's genetic profile in the context of occupational exposures in terms of risk and prevention. The pressures to consider genetics and occupational exposures may grow as pharmacogenetic assessments become more common in medical practice (32). The question that arises is who actually makes the decisions based on the individual genetic profile, the worker, the employer, or both.

Job actions

The capacity of the human body to respond to chemical exposure and physical agents varies from one individual to another. To some extent this is due to genetic characteristics which, in principle, could become part of employment testing known as genetic screening. Genetic screening is the examination of the genetic makeup of employees or job applicants for certain inherited traits. The actual use of genetic assays or tests of workers in job offering or placement is believed to be rare, but the available data to assess such activity is weak (5).

Four objectives of genetic screening have been identified: (a) to ensure appropriate placement at the job site, (b) to exclude job applicants with increased susceptibility to disease, (c) to set limit values for more susceptible subgroups, and (d) to provide individual health counseling (42). In general, pre- and post-employment nongenetic testing is a relatively common practice in selection and placement in the workplace. Susceptibility, however, is the result of a variety of genetic and nongenetic factors. Despite the profound advances in understanding the human genome, there are still no genetic tests that have been fully validated for use to screen perspective employees for occupational disease risks. Moreover, much controversy surrounds the practice of genetic screening including such issues as the poor predictive value of the tests (18, 42). Genetic polymorphisms may be unevenly distributed in the population among different ethnic groups. Thus, racial or ethnic discrimination could be a consequence of inappropriate use of genetic screening, which might be aimed at excluding workers at employment examination (42). In the practice of occupational medicine, genetic information has been used selectively, mostly as derived from medical history and used in job placement or in diagnosis (5, 39).

Genetic screening has been assessed by the European Group on Ethics in Science and New Technologies (40) which concluded that the use of genetic screening in the context of the medical examination, as well as the disclosure of results of previous genetic tests, is not ethically acceptable. Furthermore, EGE found that, to date, there is no proven evidence that the existing genetic screening tests have relevance or reliability in the context of employment. Generally, genetic screening tests still have uncertain predictive value (40).

Genetic screening information may be useful to inform potential employees of job risks, if that information is not available to employers in individually identifiable form. This was illustrated in a pilot screening program in a company where beryllium was machined.

The employer developed the program for prospective employees because of concern for the debilitating lung condition, chronic beryllium disease, in workers with beryllium exposure. Research had shown that in addition to beryllium exposure, a certain genetic characteristic, HLA-DPB^{E69} was also a risk factor. Moreover, beryllium sensitization could occur regardless of dose and had occurred even in relatively well-controlled areas. The employer established the screening program so that job applicants could receive their individual results. The predictive value of the screening test was poor, and a negative test was not an assurance for lack of risk since other variants on chromosome 6, which were not tested for, also were risk factors (47).

There are no published data on the results of the program or the issues that arose. The program was stopped after a few years. While, in principle, it seems useful that prospective employees would benefit from information about potential risks, the attendant problems are without impact. Using such a test there would be many false positive findings and many people would make employment decisions based on flawed information. Second, it is a slippery slope from voluntary anonymous screening to mandated screening of individually identifiable applicants by prospective employers. In this case with the test for HLA-DPB^{E69} many workers not at increased risk would be discriminated against. In contrast if the test had a high (>90%) predictive value would an employer have an argument for the right to use it in employee selections.

Although currently no genetic tests have been validated for assessing the increased risk of susceptibility to workplace hazards, it is anticipated that such tests will eventually become available. Whether these tests would be socially approved is still in question.

Inherited Genetic Factors –Litigation and Regulation

One of the first workplace areas where genetic information has been used is workers' compensation. In the United States there is no legal prohibition against including any medical or genetic tests in the independent medical examination that is routine in workers' compensation cases (31). In addition, informed consent for such testing is not required. By extension, genetic information may also be used as proof of causation in toxic injury litigation. However, "analysis of the role of genetic factors in multiple cause cases requires statistical and mechanistic data about how the genetic and toxic risks combine to cause disease" (39). One recent example of the use of genetic information in workers compensation type cases involved genetic factors linked to occupational carpal tunnel syndrome (37). However the genetic test had not been validated for this use. Second, unresolved is the question of whether society should use genetic testing for a susceptibility genotype to apportion causation. This question raises the issue of whether immutable traits beyond a worker's control should be factored into a claim of work-relatedness of a disease. Indeed in some jurisdictions (various states such as Iowa, Wisconsin, New York, and New Hampshire), consensual genetic testing is allowed in compensation cases. In the US, most workers' compensation statutes permit medical testing, including genetic testing, to ascertain the medical condition of the claimant and the potential work-relatedness of the claim (38). However, various U.S. organizations do not generally condone genetic testing without informed consent (4).

Regarding the use of genetic information in occupational safety and health regulations, there are no examples of where such information is required. Genetic advances push at the historic boundaries of the U.S. Occupational Safety and Health Act of 1970. The Act mandates standards and rules to assure "that to the extent feasible "employees will not suffer" material impairment of health or functional capacity." This raises the question of whether workers who could be defined by certain genetic polymorphisms as "hypersusceptible" should have special protections. The implementation of these protections raises a host of questions and issues regarding privacy, discrimination, and responsibility (7).

Acquired genetic effects-research

There is an extensive scientific literature assessing the impact of environmental hazards on genetic material (1, 3, 9, 17, 21). For the most part, this has involved assessment of cytogenetic effects (e.g., effects on chromosomes) and changes in various reporter genes such as glycophorin–A (GPA) and hypoxanthine phosphorsibosyltransferase (HPRT), mutations and the formation of DNA and protein adducts following exposure to electrophilic chemicals or ionizing radiation (2, 37). The objectives of much of this research were to determine if genetic damage did occur and if it could lead to harmful health effects (9). Much of the newer DNA and expression technologies including toxicogenomics, transcriptomics, proteomics, and metabolomics are means to assess acquired genetic effects (11, 41, 44, 45). These approaches allow for the assessment of the expression of many thousands of genes before and after exposure. Implicit in these approaches is that effects of xenobiotics can be detected in expression of genes. Critical in using this technology will be the ability to analyze and interpret the vast amounts of data that arises from the studies. Such interpretation is quite difficult because many factors affect gene expression, and there is need to distinguish adaptive or homeostatic responses from pathologic ones.

If a microarray pattern can be validated as a biomarker of effect, it may be used as an independent or dependent variable in etiologic or intervention research, and as evidence of harm in workers' compensation or tort litigation. These patterns could also be used in standards as biological exposure indices.

Acquired genetic effects-practice

The ascertainment of acquired genetic damage information in occupational safety and health practice would generally occur in the form of genetic monitoring. This is the periodic examination of employees to evaluate modification of their genetic material – e.g., chromosomal damage or evidence of increased occurrence of molecular mutation – that might have occurred during the course of employment and exposure to workplace substances (28). In principle, genetic monitoring is similar to other types of health effects or exposure monitoring that is conducted in the workplace (for example, monitoring for lead in blood) (42). However, the fact that it involves preclinical somatic genetic effects often leads to it being considered as a somewhat different form of monitoring. Genetic monitoring is similar to biological monitoring, but instead of merely assessing exposure, it assesses the effects of exposure. At present, the results of genetic monitoring can only be interpreted on a group level; they have not been validated as individual risk predictors (42). If high-throughput expression technologies become candidates for use of genetic monitoring, the issues of standardization, validation, and interpretability will have to be overcome since these will be much greater than with a single test.

Acquired genetic effects-regulation and litigation

Currently, no US regulations require genetic monitoring of workers. In part, this is because questions arise about whether genetic monitoring indicates just exposure or a potential health problem or compensable injury (37). No genetic monitoring test has been fully validated to assess an individual's risk (42). The various expression array technologies also can be applied to human or animal cell cultures that have been exposed to xenobiotics (41, 44, 45). This approach can be used to screen chemicals prior to introduction into commerce.

The gene-expression technologies have been viewed as potentially providing useful data for risk assessment; however, there are numerous interpretive questions, as summarized by Freeman, regarding the use of data from microarray experiments by regulating agencies (15).

In the short-term, transcriptomics and proteomics will probably be of most value for the hazard identification aspect of risk assessment (14, 25). However, if gene expression technology is to enter the mainstream of the risk assessment process, protocols for assays to confirm selected biochemical responses will need to be developed as regulatory requirements (25).

Conclusions

This framework provides the opportunity to compare and contrast different uses of genetics by type of genetic information. The power of genetic information both from inherited factors and acquired indicators of effects must be considered before use in relation to the workplace.

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Med Lav 2006; *97*, 2: 348-349

A harmonised approach to setting OEL's

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KEY WORDS

OEL's; metals; occupational exposure limits

Mining and metal industries are significant contributors to the world's economic well-being and growth. Globally about 23 billion tons of minerals are produced each year (including coal) and mining contributes to the employment of roughly 300 million people (1).

The potential exposures to occupational health hazards in the operations of the mining, mineral and metal processing industries cover the entire spectrum of occupational health risk. The International Council on Metals and Mining (ICMM) represents fourteen global mining and metals companies and a number of national and regional industry associations, all of whom are committed to zero harm to their employees both in the short and long term.

Responsible global companies have long recognised the need for an approach to health and safety that is consistent across the entire organisation, which means across borders. This applies in management systems and also in the application of standards. With safety standards this is easy but when it comes to the application of standards such as occupational exposure limits the situation is less simple. In general, occupational exposure limits are set by government bodies in each country and are embodied in the health and safety legislation. Despite the fact that companies are only obliged to meet the local standard in each country, most companies have internal corporate standards, based on a combination of the standards in their home country and current best practice, that are equal to or better than the respective government set limits. However, in doing this it is confusing that there are examples of significant differences in the levels set between different countries for the same material. A case in point is the exposure limit for nickel which varies from 0.05 to 1.5 mg/m^3 of air (a 30-fold difference).

In addition to the fact that legislation in different countries around the world is inevitably at different stages of development and in a constant state of flux, there is the reality that relatively few expert bodies around the world actually do the work of setting OEL's. This leads government bodies, usually in less developed countries, simply to copy the standards set by the experts in developed countries. There appears to be little, if any, coordination between the expert groups around the world and this (along with different political agendas and risk tolerance) leads to different standards being set.

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The first priority in prevention of exposure will always be to eliminate the potential for exposure through appropriate engineering and design, but this is often not possible or practicable, leaving the use of personal protective equipment and workplace condition monitoring as the preventive measures. Clear, consistent and science-based occupational exposure limits are an essential component in the effective control of workplace exposures.

In 2004 the ICMM commissioned the MRC Institute for Environment and Health (IEC) to produce a technical position paper on the subject as a basis for a workshop to be held in November 2005. This was followed up by a short paper by Shuker and Levy (2). The objective of the workshop was to explore the issues around harmonisation of the process of setting OELs and whether or not a dialogue between the various stakeholders involved in the process is possible.

This address seeks to highlight the issue for the occupational health community and stimulate to think around the need for harmonisation of the process of setting occupational exposure limits.

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La Medicina del Lavoro Med Lav 2006; *97*, 2: 350-356

Occupational Hygiene: where from and to?

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Key words
Occupational Hygiene; occupational hazards control

Summary
Occupational Hygiene was born in the forties in the USA, from the need to focus on the causes of the occupational diseases from a scientific and technical point of view. In other words this is to understand how to detect, how to evaluate and how to control the chronic risks at the workplace. The discipline developed very well from that time up to the nineties thank to a strong commitment of dedicated people and professional societies supported by international organizations such as the ILO and the WHO. Nowadays the situation of Occupational Hygiene differs considerably between countries which can arbitrarily be categorized according to the "culture and tradition" they have in this field. The development of this science has decreased in the countries where it has been very well established. This is probably due to the fact that the field of Occupational Health has been enlarged very much in the last decade so that Occupational Hygiene has to struggle more than before to defend its ecological niche (specificity) in this vast domain. In some countries the discipline is mixed with safety or environmental protection or even with the quality management and there is no curricula for Occupational Hygiene only. In many countries it simply does not exist. What will be the future of Occupational Hygiene? It is not possible to answer this question but there are clear opportunities to show the importance of Occupational Hygiene such as the REACH regulation in Europe which full comply with the core competencies of this profession. Other opportunities such as the elaboration of simple tools to assess and control the occupational hazards (toolkits) may also lead to a decrease in the need of well educated professionals since these tools will not require a long training to be used. In conclusion, the future will depend on the way the actual occupational hygienists will work to become more visible and to be considered as essential partners to reach the main goal of Occupational Health which is to build up healthy workplaces, for healthy companies in a healthy economy. The Occupational Hygiene Societies at the national level and the IOHA (International Occupational Hygiene Association) at the international level, will have a key role to play in this future evolution.

Riassunto
«L'igiene occupazionale: da dove viene e dove sta andando?». *L'Igiene Occupazionale è nata negli anni quaranta negli Stati Uniti d'America dalla necessità di individuare le cause delle malattie occupazionali da una prospettiva scientifica e tecnica. In altre parole, si trattava di capire come riconoscere, valutare e controllare il rischio cronico nei luoghi di lavoro. La disciplina ha in seguito conosciuto un notevole e positivo sviluppo fino agli anni Novanta, grazie all'ingente sforzo di persone impegnate e di associazioni professionali sostenute da organizzazioni internazionali quali l'ILO and l'OMS. Oggigiorno, la situazione dell'Igiene Occupazionale differisce in maniera considerevole nei diversi Paesi. Una distinzione arbitraria può essere tracciata sulla base della differente dotazione di "cultura e tradizione" che i diversi paesi hanno in questo campo. Lo sviluppo di questa scienza è diminuito in quei paesi dove ha in*

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precedenza conosciuto una forte istituzionalizzazione. Questo è avvenuto probabilmente a causa del notevole allargamento che negli ultimi decenni ha avuto il campo dell'Igiene Occupazionale, tanto che questa si è trovata, in misura maggiore rispetto a prima, nella necessità di difendere la propria "nicchia ecologica" (specificità) all'interno del vasto dominio che la caratterizza. In alcuni Paesi la disciplina è intrecciata con l'ambito della protezione della sicurezza e dell'ambiente o addirittura con quello della gestione della qualità, senza che vi sia un curriculum specifico per l'Igiene Occupazionale. In altri Paesi invece semplicemente non esiste. Quale sarà dunque il futuro dell'Igiene Occupazionale? Pur non essendo possibile rispondere a questa domanda, esistono chiare opportunità di dimostrare tutta l'importanza dell'Igiene Occupazionale, come per esempio il regolamento REACH in Europa, che riflette in maniera esaustiva le competenze centrali proprie di questa professione. Altre opportunità come l'elaborazione di semplici strumenti per la valutazione e il controllo dei rischi occupazionali possono anche condurre ad una diminuzione del fabbisogno di professionisti qualificati, non essendo richiesto un training di lunga durata per l'uso di questi strumenti. In conclusione, il futuro dell'Igiene Occupazionale dipenderà dal modo in cui gli attuali igienisti lavoreranno al fine di rendersi più visibili e di essere considerati come partners essenziali nel raggiungimento dell'obiettivo centrale della Medicina del Lavoro, che è quello di costruire luoghi di lavoro sani per aziende sane in un'economia sana. Le Associazioni di Igiene Occupazionale a livello nazionale e l'IOHA (International Occupational Hygiene Association) a livello internazionale giocheranno un ruolo chiave in questa futura evoluzione.

Introduction

I would like to express my thanks to the Italian Industrial Hygiene Association (AIDII) for offering me the opportunity to present my views about the discipline I am dedicated to for years and which I consider as a key component of Occupational Health for the management of occupational chronic risks.

The scope of this talk is a broad international perspective about Occupational Hygiene (OH) based on my personal experience of more than 35 years. I do not pretend to have a very objective perception of the situation, so my analysis is certainly biased not only by my specific experience but also by my wishes, hopes and my personal scientific interests as well as my ethical values.

The objectives of this presentation is to look back at the short history of Occupational Hygiene (OH) in order to better understand why it has been developed only in certain countries and what could be its future in those countries and elsewhere. It is also an opportunity to stimulate the necessary debate about our identity in a so rapidly changing society.

In September last year, the International Occupational Hygiene Association (IOHA) organized its 6th International Scientific Conference in South Africa, through the National Society of this country (Southern African Institute for Occupational Hygiene) and I was invited to present a keynote speech about the "Global Trends in Occupational Education and Training". To prepare this speech I did an informal survey through all the societies belonging to IOHA and through a short review of the literature as well as through contacts with peers all around the world. This gave me a rather good "photography" of the present situation of Occupational Hygiene, at least in these countries. From this material are issued the facts and comments which will be presented in this paper.

From Ramazzini and Alice Hamilton up to now

The history of Industrial Hygiene (which has been later called Occupational Hygiene since it is not limited to industry) is short and does not start before Alice Hamilton, in the forties in the USA. Alice Hamilton, a physician, is considered as the mother of Occupational Hygiene because she introduced at Harvard University, where she became in 1919 the first woman faculty member, the basic elements of the science of detection, evaluation and control of occupational hazards which impact on workers' health (6).

Before this, occupational medicine was devoted to the diagnostic and the prevention of occupational diseases. Bernardo Ramazzini (1633-1714) is considered as the father of Occupational Medicine since it was the first one to publish a review of the medical problems caused by work (12). He can be in fact considered as the father of Occupational Health, because all the disciplines actually dedicated to the workers' health protection and which constitutes the broad field of Occupational Health were developed a long time after the emergence of Occupational Medicine.

Occupational Hygiene was born from the need to better understand the causes of the diseases and therefore from the need to involve the science of chemistry and physics in order to characterize the pollutants identified as causing occupational diseases such as silicosis or "saturnism" (lead intoxication). The core business of this new profession has been to assess quantitatively the workers' exposure to specific hazards, in order to detect where control measures are needed and which ones are efficient enough to protect the workers. The knowledge and competence to carry out such assessments and controls belong to the engineers and are not anymore a medical field.

From this time and up to now Occupational Hygiene (OH) has grown in the USA and in the UK (later in several other ones) and has adapted to the trends in our Society such as, in the eighties, the environmental protection and the sustainable development. Several scientific journals in the field of Occupational Health have added, a few years ago, the word "environment" to their title previously dedicated to a more specific area (Occupational Medicine or Industrial Hygiene). In some countries, OH and environmental protection in companies are under the responsibility of one single person. Nowadays, the psychosocial issues are of growing concern and are being introduced in the education programs of the occupational hygienists and the overlapping of competencies of other disciplines such as occupational psychology or ergonomics does not help to increase the visibility of the core competencies of OH.

The international organizations such as the ILO and WHO have played a major role in supporting OH and have contributed to its development in several countries. The ILO and WHO published in 1981 a report form a Joint Committee on education and training in Occupational Health (11) and in 1988 a WHO Study Group redefined the needs and the professions belonging to the occupational health team (16). In 1990 the WHO published a booklet entitled *Occupational Hygiene in Europe – The Development of the Profession* (15) which described the specificity of this discipline, its utility and the basic curriculum for its education and training. This was mainly based on the American and British experience. In some countries (for instance in Switzerland), this publication boosted the development of Occupational Hygiene (OH), its official recognition and its teaching at a post-graduate level. A few years later, a survey of the certification schemes related to this field was carried out by the IOHA (3) and confirmed that the profession was well recognized and considered in different countries. The WHO, through its network of Collaborating Centers in Occupational Health has promoted a lot of activities where OH is important, visible and relevant (14).

The situation today

From an international perspective, countries may be divided into three arbitrary categories related to the recognition and development of Occupational Hygiene (OH) :

1. long tradition and strong commitment of professional associations;
2. OH is recognized but not "culturally" integrated;
3. OH is not recognized.

Such a categorization necessarily biases and oversimplifies the reality (some countries may be in between two categories), but it helps to understand the differences in the way OH is established and recognized in the different countries throughout the world.

In the countries of the first category (North America, Australia, UK, etc.) the core competence of OH is needed "in the field" (not at the corporate level) and is provided by *in house* hygienists in the big companies or by external consultants (2). For research and education, J.H. Vincent recently emphasized the "*undisputed continuing need for occupational graduates at advanced level*" (13). The certification is part of the culture in these countries (3).

Those countries and especially the USA which is a pioneer in OH, are defending the traditional roots of our profession and the sustainability of OH and have strong professional associations very active and efficient in promoting the field. But even there, the legislation does not mention frequently or even ever OH as a necessary competence for managing occupational chronic risks.

The *US News & World Report* predicted in 1991 that Occupational Hygiene would become one of the "top 20 professions" in this country (4). This prediction unfortunately has not been confirmed, and the present situation is not so good, even in countries with the longest tradition in this field. There is no sign showing a good development of OH, worse the profession is attracting less students than in the past.

For the countries of the second category (those represented in the IOHA and not belonging to the first category) OH responsibilities are frequently mixed with other disciplines such as safety, environmental protection, ergonomics or even quality. Due to the fact that prevention started first to prevent accidents and injuries, the safety professionals has been for a long time, the only partners on the side of science and engineering. On the other side (medical), the physician was devoted to the prevention of occupational diseases and the room for OH was taken either by the safety people or by the doctors. In such countries, Occupational Medicine remains the core of the Occupational Health Services and the other members of the team have frequently a less visible identity. T.W. Tsin has nicely described this trend in a paper presented with E. Hau (7). In the developing countries, like in Asia, the demand in OH is parallel to their industrial development.

Certification of OH is usually not required in these countries with a few exceptions (3). OH is looking for a "niche" in such multidisciplinary teams but with a limited success up to now. In France, for instance where Occupational Medicine is well developed in comparison with the other disciplines, the enforcement of the European framework Directive for the management of occupational risks (5) posed some legal problems due to a lack of competence in OH and a new actor of the Occupational Health & Safety team has been created to be in compliance with the Directive : "*intervenant en prévention des risques professionnels*" which could be translated by "professional in prevention of occupational risks". The reasons why such a professional is not named "occupational hygienist" may be attributed to a lack of visibility of OH in this country but this is true also for many other European countries.

There is some hope for the development OH in Europe thank to the new regulation recently adopted and called REACH (Registration, Evaluation and Registration of CHemicals) because the competencies to enforce such a regulation fall in the core business of OH. Hazards from chemicals must be managed from information about their uses leading to exposure scenarios and from risk analyses based on the toxicological properties of these chemicals. An international workshop, organized by the British Occupational Hygiene Society together with the Belgian Society for Occupational Hygiene, in December 2005, presented and discussed these issues by stressing the opportunities this regulation offer to OH (1).

In countries of the third category (most of those not represented in IOHA) OH is simply not recognized and therefore there are no specific education and training programs for this field. Big companies may have their own experts educated elsewhere. In Australia, for instance, the Deakin University is offering a Diploma in OH through a 2 years distance learning course which is quite convenient for people from countries of this category. In the developing countries, the influence of the past (colonies) impacts on their approaches to occupational safety and health issues.

Globalization is helping those countries to find their ways through international exchanges, cooperation and assistance from international organizations and many other means. Human and financial resources being limited everywhere, such a situation does not represent an opportunity to develop

OH in those countries. Moreover, there is a trend in the countries of the two first categories, to develop simple tools to assess and control occupational risks and to provide them to the developing countries, so that the minimum requirements to use these tools do not involve much competence in OH. The control banding approach which has been proposed first by the Health and Safety Executive in the UK under the label of COSHH Essentials (*Control of Substances Hazardous to Health*) (9) raised huge hopes in the international organizations (WHO and ILO) who promoted its development under the form of "tool kits" (10). The future will show if these tools are efficient and if they boost a better prevention at the workplace. It should be stressed and repeated here that Occupational Hygiene is a well recognized field in the WHO and the ILO who both recognized IOHA as an NGO (Non Governmental Organization) and cooperate with it in their programs. The ICOH (*International Commission on Occupational Health*) has also been a support to OH for a long time and has reconfirmed its commitment in 2003 (27th Congress, Iguassu Falls, Brazil) by signing an agreement with the IOHA.

From this analysis of the situation in the different categories of countries, it can be concluded that OH is in front of opportunities, difficulties and challenges to survive or better to develop itself. At the moment its visibility and recognition are not sufficient but this may change in the future if it becomes clear that OH is the field which really fits to the needs for a better professional management of the occupational risks.

SCENARIOS FOR THE FUTURE

The future is unpredictable, therefore the scenarios presented here represent only a few hypotheses based on the experience and "feelings" of the author. Although the globalisation tends to break the boundaries between countries, it is not sure that one of the scenarios presented below will predominate. It is possible that different scenarios (including many other ones than those listed here) will co-exist in different countries.

a) OH becomes a specialized field restricted to highly qualified experts. If OH continues to be the science devoted to the quantification of "objective" risks (mainly chemical, physical and biologic ones), the probability that it shifts to a "field for highly qualified specialists" is great. In the developed countries, the trend towards a diminution of the so called "traditional" problems is clear and is paralleled by an increase in less "objectively measurable" problems, such as stress, burn out or burn in, harassment, etc. So, the needs in the field will be oriented towards other competencies than those of OH. With such a scenario, OH will remain a relevant field in the universities and research centres to continue to bring new knowledge and tools to better assess and control the occupational risks, but it may loose its place in the Occupational Safety & Health team, with probable exceptions in large companies or large centres providing services and consultation. The gradual approach where simple problems may be solved by the company itself and the more complex but still usual can be solved by people with a broad education in occupation safety and health illustrates such a scenario. Topics which still require research and high competence in OH are, for instance, nanotechnology (nanoparticles) (8), genetically modified organisms, interactions between stressors and many others which will require a lot of research in order to know how to manage properly these problems.

b) OH broadens its scope and merges with other domains. It is clear that the field of Occupational Health is changing nowadays and that another perception of health is emerging together with the need to involve other actors and other competencies. To develop this trend is far out of the scope of this presentation, but it can be summarized by stressing the fact that Occupational Health must be understood in much a broader perspective than before, including the need to be more "proactive" than before and to increase its action in developing the factors of the work which promote a good health and to take into account the individuals' need of an harmonized work-life balance. Moreover, the causes leading to absenteeism or "presenteism" (presence without motivation and efficiency) must be better understood and taken into account in the work organisation (including the assessment of their costs). If this development continues to grow, new approaches with new actors (economists, sociologists, human resources experts, etc.) will be needed. What about OH in these big changes? One way could be to merge OH with its closest related field (safety and ergonomics, for instance) and rename and redefine a new field, more general, which would find its place and visibility in this enlarged scope of Occupational Health. It is interesting to know that in The Netherlands, the safety engineers, occupational hygienists and work organisation psychologists have signed a agreement to cooperate in this way (T. Spee, personal communication). However, the reluctance to changes is understandable since the need to better apply all the principles of OH in the field is still there (especially in the developing countries) but the courage to reconsider the situation in this new context may contribute to avoid inefficient and useless struggles between peers and colleagues who share the objectives of a better workers' health protection and development. Moreover the challenge to really develop the transdisciplinarity between all the concerned disciplines sounds exciting.

c) OH disappears and is dispersed among the other disciplines. This most pessimistic scenario may occur in a medium or long range period of time if nothing is done to give OH a new impulse and a much better visibility. By which means such a boost could be done? I have no original ideas or strategies to propose here but I do hope that others will have some. In countries of the second and the third categories described above, OH is already dispersed either in the safety or in the medical fields and even in the field of ergonomics. But there is some trend in the opposite direction since the number of occupational hygienists is increasing quite significantly in Asia and is not decreasing in Europe and Australia/NZ (IOHA statistics from the secretariat communicated by T. Spee). Therefore the future may be positive for OH.

Conclusion

The future of OH depends first on the occupational hygienists themselves. Therefore the IOHA, which brings together almost all the hygienists on the planet, has a key role to play. What will be its choice, its policy and its strategy to cope with this essential problem? I cannot answer this question because it does not depend on me, although I am still in the Board of directors of IOHA. I do believe that this international association should take the leadership of a redefinition of OH and should cooperate with the sister associations to be part in the development of the "New occupational health", much broader than before and much more efficient to promote the workers' health and well being.

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Low-dose occupational exposure to asbestos and lung cancer risk

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Key words

Asbestos; lung cancer; low dose

The risk of lung cancer in the low dose-range in down-stream use of asbestos has mainly been estimated by extrapolation from high-exposed asbestos industry workers. A linear dose-response model is widely accepted, specifying a doubled risk of lung cancer at a cumulative dose of 100 fiber-years. We performed a population-based case-control study of lung cancer using measurement-based exposure assessments. The study indicated a high risk per fiber-year in the low dose range; the risk was doubled at only 4 fiber-years. Other population-based case-control studies support the findings. The aim of the present study was to investigate potential explanations for the discrepancy in risk estimates.

Risk estimates from cohort and case-control studies of lung cancer were plotted and evaluated graphically, while addressing the potential influence from asbestos type, proportion of tobacco smokers, confounding or effect modification from other occupational exposures, and bias in the exposure assessments.

The risk estimates from occupational cohorts in the asbestos industry vary considerably with industry type. As expected, the risk per fiber-year was high with crocidolite miners, but also among asbestos textile workers. Workers in the asbestos cement industry and chrysotile miners had a considerably lower risk per fiber-year. The proportion of smokers affect the exposure-response curve. The precision in the exposure estimates varied, and the information on potential confounding or effect-modifying exposures was usually scarce.

Although there is uncertainty in how much of the discrepancy in risk estimates that may be attributed to the considered factors, non-linearity in the dose-response curve seems to be a likely explanation. The risk in the low dose range may thus be much higher than that predicted by extrapolation from high-exposed cohorts, emphasizing the need for an international ban of asbestos. It has also bearing on the evaluation of compensation claims for occupationally induced lung cancer.

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La Medicina del Lavoro Med Lav 2006; *97*, 2: 358-367

CASH - An innovative approach to sustainable OSH improvement at workplace

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Key words

Developing economies; health and safety; workplace

Summary

Occupational health department of a large private enterprise located in India launched Project CASH - Change Agents for Safety and Health, at manufacturing units of the enterprise to bring about a positive change in work environment and improvement in work practices to reduce occupational health risk. Multidisciplinary teams of change agents were constituted and were given intensive training inputs. Reduction in exposure to noise, dust and heat stress were identified as specific objectives after a baseline survey of the work environment. Occupational safety and health knowledge and training was imparted to all field personnel to improve their work practices and attitudes. The focus of the actions was on engineering control measures and process engineering changes necessary for workplace improvement. Noise levels were reduced by an average of more than 9dBA in most of the top ten high noise locations. Out of two locations identified for dust exposure, one was fully eliminated and dust levels at other location were significantly reduced. Heat stress was reduced in all three identified locations with an average reduction of more than 3°C in WBGT levels. Thus, final evaluation of workplace environments revealed significant reduction in exposure to all identified agents, viz noise, dust and heat fulfilling the project objectives. Educating and empowering the team led to reduction of occupational health risks in the work environment. There was positive attitudinal and behavioural change in safety and occupational health awareness & practices among employees. The monetary savings resulting from improvements far outweighed the investments. Success of this pilot project was followed up with further similar projects and their number has grown in geometric proportion for the last three years indicating the sustainability of the project.

Riassunto

«CASH – Un approccio innovativo allo sviluppo sostenibile della salute e sicurezza occupazionale nei luoghi di lavoro». *Il dipartimento di medicina del lavoro di una grande impresa privata situata in India ha dato avvio al Progetto CASH (addetti al cambiamento per la salute e la sicurezza) all'interno delle divisioni di manifattura, con la finalità di produrre cambiamenti positivi nell'ambiente di lavoro e sviluppare pratiche favorenti la riduzione del rischio occupazionale per la salute. Allo scopo sono stati costituiti e sottoposti a corsi di formazione intensivi team multidisciplinari di addetti al cambiamento. In seguito ad un'indagine preliminare dell'ambiente di lavoro, l'obiettivo specifico degli interventi è stato individuato nella riduzione dell'esposizione al rumore, alle polveri e al calore. Al fine di migliorare le pratiche e gli atteggiamenti lavorativi, il personale nel complesso è stato sottoposto a corsi di formazione ed ha acquisito conoscenze in materia di salute e sicurezza sul lavoro. Gli interventi si sono focalizzati su misure ingegneristiche di controllo e su cambiamenti a livello di ingegneria di processo necessari al miglioramento dei*

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luoghi di lavoro. I livelli di rumore sono stati ridotti in media di più di 9 dBA nella maggior parte dei dieci luoghi di lavoro più rumorosi. Dei due siti identificati come problematici per l'esposizione alle polveri, in uno l'esposizione è stata completamente eliminata, mentre nell'altro è stata significativamente ridotta. L'esposizione al calore è stata ridotta in tutti i tre siti identificati come problematici, con una riduzione media di oltre 3 gradi centigradi nei livelli di WBGT. Nel complesso, la valutazione finale degli ambienti di lavoro ha rivelato una riduzione significativa nell'esposizione a tutti gli agenti identificati (ossia il rumore, le polveri e il calore), raggiungendo in questo modo gli obiettivi del progetto. L'educazione e l'empowerment del gruppo di lavoro hanno condotto ad una riduzione dei rischi occupazionali per la salute all'interno dell'ambiente di lavoro. Si sono verificati nei lavoratori cambiamenti positivi di tipo attitudinale e comportamentale a livello della consapevolezza e delle pratiche relative alla sicurezza e alla salute occupazionali. Il risparmio economico derivato dagli interventi migliorativi ha di gran lunga compensato gli investimenti effettuati. Il successo di questo progetto pilota è stato in seguito replicato da progetti simili. Negli ultimi tre anni il numero dei progetti è cresciuto in proporzione geometrica, confermandone la sostenibilità.

Industries in developing economies usually treat 'health' as a welfare activity with stress on curative services and managing accidents. While there is much 'talk' about safety, thanks to statutory regulations and immediate consequences in accidents, occupational health does not receive the requisite attention mainly due to long latent periods of occupational diseases. Moreover, both these functions are rarely integrated in manufacturing complexes. Medical professionals employed in industries are also content with managing curative and liaison activities.

CASH (Change agents for Safety and Health), is an innovative project undertaken by the occupational health department at manufacturing sites of Reliance Industries Ltd., India during the last three years. Started initially as a pilot project, the project resulted in significant improvement in the work environment and reduction in OSH risks at workplace. Consequently, the number of CASH projects grew in geometric proportion with the initial success replicated. This article describes the initial pilot project in detail and traces the subsequent events leading to a "cultural change" ensuring employee and management involvement in improving OSH (occupational safety and health) at the workplace on an unprecedented scale.

Introduction

The Reliance Group is India's largest business house, and has been growing rapidly. The growth is by backward integration, setting up new manufacturing complexes and, lately, also by acquisition of other enterprises. The group's activities span petrochemicals (polyester, polymers and intermediates), refining and marketing, textiles, exploration and production of oil and gas. Reliance Industries Ltd. is the flagship company of the Reliance group. Reliance Industries has six major manufacturing sites: Jamnagar Refinery/Petrochemicals, Hazira - Petrochemicals & Polyester, Patalganga - Polyester Fibre & Yarn, Baroda - Petrochemicals & Fibre intermediates; Nagothane - Petrochemicals & Polymers, and Gandhar - Petrochemicals & Polymers. Reliance also has a subsidiary, Silvassa Industries at Silvassa, for processing yarn. A typical Reliance site has 3,000-4,000 employees. Reliance Group has about 12,500 employees in India. The enterprise is progressive, safety conscious with corporate health, safety, environment (HSE) policies and ISO 9000 & ISO 14000 certifications at all these locations.

The pilot project was undertaken at the Fluidised Catalytic Cracker (FCC) plant in the Jamnagar Petrochemical Refinery site. Sensitisation, awareness, training and development activities were extended to all other manufacturing sites. For this purpose, a specific area was selected at each site.

Fluidised Catalytic Cracker Plant

Out of 16 operating plants at Jamnagar, the Fluidised Catalytic Cracker (FCC) Plant was selected for the project, as the theme was very appropriate because various activities in the plant can potentially cause occupational illnesses among the personnel. The FCC Plant is a very critical part of the refinery. Fluidised Catalytic Conversion is a process of cracking heavy ends from atmospheric units in order to produce lighter and more valuable products. The process uses high temperature, moderate pressure, finely divided Silica - Alumina catalyst and a regenerator to burn off the coke deposited by cracking reactions. The FCC Plant products include fuel gas, LPG, gasoline, LCO, CSO and coke. The main ingredients of the FCC Catalyst are alumina, silica, quartz, sulfate, rare earths, titanium and sodium oxide. The causes and consequences of hazards were analysed and visualized with the help of the Logical Framework Approach (5), whereas the "ILO Guidelines on Occupational Safety and Health Management Systems" (1) were applied to management and alleviation of hazards. There is exposure to noise, heat and dust in this area.

Other sites and areas

Other sites and areas selected for sensitisation, awareness, training and development activities are as follows:

Hazira - Cracker/Aromatics Plant: Exposure to noise, heat & chemicals

Patalganga - PTA Plant: Exposure to noise, chemicals & dust

Baroda - Dry Spun Acrylic Fibre Plant: Exposure to noise & chemicals

Gandhar - C2-C3 Plant: Ethane Propane Recovery Unit: Exposure to noise

Nagothane - Gas Cracker Plant: Exposure to noise, heat & chemicals

Silvassa - Twister Plant: Exposure to noise.

Since significant gains were observed in the project area, the work environment improvement measures were subsequently extended to other sites as well.

Project objectives

The overall project objective was to bring about a positive change and continual improvement in occupational health practices at the enterprise leading to improved quality of work life. The project was planned to manage OSH problems through planning and implementation of measures to prevent, correct or reduce the impact of unhealthy work practices. Such measures may lead to the reduction and prevention of work related diseases and injuries, the creation and further improvement of a safe and healthy work environment and a reduction in absenteeism, which will ultimately lead to an improvement in productivity.

Specific project objectives were formulated after a workplace evaluation of project sites, and priorities were identified as follows:

– reduction of noise levels at identified locations. Reduction of employee exposure to noise;

– reduction of exposure to dust in identified areas (catalyst bagging and RCH fines loading area);

– reduction of exposure to heat.

In addition to the above objectives, plans were created to identify and train a pool of internal experts capable of identifying and mitigating occupational health problems. In accordance with the project objectives and evaluation procedures, the following indicators of attainment of project objectives were defined:

– reduction of noise exposure as indicated by a reduction in noise levels measured at workstations at the beginning and end of the project period;

– reduction of dust exposure as measured by direct/indirect measurement at the workplace at the beginning and end of the project period;

– reduction of heat exposure as measured by employee exposure / WBGT;

– development of resource persons capable of identifying and mitigating occupational health problems at all participating sites.

Methods and activities

Discussion with management and other stakeholders

The concept of the project was initially discussed and agreed with the Corporate Medical Department and Group Manufacturing services. The meeting recommended that the project activities be extended to all manufacturing sites of the company. During the discussions it was decided to name the project *Project CASH - Change Agents for Safety & Health* (used hereafter in this article) and to refer to team members as 'Change Agents'. It was decided to meet with the Presidents (i.e. chief executives), of all the sites to present the concept and to seek support.

Visits were then made to all sites and presentations given to local management teams. Discussions were held with various stakeholders such as Site Chiefs, HSE Chiefs, Plant Managers, Occupational Health Specialists, etc, and upon their approval, a formal proposal and budget was sent to the Chairman of the company for approval. The project and budget of approx US $40,000 was approved for procurement of equipment, training and awareness and other centralized activities. Local expenses for specific equipment and other activities were to come from the respective site budgets. This process was completed by the end of January 2003.

Identification of project area and 'Change Agents'

The project plan envisaged identifying 4-5 supervisors/managers, (based on the improvement needs of each work area), from different disciplines to become the 'change agents'. This process was done by involving and seeking support from the heads of departments/areas. A one-day training and orientation programme for all team leaders and representatives from various sites was conducted in February 2003 in Mumbai.

Baseline survey of identified project area

A workplace evaluation survey was conducted at all sites in order to assess the work environment and to identify problems for corrective action. A team comprising the industrial hygienist, safety officer of the plant, plant manager and project coordinator conducted the survey. Measurements were carried out for area noise levels, individual exposure dosimetry, heat stress, dust levels, etc. Workplace evaluation at all sites was completed in April 2003 and the findings communicated to team leaders.

Important health risks at the workplace were identified. One or more of them were selected for reduction through improvements in work environment. The most common target was noise, followed by reduction of exposure to dust/chemicals and heat. These results and action plans were discussed in the training workshop.

Identification of priorities and preparation of training plan

Planning and organising the training workshop was a very time consuming but exciting experience. It included budgeting, selection of venue, organizing logistics, identification and availability of faculty members, communication with participants and their superiors.

It was preceded by study of the relevant literature including the WHO publications "Educational handbook for health personnel", by J.-J. Guilbert, (2), "Positive Programme - Trainers Manual for Occupational Safety and Health", by Kogi and Kawakami (4), both of which were useful for planning the training programme. The training manual, "Workplace, Safety and Working Conditions", published by the Swedish Joint Industrial Safety Council (3), was the core training material issued to all participants. There were also lectures by experts of national repute. Topics included modern trends in Occupational Health Management; noise; VDUs; heat; ergonomics; human factors in OSH and training methodology. Special guidelines were given on implementing work environment improvement measures.

Training of selected 'Change Agents'

Forty hours of training was planned for the CASH agents and the first part was conducted in February 2003 in Mumbai. The next part of the training was conducted at the Jamnagar Refinery site in June 2003 as a residential workshop comprising lectures, discussion, syndicate discussions, workplace audits along with presentation of observations and reading of the course manual.

28 participants attended the workshop, an average of four participants from each of the seven sites. For the syndicate discussions, workplace visits and training manual discussions, the participants were divided in groups of six. Each group had an Occupational Health Physician acting as coordinator/facilitator. On the last day of the workshop, all team leaders presented their workplace improvement and training plans for employees in the CASH area. The President of the Group Manufacturing plant reviewed these presentations.

Validation of training

The Project Coordinator validated the training during follow-up visits to all sites, through interaction and witnessing the application of learning at their workplace. The visits were also used to revise the learning gained during the training workshop at Jamnagar, to re-motivate CASH agents, to review progress of activities at ground level, to offer suggestions for improvements and to interact with workers in the project area.

On the job implementation by 'Change Agents'

On the job implementation was the most important part of the project. Change agents were from plant operations, maintenance, safety and occupational health. They started with visits to the workplace to identify problem areas and prioritise the actions needed. Exposure to noise and dust emerged as primary concerns.

Actions were taken on two fronts. 1) Imparting knowledge and training to personnel working in the field to improve their work practices and compliance to occupational safety and health measures. 2) Identifying and implementing engineering control measures and process changes necessary for workplace improvement.

The CASH team in consultation with Project Coordinator developed a road map for implementation of the project. The road map contained: a detailed "Action Plan", a schedule for weekly review meetings, training of field personnel for awareness and attitude change towards OSH, monthly progress reviews, development of literature to increase awareness through handouts, booklets and an enterprise Intranet portal on noise. It also included medical surveillance of all personnel with special attention paid to identified health risks and periodic workplace monitoring for noise, dust and heat stress.

Evaluation of effects in work area

The evaluation was carried out in accordance with the plan mutually agreed on with the CASH team in February 2003. A team comprising the Project Coordinator, an industrial hygienist and an observer from another site, carried out the evaluation. The CASH team members at the site were simultaneously trained in the use of monitoring equipment and also participated in the exercise. The findings were compared with the initial workplace evaluation survey.

Recognition of the gains from the CASH project led to the decision to continue the improvement activities and to extend them to other plants at all the manufacturing sites. After initiating the CASH project at Jamnagar, work environment improvement activities were also undertaken at other sites.

Problems and limitations

Though there was full support from management and total commitment from the CASH agents, some unforeseen problems were encountered.

There were continuity issues of CASH agents with some agents opting for a 'Voluntary Retirement Scheme' offered at the site. Some were affected by organisational changes and were relocated to new sites.

Unforeseen technical difficulties and problems at the site occurred from time to time leading to last minute schedule changes.

There were limitations with regard to sampling methodology, aimed at getting indicative readings of the work environment in the available time frame.

The final evaluation was carried out at the end of February, which has cooler weather (slightly lower ambient temperatures) as compared to the baseline evaluation, conducted in mid April.

RESULTS

Noise

Noise monitoring conducted by project team members during the baseline evaluation (in the areas identified in the process of qualitative exposure assessment), indicated that the sound pressure levels measured ranged from 65 to 110 dBA. During the final evaluation, the maximum sound pressure levels was reduced to 97 dBA. Noise levels were reduced significantly in nine of the ten noisiest locations. Out of 23 high noise locations identified, noise levels were fully controlled in 14 locations and significant noise reduction was achieved in most of the remaining locations.

Personal noise monitoring conducted for operators working in two specific areas during baseline monitoring indicated that average noise exposure for the sampling duration was 87 dBA and 89 dBA, respectively. The equipment and machinery contributing to the noise were identified. During the final evaluation, noise exposure for operators (TWA) in these two areas was reduced to 82 dBA and 86 dBA.

There was an overall reduction in ambient noise levels observed at various locations and efforts to further reduce noise are being continued. Important examples are given below.

Noise reduced from 110 to 95 dBA by providing acoustic insulation. The design centre is studying the issue to devise ways to further reduce the noise levels. Noise from a newly installed fuel gas compressor was reduced from 114 to 106 dBA through insulation of discharge piping with cladding sheet. A tail gas control valve was insulated with sound absorbing material reducing the exposure from 110 dBA to 88 dBA. All steam traps and openings were covered to reduce the noise. Noise at the reactor riser bottom has been reduced from 100 to 85 dBA by installing a silencer, designed in-house by the CASH team. The modifications also resulted in saving of LP steam valued at more than US$60,000 per year. Exposure of field operators to noise has been reduced from 90 to 76 dBA by relocating the field cabin.

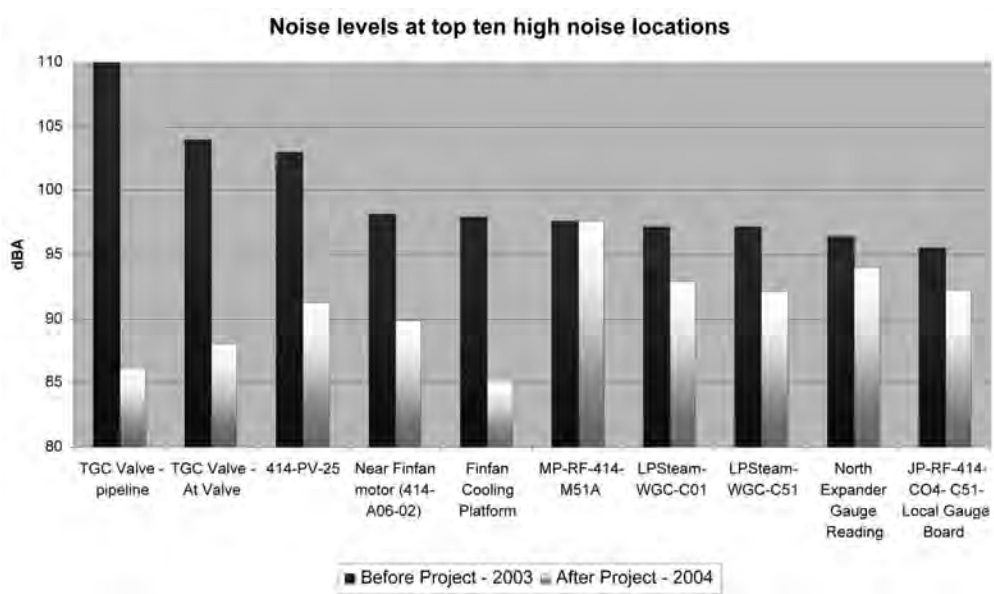

Figure 1 - Workplace noise at selected locations before and after project

Table 1 - *Personal noise exposure (dosimetry) before and after the project*

Area/Activity	TWA (dBA)	
	April 03	Feb 04
411/412 Area	87	82
414 Area	89	86

Dust exposures

Dust exposure appeared to result from emissions of fine dust from dumpster loading and bagging activity. As already stated, the ingredients of the dust include alumina, silica, quartz, titanium and sodium oxide. An illustrative personal exposure monitoring was conducted during catalyst fines (dust) collection and catalyst bagging activities. The operator's exposure to respirable dust during the catalyst fine collection activity was found to be 5.6 mg/m^3. During the final evaluation, the operator's exposure to respirable dust during the catalyst fine collection activity was eliminated by providing a rotary valve and diverting the dust back to the catalyst hopper. The operator's average exposure to total dust during the catalyst bagging activity was initially 11.2 mg/m^3 but was reduced to 1.1 mg/m^3.

Catalyst bagging and RCH fines loading area were identified as important places to reduce dust exposure. In the RCH fines loading area the dust emanating during the filling of dumpster was eliminated by providing a rotary valve and diverting the dust back to the E-cat hopper. Personal exposure to dust during catalyst bagging was practically eliminated by providing a special adapter at the outlet of the E-cat loading hose. Respirable dust exposure reduced from 5.57 mg/m^3 to 2 mg/m^3.

These actions have produced an annual savings of US $300,000 worth of catalyst, a reduction in workforce and fewer environmental concerns.

Heat stress

Heat Stress was reduced in all three identified locations with an average reduction of more than 3°C (WBGT).

The WBGT index measured on the regenerator and catalyst sampling point was 34° C during the baseline evaluation. This was reduced to 30° C by the final evaluation. Operators used to spend 15-20 hrs a week on the regenerator during the catalyst unloading process. By providing an orifice valve on the outlet of regenerator, this process was reduced to 4-5 hrs, significantly reducing the heat stress of operators. Exposure to heat stress was reduced at the goggle valve area by provision of a ceramic insulation heat shield.

Creating a pool of trained resource persons

The training of field personnel was a very important part of the project in order to ensure the establishment of healthy work practices and changes in attitude.

Table 2 - *Results of area heat stress monitoring*

Area/Activity	GB (^{0}C)	WB (^{0}C)	DB (^{0}C)	WBGT (^{0}C)
April – 2003				
Regenerator	53.3	28.2	40.6	34.4
Regenerator Catalyst Unloading Line	44.5	23.9	36.6	29.3
Catalyst Sampling Point	48.0	27.3	43.0	34.7
February – 2004				
Regenerator	43.4	25.6	32.5	30.4
Regenerator Catalyst Unloading Line	37.3	24.5	1.5	27.6
Catalyst Sampling Point	42.9	25.2	35.6	29.7

GB=Globe Temperature; WB=Wet Bulb Temperature; DB=Dry Bulb Temperature; WBGT=Wet Bulb Globe Temperature Index

Change in attitude towards occupational safety and health

Awareness and compliance with occupational safety and health practices underwent a significant improvement particularly in the attitude of workers towards use of PPEs and the importance of housekeeping. As a result the FCC plant bagged the first prize in an inter-plant housekeeping competition conducted recently - up from the previous year's eighth position.

Sensitisation, awareness, training and development activities were extended to change agents from other sites through participation in the training workshop and interactions between various sites. All change agents have become resource persons for their sites. Similar improvements in employee attitudes towards occupational safety and health practices and improved compliance with the use of PPE have been noticed at all sites.

Other results

Many actions aimed at reducing the ergonomic stress were implemented. A crane pendent operator was experiencing stress on his shoulders due to a short pendent cable. A cable of the proper length was installed immediately with the result of reducing the operator's physical stress.

Discussion

The work improvement measures included actions of varying complexity. While acoustic insulation and engineering actions needed budgetary support, relocation of an operators' cabin was a simple, inexpensive and effective action. Since the CASH team comprised members from different disciplines (e.g. production, maintenance, technology, etc.), inexpensive in-house solutions were found for most problems.

Though the project resulted in significant improvements in the work environment, there are more areas needing improvement. Therefore, the emphasis has been on training the CASH agents to identify occupational health risks, evaluate the work environment and plan actions for improvement on an ongoing basis.

As evident from the above discussion, the project met with resounding success. Specific objectives to reduce exposure to noise, dust and heat, were achieved. The major success of the project was on the human resources front. Project CASH resulted in a "cultural change" which ensured employee and management involvement on an unprecedented scale.

The procurement of equipment and organisation of training cost a total of US$20,000. Since the project was eventually extended to seven sites, all sites shared the benefits. The Project Coordinator, spent around 20% of work time planning, coordinating and visiting various sites during this period. Other members of the CASH teams spent about 10% of their time in project activities at their sites, which was within the scope of their routine work. Expenditure on engineering changes came out of the operating budget of the plant. A spin-off from the project was the huge saving of more than US$ 400,000, which surpassed the initial investment. This has pleasantly surprised top management and proves that OSH and profitability need not be mutually exclusive. In fact, a strong business case could be made out in most of the projects selected.

The relevance and importance of this project is that it provides a model for development of change agents for OSH at the enterprise. All change agents have become resource persons who help replicate this effort at all locations of our enterprise. Following the successful outcome, an enterprise-wide movement for improving occupational health practices and in the work environment has been initiated.

The project called for close interaction between OSH staff and production managers. It was found that solutions to safety and health problems increased work productivity and effectiveness rather than decreased it. This project highlights the positive relationship between occupational safety and health (OSH) and productivity. The project resulted in occupational health gaining recognition across the organisation. Occupational Health professionals started moving out of the Health Centre to visit production / process areas. There is a better appreciation of occupational health issues by non-OSH professionals and management.

Concerning sustained and future action, the following recommendations were made to the management:

a) Project CASH was a new approach, tested as a pilot project in the enterprise. Given the success of this pilot project, it was strongly recommended that the project should be gradually extended to all manufacturing plants.

b) The success of the project was largely due to multidisciplinary teams. It is recommended that there should be more interaction and cooperation between different functions like process / production and occupational health. Occupational health physicians should visit the workplace frequently to better appreciate workplace hazards.

c) All new projects, modifications, and expansion plans should give due consideration in order to avoid occupational health hazards (such as noise). This needs to be done at various stages such as during design, procurement, commissioning, sustaining and monitoring.

d) Occupational health surveys should be done at the commissioning stage of all projects to confirm the fulfilment of performance with regard to design and procurement specifications. All plant personnel should be given training in occupational health and industrial hygiene.

e) Problems such as high noise levels are universal so noise reduction at source should be given top priority, and all sites should establish hearing conservation programmes. It is important to continue and further reduce the noise in high noise locations.

Further progress

Looking at the gains of pilot CASH project it was decided to extend the work improvement activities to other plants identified for sensitisation, awareness, training and development activities. A review meeting and award function was organized on 5th March 2004 at company headquarters. All team leaders gave brief presentations of their progress and future plans to the Director of the enterprise.

To institutionalise the process and to motivate all plants, it was decided to award a trophy named after the founder-chairman of the enterprise to the best workplace improvement project. After a review of presentations, progress reports and evaluation feedback from all sites by an independent expert jury, the first trophy was awarded to the CASH team from Jamnagar.

2004 - 2005

Encouraged by the positive results of the pilot projects and support by the top management of the company, all sites decided to extend the CASH projects to more plants. Consequently a total of 35 plants, from all seven sites together, implemented the CASH projects with varying benefits. The 'Change Agents', identified in the pilot project stage, acted as facilitators and resource persons for these projects. Three training workshops were arranged for the new batch of CASH team members. The same methodology of workplace evaluation before and after the project associated with employee awareness and training was followed. The outcome comprised numerous improvements in reducing exposure to various hazardous agents such as noise, heat, ergonomic stress, exposure to chemicals and improvement in compliance to the use of PPEs.

A systematic review was conducted to determine the winner of the trophy, which is a two-tier process. All plants at the site competed with each other to represent the site in enterprise wide Inter-site selection. The criteria for selection are communicated at the beginning of the year. An external jury comprising OSH professionals does the selection in a transparent manner. High enthusiasm and keen competition resulted in a tie between two teams with the jury deciding to award the trophy jointly to both plants.

2005 - 2006

Seeing the impressive outcome, the Director of the company desired extending the CASH projects to all manufacturing plants of the enterprise. It was also decided to extend the project to newly ac-

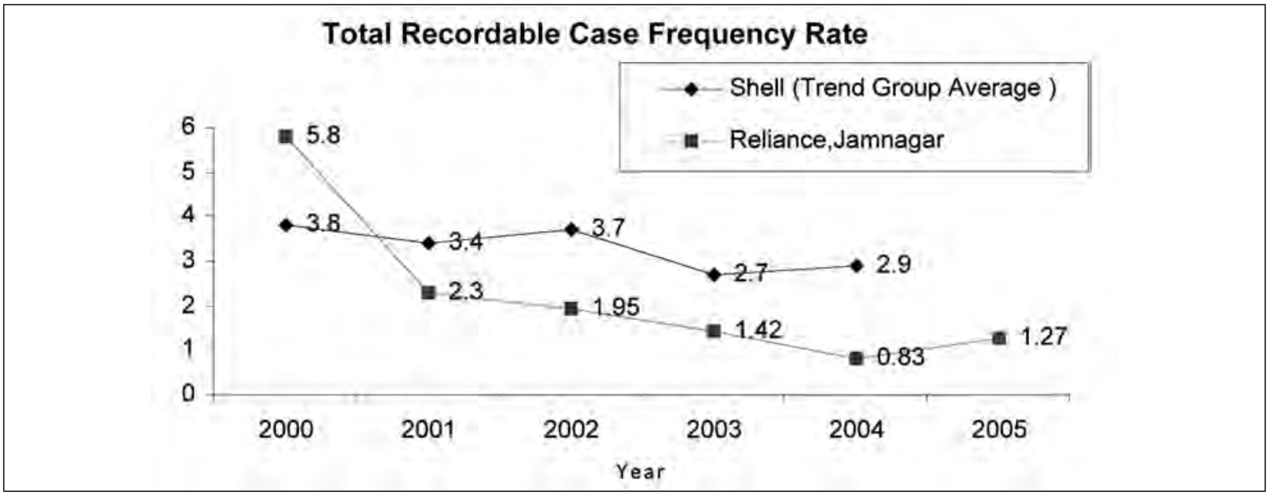

Figure 2 - Safety statistics at Jamnagar Refinery Complex

quired units of the company. The focus was on small, low cost improvements, creating awareness about occupational health among all stakeholders including contractors and adopting safe and healthy work practices.

Members of the outgoing CASH teams are playing the roles of resource persons and facilitators in the new projects. These developments indicate the sustainability of Project CASH activities. The institution of a trophy for the best project has had a tremendously positive impact on the outcome and creates strong motivation. Important factors in this OSH success story include strong management support evidenced by the time spared by top management and involvement of all layers of employees. Though monetary benefit is not an objective in Project CASH, in almost all cases, the returns have far outweighed the investments. The process of review and selection of best project during the year 2005 / 2006 is underway at the time of writing this manuscript.

The ultimate proof of effectiveness of improvement in OSH is revealed by the safety statistics of the Jamnagar Refinery complex which has shown significant improvement when benchmarked with gobal leaders like Shell (figure 2).

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Acknowledgements: *Authors are grateful to the management of Reliance Industries Ltd., to all CASH teams, to occupational health teams at all participating sites. The initial pilot project at Jamnagar refinery was carried out as requirement of the advanced international training course on "Occupational Safety and Health & Development" (OSH&D) conducted by the National Institute for Working Life, Sweden for occupational safety and health professionals from Asian countries. The course was sponsored by the Swedish International Development Agency. The authors would like to express their gratitude to these agencies and to their tutor, Kaj Elgstrand, for his valuable guidance and help*

La Medicina del Lavoro Med Lav 2006; *97*, 2: 369-375

Lessons from SARS in an age of emerging infections

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KEY WORDS
SARS; infections

SUMMARY
SARS, the first pandemic of this century, commanded the world's attention and required public health actions at the national and international levels. In an age of emerging infections, the lessons learnt from combating SARS can be used to improve our preparedness capabilities in three key areas to effectively tackle a public health emergency of international concern. The first area is in outbreak alert, which encompasses use of surveillance to detect, assess, notify and report events involving death or disease, and share information widely to enable proper risk assessment. The system must able to build up a comprehensive picture with appropriate warning for zoonotic diseases, environmental health and food safety. The second area is in public health response. In the event of an outbreak alert, the authorities must be able to quickly investigate cases/deaths and institute comprehensive control measures to break the chain of transmission. Protection of healthcare workers and reducing the opportunities for spread of infection through contact tracing and quarantine are important. The third area is in international health. This comprises health requirements for inbound and outbound travellers at the border checkpoints and global information exchange to mitigate the risks of travel abroad. Extrapolating these lessons to a wider public health context, our rapidly changing global infectious diseases situation mandates that we evaluate all available public health tools and build institutional capacity to effectively manage emerging infections.

RIASSUNTO
«Insegnamenti derivanti dalla SARS in un'epoca di infezioni emergenti». *La SARS, la prima infezione pandemica di questo secolo, ha richiamato l'attenzione mondiale esigendo azioni di sanità pubblica a livelli sia nazionali che internazionali. In un'epoca di infezioni emergenti, gli insegnamenti derivanti dalla lotta alla SARS dovranno esser utilizzati per migliorare la nostra preparazione in tre particolari situazioni chiave per affrontare in modo efficace un'emergenza di salute pubblica di interesse internazionale. La prima situazione chiave riguarda il periodo iniziale dello scoppio dell'epidemia e comprende interventi di sorveglianza per individuare, valutare, denunciare e riportare eventi riguardanti morte o malattia, e raccogliere diffusamente informazione per consentire l'appropriata valutazione del rischio. Il sistema deve essere in grado di costruire un quadro esauriente con opportuna attenzione per le zoonosi, la salute ambientale e la sicurezza alimentare. La seconda situazione chiave riguarda la risposta in materia di salute pubblica. Nel caso di allarme di possibile scoppio dell'epidemia, le autorità devono esser in grado di valutare velocemente i casi e le morti e istituire adeguate misure di controllo per rompere la catena di trasmissione. La protezione della salute dei lavoratori della Sanità, riducendo le possibilità di propagazione dell'infezione attra-*

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verso il percorso dei contatti e la quarantena è importante. La terza situazione chiave riguarda la salute internazionale. Comprende informazioni per i viaggiatori ai checkpoint *di confine e scambi di informazioni per ridurre i rischi dei viaggi all'estero. Estrapolando questi punti a un più ampio contesto di salute pubblica, la nostra situazione globale in continua evoluzione per quanto riguarda le infezioni implica la valutazione di ogni strumento di sanità pubblica e l'istituzione di un organismo per controllare efficacemente le infezioni emergenti.*

INTRODUCTION

The experience of SARS (severe acute respiratory syndrome) in 2003 has shown that new infectious diseases can catch healthcare institutions and public health authorities by surprise. Unwelcome events as they are, outbreaks occur from time to time and represent natural experiments which afford opportunities for us to derive valuable lessons about the microbial world, sources of infection and modes of transmission. Despite major medical and public health advances, today's outlook on infectious diseases remains ominous. The modern-day evolution of emerging infections is one of microbial agents taking full advantage of economic and environmental activities that allow for them to thrive, prosper and spread among humans. It is imperative that we maintain a high level of vigilance and be prepared to respond to this new challenge in ways that drastically reduce opportunities for spread from reservoirs of infection.

This paper draws on the work done on SARS in Singapore, describing the origins of the outbreak and the control measures to contain spread of the disease. It presents the lessons learnt from the outbreak to improve our preparedness capabilities to tackle a public health emergency.

SARS IN SINGAPORE

The outbreak

In 2003, SARS moved from southern China across several countries and threatened to establish itself endemically in Singapore (3, 5). The first three imported cases with clinical manifestations of atypical pneumonia were identified on Mar 6, 2003. Introduction of the outbreak into Singapore was through one of the three, a young woman who had stayed on the same floor of Hong Kong's Metropole Hotel and at the same time in late February as the Guangdong professor who carried the SARS virus out of mainland China. Back in the city state, this young woman infected 23 others.

At the initial stages, SARS was easily transmissible in hospital because the routine infection control practices were inadequate to prevent spread. The novel virus moved rapidly among healthcare workers, patients, visitors, and their close family contacts. Later spread occurred when patients with underlying disease which masked the tell-tale symptoms of SARS were transferred to other hospitals, placed in rooms with other patients, and managed without adequate protection. One hallmark of the outbreak was the phenomenon of super-spreading events – events in which the case, for as yet unexplained reasons, became highly efficient in spreading the virus to many. A total of 144 secondary cases were linked to just five such events.

A total of 238 SARS cases were identified with onset of illness between Feb 25 and May 11, 2003, of whom 33 (14%) died. Transmission of the infection in Singapore was largely through close person-to-person contact via infected droplets. The risk of community-acquired infection was real if any case could not be readily traced back to another case or if a symptomatic case circulated in the community for several days prior to isolation. When SARS actually moved into the community, it did so through an infected vegetable hawker working at a crowded wholesale market. Immediate closure of the market and contact tracing of all persons who had been to the market between Apr 5 and Apr 19, 2003, resulted in the quarantine of more than 1,200 contacts, limiting spread of infection to a total of 12 cases.

Prevention and control

The key control strategy was to detect early and isolate all cases, and contain the spread by ring fencing those exposed. Control measures that were instituted against SARS included centralising all patients in a single SARS-designated hospital, use of a dedicated ambulance service to ferry all possible cases to the SARS-designated hospital, restriction of movement of healthcare workers, patients and visitors in the healthcare institutions, thermal screening for all travellers at border checkpoints, and implementation of rigorous contact tracing with home quarantine. In the absence of specific anti-viral treatment and vaccine against SARS, the "detect-isolate-and-contain" strategy hinged on effective quarantine of all persons who had unprotected close contact with symptomatic cases.

The public health authorities established a contact tracing centre to undertake comprehensive procedures for the identification of all close contacts of probable/suspect SARS cases and observation cases in whom SARS could not be ruled out. The components of contact tracing included: obtaining all patient movements during the symptomatic stage; identifying the persons exposed to these movements; and instituting follow-up on all the close contacts over a ten-day period. The Infectious Diseases Act was first invoked on Mar 24, 2003, to impose quarantine on persons who had been exposed to SARS but it soon became clear that the existing legislation was inadequate because it was not an offence to break quarantine. On 28 Apr 2003, the Infectious Diseases Act was amended in Parliament to strengthen the legal provisions for quarantine.

The decision to quarantine rested with the Director of Medical Services, assisted by a Quarantine Board which provided advice based on clinical and epidemiological findings. Public health messages to the quarantined persons and general population were clearly communicated to help them understand the way SARS was transmitted, the rationale for quarantine, and how it affected children staying in the same household (ie, unable to attend school). Singaporeans served with the home quarantine order (HQO) were offered a choice to be quarantined at home or at a designated quarantine centre as "temporary home". However, there were qualifying criteria and payments involved in the latter option. Travellers to Singapore who were served with the HQO were also offered two options. They could choose to leave Singapore within 24 hours so long as they were afebrile (the public health authorities would inform their respective country missions), or to remain in Singapore at the designated quarantine centre.

The SARS outbreak in Singapore lasted from 25 Feb until 31 May 2003. Management of the outbreak was complicated by difficulties in the tracing of contacts for incidents involving planes, taxis, cruise vessels, large educational institutions, hostels, factories, markets, food centers, places of worship, public buildings and a mental hospital. While the quarantine measures came across to the public as hard but necessary, the approach was softened by home visits carried out by Health Promotion Board nurses. During these visits, those on HQO will be given a home quarantine kit each, which included an oral thermometer and a mask. The nurse would explain to them the conditions in the HQO which they had to observe, and how to monitor their temperature and chart it twice daily.

In the course of the outbreak, a total of 26 quarantine breakers were identified. One was jailed for six months for violating his HQO on a number of occasions and flaunting the fact that he had violated his HQO; another two were detained in an isolation facility to serve the remaining of their HQO period for violating their HQO on at least three occasions; while the rest were first time offenders who strictly observed their HQO after being issued with a warning letter and tagged.

As part of a comprehensive financial and social support system, the government implemented an HQO Allowance Scheme. Under the scheme, the government would pay an allowance to self-employed persons to make up part of their lost income whilst on quarantine. The scheme also gave the allowance to establishments whose employees had been affected by HQOs. When the final tally was made, 7,863 persons had been put under quarantine. The financial cost of the HQO allowance scheme based on the above payouts alone amount-ed to US$1.8 million. Another US$3 million was incurred in engaging auxiliary police officers to administer and enforce HQOs.

Lessons learnt from SARS

The experience of Singapore in mounting large-scale public health operations during the SARS outbreak confirmed the importance of having proper systems within an organisational framework for resources to be deployed effectively. To tackle a public health emergency, it is necessary to have the preparedness capabilities in three important areas: 1. outbreak alert; 2. public health response; and 3. international health.

Outbreak alert

Outbreak alert requires surveillance, which is defined as the ongoing systematic collection, analysis and interpretation of health data essential to the planning, implementation and evaluation of public health practice, closely integrated with the timely dissemination of these data to those who need to know (10). Most of the surveillance systems today involve "health events" and are dependent on physician-initiated reports of notifiable infectious diseases or information from laboratories regarding bacterial or viral isolates. However, the bigger risk picture would include animal surveillance for zoonotic diseases, environmental surveillance for vector breeding and rodent infestation, and food safety surveillance for food-borne pathogens. These forms of surveillance are often carried out outside the health sector in veterinary, agricultural and environmental circles, but need to be linked for effective early warning. In addition, situational awareness can often be improved by tracking emerging diseases overseas (7) and capturing anecdotal information from sentinel events.

Use of surveillance

In the SARS outbreak, the success of surveillance systems in detecting the disease were facilitated by ready access to health care among the ill persons and good information exchange. Clusters of atypical pneumonia were being identified even before confirmation of the microbial agent. Subsequently, SARS was found to be caused by a novel coronavirus that spread from person-to-person by close contact: caring for, living with, or direct contact with respiratory droplets or body fluids of a suspect or probable case. The modes of transmission were later established to be primarily via droplets and secondarily through fomites and opportunistic aerosolization (2). Surveillance also picked up the phenomenon of super-spreading events triggered by cases who were highly efficient in amplifying the virus and spreading it to ten or more people (4). The contributing risk factors included clinical severity of the disease, presence of co-morbid conditions which masked the tell-tale symptoms of SARS, and failure to isolate the cases early.

With all the components of surveillance in place, the public health authorities would be able to detect, assess, notify and report events involving death or disease above expected levels for the particular time and place. However, proper surveillance requires training for specialized staff, laboratory capacity to analyse samples (domestically or through collaborating centres) and logistical support.

Public health response

The goal of outbreak alert is to enable prevention and control measures to be instituted in a timely and effective fashion. Preparedness to mount the public health response encompasses operations planning, training for field officers and healthcare workers, and stockpiling of vaccines, chemoprophylaxis and personal protective equipment for those considered at risk. In the event of an emergency, the public health authority must move quickly to investigate all cases/deaths and trace all contacts for screening and follow up. Depending on the situation, measures to break the chain of transmission include stepping up of hospital infection control practices, quarantine, environmental sanitation and hygiene, decontamination of hot zones, disposal of contaminated materials, and burial/cremation of deceased persons.

Protection of healthcare workers

In the SARS outbreak, the healthcare institutions constituted the frontline defense in the fight to prevent further spread of the disease (9). A single case could infect many secondary cases in a population that had not instituted control measures (1). Stringent measures were instituted to prevent and contain SARS in the hospitals, national healthcare centres, nursing homes, medical, dental and traditional Chinese medicine clinics. Healthcare workers were required to wear N95 masks, gloves and gowns and practice frequent hand-washing after every patient contact. Goggles were compulsory in isolation facilities, emergency departments and intensive care units. When performing high risk procedures such as bronchial aspiration and intubation, positive airway pressure respirator hoods were used. All healthcare institutions were also required to monitor their staff closely through twice- or thrice-daily temperature monitoring and strict instructions were given to disallow anyone who had fever or was unwell to work. To prevent cross-infections, no inter-hospital transfers of patients were allowed. Doctors and other healthcare workers in the private hospitals were required to work in one hospital only. In addition, all visitors had to be registered so that they could be traced quickly. The public health authorities provided directives to all healthcare institutions on hygiene, sanitation and infection control practices and carried out regular audits to ensure compliance.

By reducing opportunities for the virus to spread, the outbreak was characterised by nosocomial and intra-household infection. Contact tracing further limited community exposure to potential reservoirs of infection and as a result, over 80% of the 238 cases did not transmit infection to others. The low number of new cases generated by each case can be contrasted with a model which showed that a single infectious case of SARS infected about three secondary cases in a population that has not yet instituted control measures (6). The public health actions also effectively shortened the time between onset of illness and isolation in hospital from over three days in the early phase of the outbreak to 1.6 days, reducing by half the amount of time infected persons could expose others to the virus. The experience underscored the importance of preparedness and public health response.

Healthcare institutions, through their physical environment and practices, encounter many challenges to infection control. To successfully address these issues, architects, engineers, epidemiologists, health policy makers, hospital managers and healthcare workers must work together at all stages before, during and after the construction and commissioning of the healthcare institution. A high level of vigilance is needed, and also preparedness to respond to any emergency. Failure to do so could expose patients to nosocomial infections which spread to involve staff and visitors.

INTERNATIONAL HEALTH

Outbreak alert and response preparedness are equally applicable at the international level. When an infectious disease of uncertain aetiology emerges, the information has to be shared widely, under the auspices of WHO if necessary, in order for scientists to elucidate the causative agent, source of infection and mode of disease transmission, and for other national authorities to weigh their risk management strategies. Systems which have been set up to gather information include the Global Public Health Intelligence Network and Pro-Med. In an emergency, time is in short supply. WHO can play an important role in working with the affected country to gather epidemiological information, and coordinating global resources for response through its Global Outbreak Alert and Response Network.

Mitigating the risks of travel abroad

In the SARS outbreak, while the main battle against the disease was in the healthcare institutions, health screening at the border checkpoints formed another line of defense against export and import of infection (8). The public health authorities had to work closely with WHO on the border health issues in accordance with provisions of the International Health Regulations. As part of core capacity requirements for designated airports, ports and ground crossings, the authority had to apply checkpoint exit and entry requirements for outbound and inbound travellers, respectively, and provide facilities for their health assessment, quarantine, isolation and clinical management. In addition, WHO was provided with timely communications providing accurate and detailed public health information on the notified events, case definitions, laboratory results, source and type of risk, numbers of cases/deaths, conditions affecting the spread of the disease, and the health measures employed. The difficulties faced in responding to the emergency and mitigating the risks were also highlighted.

In these times of globalization, there is increasing population movement with travel and work abroad. When a public health emergency of international concern occurs, public health authorities must be able to sound a global alert early and disseminate factual information and recommendations on disease control rapidly to the community at large. Outbreaks are frequently marked by uncertainty, confusion and a sense of urgency. Hence, clear outbreak communications on issues such as monitoring of symptoms, personal preventive measures, and travel precautions are of immense value in maintaining the public trust. These international health measures are collectively important because slowing the spread of infection at the start of a potential pandemic can buy time for other countries to draw up controls.

Conclusion

The authors have approached the subject of preparedness for emerging infections by drawing some key lessons from SARS. The importance of outbreak alert and response cannot be overemphasized. In particular, it was found that contact tracing, with or without quarantine, was an important measure in both the assessment and control of an emergency. While quarantine was effective in the control of SARS (11), it cannot be universally effective for all other emergencies. Public health response preparedness must include plans for instituting mass chemoprophylaxis, vaccination and other interventions. Outbreak communications are equally important as affected persons, national agencies, international organizations, the media, and members of the public are keen to do their part but need to understand the disease and measures for prevention and control. The public health authorities must stay flexible and be prepared to use extraordinary measures, adjusting strategies as new challenges emerge. Extrapolating these lessons to a wider public health context, our rapidly changing global infectious diseases situation mandates that we evaluate all available public health tools and build institutional capacity to effectively manage emerging infections.

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ACKNOWLEDGEMENTS: *We would like to thank A/Prof Chew Suok Kai and our many colleagues at the National University of Singapore, the Ministry of Health and the Health Promotion Board. Without them, this paper would not have been possible*

La Medicina del Lavoro Med Lav 2006; *97*, 2: 376-382

Is globalisation outpacing ethics and social responsibility in occupational health?

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Key words
Globalisation; social responsibility; ethics

Summary
Introduction: *The definition of globalisation is varied. However, one certainty is that in a globalised world the borders are porous in many aspects; people movement, goods exchange, knowledge sharing and redistribution of labour. The concept of globalisation, its impact on society, and its direction leads to a two-sided argument. Could this be the effect of globalisation on ethics and social responsibility, as it is perceived? This paper endeavours to further our understanding of the dynamic relationship of globalisation, ethics and social responsibility in occupational health.* **Method:** *The multidisciplinary activity approach to occupational health was used. The globalisation, ethical and social responsibility relationship of the activities in occupational health was analysed using a schematic map of the direct and indirect influences.* **Results:** *The analysis revealed areas that can be clustered to address the interaction between driving forces in occupational health ethics and social responsibility for a healthy workforce.* **Discussion:** *Each cluster is discussed highlighting areas of concern. In the discussion proposals are made on how we can modify the way we think in order to avoid repeating mistakes. Suggestion is made of using an innovative method borrowed from other disciplines and adopted for use in occupational health. A partnership approach is proposed and explored on how it will be applied in situations of unequal balance of power.*

Riassunto
«Nell'ambito della salute occupazionale, la globalizzazione sta avendo regione dell'etica e della responsabilità sociale?». *Vi sono diverse definizioni del termine "globalizzazione". Tuttavia, una risiede certamente nel fatto che in un mondo globalizzato i confini sono permeabili sotto molti profili: spostamenti di persone, scambio di beni, condivisione della conoscenza e redistribuzione del lavoro. Il concetto di globalizzazione, il suo impatto nella società e la direzione che sta prendendo può essere visto da due prospettive diverse. Può la diversa prospettiva adottata derivare dall'effetto della globalizzazione sull'etica e la responsabilità sociale, a seconda di come questo effetto è percepito? Questo articolo tenda di migliorare la nostra conoscenza sulle relazioni dinamiche intercorrenti fra globalizzazione, etica e responsabilità sociale nell'ambito della salute occupazionale. Nella conduzione di questo studio è stato impiegato un approccio multidisciplinare alla salute lavorativa. La relazione fra globalizzazione, etica e responsabilità sociale connessa alle attività di salute occupazionale è stata analizzata attraverso una mappa schematica delle influenze dirette e indirette. L'analisi ha rivelato aree che possono essere raggruppate ad indicare l'interazione tra forze in grado di sostenere la salute della forza lavoro mediante l'impiego dei principi di etica e responsabilità sociale nelle attività di salute occupazionale. Ciascun gruppo viene discusso evidenziando le relative aree di*

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interesse. In questo contributo vengono inoltre discusse proposte su come modificare il nostro modo di pensare per non ripetere gli errori precedenti. Viene anche suggerito un metodo innovativo preso in prestito da altre discipline e adottato per gli scopi della salute occupazionale. Viene infine proposto un approccio basato sulla partnership, con un approfondimento sulle sue modalità di applicazione in situazioni di distribuzione iniqua del potere

Introduction

The concept of globalisation and its direction leads to a two-sided argument as viewed by those who see the benefits on the one side and those who see the demise brought about by this phenomenon.

The pro-globalisation view is that, democracy as a component of globalisation, brought about benefits for civil society with millions attaining high standards of living (15). To a large extent, it is countries that took charge of their own destiny that benefited from globalisation. The results are that governments have recognised that they should be proactive rather than rely on outside forces to determine their economic growth.

Those who are cautious about the benefits of globalisation see it is a capitalist threat that results in fast growing inequality and greed among the nations (17). The rich and industrialised countries are getting richer with their economies getting stronger while the poor are getting poorer (18). The debt in the poor countries is consuming their scarce resources with little or no chance of development (11). Whatever the case maybe, globalisation cannot be ignored.

The moral principles that society lives by, which are collectively known as ethics, are also impacted upon by globalisation. When problems arose from medical research and the abuse of human subjects, bioethics was born. The global ethics in health today is mainly bioethics that is associated with clinical trials and other types of investigation involving humans and animals in biomedical research. Business ethics, is defined as knowing what is right or wrong in the workplace and therefore doing what's right with regard to effects of the products/services as well as in relationships with stakeholders (4). This behaviour is also expected from general business dealings. However, the emphasis is not great when it comes to occupational health, this will be established later in the discussion. On this issue, others are arguing that globalisation has developed in an ethical vacuum (8). There is a need therefore to critically review the relationship and explore the development of a framework or guide, which will form a base for addressing the shortcomings, if any.

Social responsibility is seen as the overall relationship of corporate business and its stakeholders. These can be employees, communities, customers, suppliers, government, shareholders and competitors. The latter two can have a tremendous influence in the way the company conducts its business at home and abroad. A strange phenomenon is that companies seem to understand that social responsibility only features outside the working environment and has little to do with occupational health. Building houses for employees, donating funds for charity and contributing to sports development is commendable. However, the health of employees within the workplace should not be overlooked.

The 2004 report of the World Commission on the Social Dimension of Globalisation highlights the call to a greater coherence between economic, social and environmental policies (8).

This paper endeavours to further our understanding of the dynamic relationship of globalisation, ethics and social responsibility in occupational health.

Method

A schematic diagram of the multidisciplinary approach to occupational health is used to map the direct and indirect relationships in occupational health (figure 1).

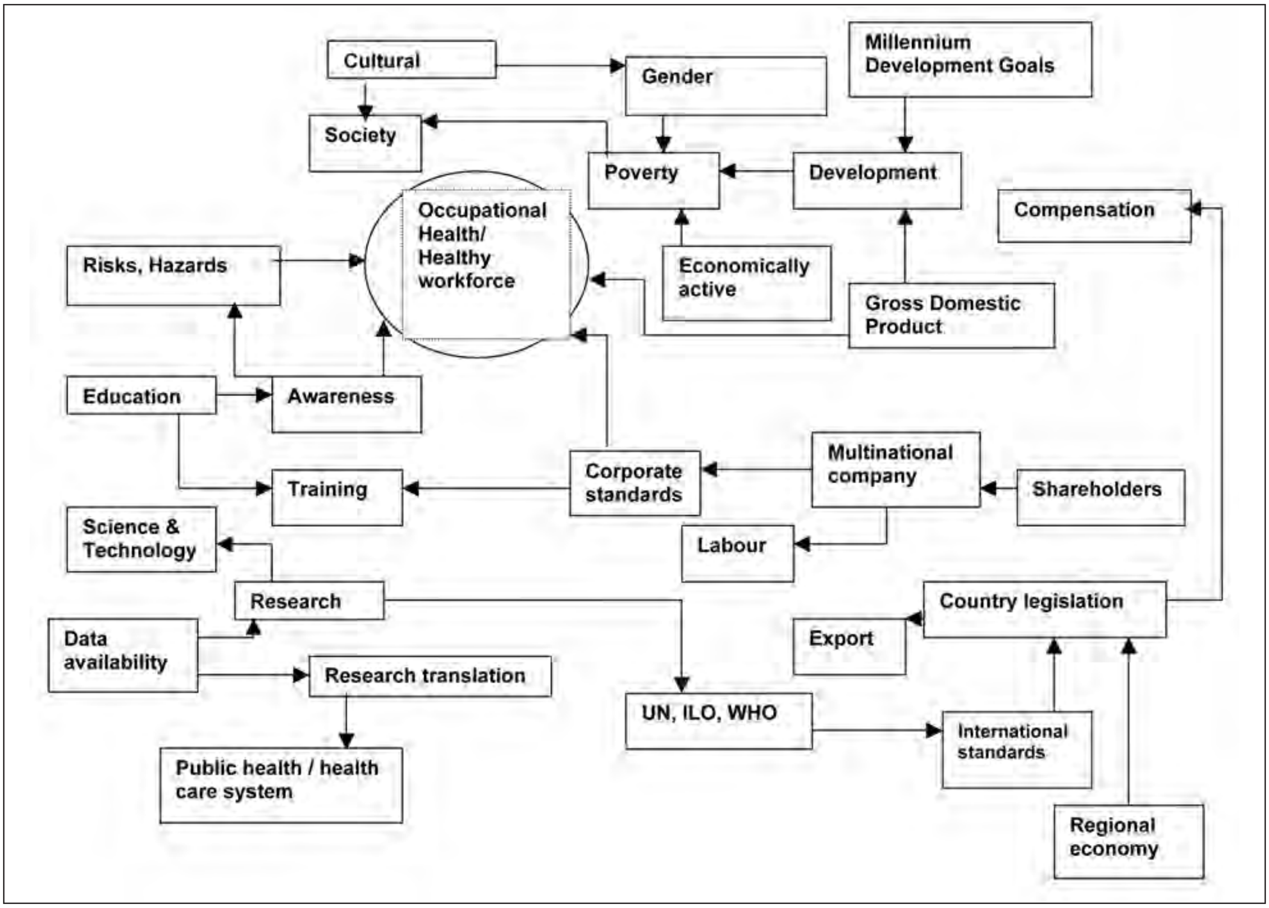

Figure 1 - Schematic diagram of the multidisciplinary approach to occupational health

Business and labor

Occupational health is being influenced by events that are outside the working environment. The reality is that the job market is shrinking while the unemployment pool is increasing. There is a growing tendency to opt for a small core of permanent employees that is surrounded by spheres and sectors of temporary employees (16, 22, 24). These temporary employees are at higher risk to lose their jobs and are therefore socially disadvantaged. This leads to a growing uncertainty among the workers, giving the employers power on how to conduct their business with little or no thought on occupational health and safety. However, not all companies behave in this manner. There are some who carry out their business as in their nation of origin. They transfer good occupational policies and practices to their host countries and to areas where they practice.

The structure of the workforce has changed to reflect the impact of globalisation on employment; there is active migration from one country to another and from rural to urban areas. A number of cross boundary problems have been observed as a result (10). Firstly, it is difficult to follow up on ex-employees' health when they have gone back home. This implies that workers have a slim chance of being traced and compensated for any illness resulting from their exposure to hazards in the workplace. This creates a burden for their family who have the duty of looking after them when they become ill. The family's resources are used up on medical care and by implication they get poorer. Secondly, the unemployment backlog resulting from unplanned rapid urbanisation is absorbed by small business enterprises. The workers seeking employment in these urban areas end up being exposed to occupational hazards and other social problems comparable to the industrial revolution (26). Furthermore, women are entering the workforce in lower skilled jobs and experience far worse conditions than their male counterparts (3).

Finally the multinational companies have become much more influential in the history of employment.

Can addressing Millennium Development Goals contribute to sustaining good occupational health?

The phrase making poverty history has been brandished about a lot in a bid to refocus the energy of the world towards this goal. There is a strong drive to regional economic development within globalisation. The stronger regions tend to develop a protective and manipulative shield around them that keeps the poor countries as well as other regions in the periphery as trading partners.

Health and development are closely related; the development of a society determines the health of its people whereas development is used to improve human welfare. It is unlikely that the goals will be met without education. Education has been found to be associated with lower mortality and better health. Furthermore, regardless of the particular country's philosophy, education is essential to give its citizens the power to take charge of their health, particularly in the workplace. Therefore, if this argument is accepted, then, education and development are closely related. Increasing education of an individual makes an important contribution to economic growth of the society and that of the individual (23).

In a study of estimates of potential health gains from reducing major risks, Ezzati et al. found that removal of risks e.g. hearing loss, injuries, and road traffic accidents among others results in an increased global health life expectancy even with regional comparison (5). These gains can only be achieved when the workforce is educated to adopt new technology to reduce and eliminate hazards in the workplace. Without education, awareness of risks is low, especially among the informal and small enterprise employees.

To what extent is poverty used to influence or exploit occupational health?

The freedom that comes with globalisation has in other cases led poor countries to compete for the suitability to host the multinational companies. Because of this the hosting country can find itself in a situation where social security and occupational health and safety is compromised. This situation can in part, be in the form of pressure to reduce production costs, and because occupational health is perceived to be a cost for the employer, it will suffer accordingly. Underreporting of health problems may be exacerbated by job insecurity. This results in occupational health being least visible in the most marginalised groups. The burden is borne by an equally weak health care system in the public sector (12). In this instance the employer is relieved of their social responsibility to employees health at a heavy cost to the public health system.

In a poor society the perception of health changes as dictated by circumstances, and because of this, the delivery of health care tends to follow a similar pattern (2, 25).

Even if a country was willing to protect employees from occupational diseases and risks, the fact that there is a mixture of temporary and permanent workforce makes it difficult to manage. To offer unemployment security and health care to temporary employees becomes a serious challenge.

In the case of investor pressure, a poor country may not be in a position to apply results of research that has proven risks in a work situation. The pressure is exacerbated by the threat of job insecurity that could lead to high unemployment figures in the country.

Role of donors, funders and multinational companies in occupational health

For developing countries, their worst enemy is debt. Repayment consumes all their meagre resources thus diminishing any possibility of development (10). Countries that are willing to offer assistance in the form of aid and loans for economic and industrial activities usually insist on appropriate occupational health programmes in the receiving country. However, uptake of these programmes will depend on the ability and character of the government of the day. Besides giving monetary support and setting conditions, technology transfer can be used as a carrot and thus encourage ethical and social responsible business dealings while empowering the recipient. The transfer of internationally funded research and capacity building has been beneficial to the receiving country (14). However, unwanted technology or dirty technology that is rejected from the donor country should not be exported. Development is required but not at the cost of workers lives.

It can be debated that foreign companies are not responsible for the failure of systems to protect workers in e.g. China (13), however this is not acceptable since the multinationals would not continue in their own countries under such circumstances. They enjoy the absence of or weak regulatory systems to benefit their profits margins (7). In the small and medium enterprises, there is a big challenge for all interested to improve occupational health. Without effective international interventions the process of globalisation would be used to take advantage of vulnerable people.

Has science improved the plight of workers?

It is accepted that science and technology have played, and will continue to play, a significant role not only in the search for new knowledge and more efficient means of agricultural and industrial production systems, but also in improving health, environmental conditions and promoting human development. In applauding this we need to keep in mind that not all countries, even the developed ones, have the political mechanisms to translate scientific findings into policies and regulations that are enforceable. Secondly, science is not without its shortcomings in the discussion at hand. There needs to be a closer link between research and policy in order to set a clear research agenda and later apply the research findings. For example, the lack of global data is seen in the vastly different figures given by World Health Organisation (WHO) and International Labour Organisation (ILO). The ILO estimates that there are 2 million deaths due to occupational risks, however the WHO provides details for only 40% of this total (6).

Research is revealing that less is known about the harmful effects of chemicals on people and therefore more needs to be done. Therefore demanding hard science as proof before any action is taken in prevention is not realistic (1). This is where the precautionary principle is beneficial, supported by risk assessment and management techniques in determining validity and strength of the science.

In studying occupational exposure and disease, there are so many confounders that causality becomes difficult to prove. It has been found that occupational health scientists have been successful at times in addressing issues of workers health scientifically (14).

Discussion

The above sections paint a grim picture giving the impression that all is lost. However, the world is not necessarily helpless in the face of globalisation. There is a price to be paid in raising corporate social benefits to improve occupational health. Adopting the lowest possible labour strategies harms not only society but also it is not good for business. This means people should deal with globalisation in intelligent and democratic governance allowing for greater participation by all concerned. Is this suggestion realistic? It may seem not to be, given that each country is unique and solutions are not universal. Currently occupational health is fought on a country-by-country or even region-by-region basis. These imbalances point to a need for better approach to globalisation using frameworks and policies that are driven by basic human rights. Developing countries in particular lack political mechanism that will translate available information into action to address occupational health issues. In most instances it is the powerful multinationals that influence legislation in these countries. It is for this reason that engaging them is crucial in order to influence the way business is done for the development of society. Power without principles is corrupt and leads to destruction of societies.

In order to realise a healthy workforce supported by ethical and socially responsible occupational health practice, there is a need to modify the way things are currently done. A radical reform is required if the commitment to occupational health is to be revived. This can be achieved by firstly breaking the barriers between the disciplines and take a holistic approach in providing solutions for occupational health problems. International guidelines are becoming more important for ethical and social responsibility. Through managing these with other stakeholders, e.g. media, scientific community, governments and other business partners, the possibility exists that achieving the Millennium Development Goals in the poor society can be realised.

An interesting avenue to explore is that of partnership (19). It is not possible that a single entity can manage to solve occupational health problems and still address the issues of ethics and social responsibility at the same time. Certainly not the public nor the private sector could manage this. Partners can serve as each other's conscience, using a rule based multilateral system that will help ensure a healthy workforce and society. This system should be built on moral and ethical framework that is shared by all. An example of how this system could work is presented in Box 1. There is nothing stopping public-private partnership for public health to be implemented in occupational health. The multidisciplinary structure of occupational health lends itself to be a good candidate for this innovative method of managing public health.

Box 1
Epidemiological studies could generate new knowledge that brings to the fore health risks and related costs to the nation. The response then increases the awareness of politicians, workers, industries and the rest of the society through well-planned and organised media reviews. Training is then offered to the employers and workers as well as the occupational health experts. Mandatory regulations are set and provision is made for monitoring and enforcement.

In conclusion, globalisation can be and is beneficial. It is in the way it has developed, in an ethical vacuum, that problems arise. To reclaim productive working life this century, it is essential to establish norms and standards that will govern all spheres of occupational health in an ethical and socially responsible manner.

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La Medicina del Lavoro Med Lav 2006; *97*, 2: 383-392

Friday - June, 16 2006 - Plenary

The scientific basis of a total asbestos ban

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Key words

Asbestos; carcinogenicity; mesothelioma

Summary

Worldwide, in the new millennium, standards for the protection of workers and the general population from asbestos risks are not equally stringent in all countries. The present review analyzes some arguments which in recent years have been proposed as a rationale for the reconsideration of the scientific background of a total asbestos ban, such as that adopted in the European Union. The conclusion is that in order to ensure adequate protection, there is no alternative to a total ban. The evidence for carcinogenicity of chrysotile is as good as for the amphiboles, the carcinogenic potency of chrysotile is lower than that of the amphiboles, but risk estimates must also be based on extent of exposure (nowadays chrysotile represents 95% of asbestos used worldwide). The fact that induction of mesothelioma by asbestos results from the interaction of environmental exposure and genetic factors reflects a general phenomenon in carcinogenesis and does not warrant any re-consideration of the role of asbestos. The role of SV40 as yet is unclear: even assuming that current risk estimates are correct (which is debatable), this agent would interact with asbestos in only a fraction of mesothelioma cases. The effectiveness of protocols suggested for "controlled use" has not been tested with a scientific approach: they seem hardly practicable, particularly in the countries which are currently the major consumers of asbestos.

Riassunto

«Le basi scientifiche della completa abolizione dell'amianto». *Le norme mondiali per la protezione dei lavoratori e della popolazione generale dai rischi derivanti dall'amianto, nel nuovo millennio, non sono ugualmente rigorose in tutti i paesi. La presente recensione analizza alcuni argomenti che negli anni recenti sono stati avanzati come fondamento per riconsiderare le basi scientifiche che hanno condotto ad una completa abolizione dell'uso dell'amianto, come quella adottata nell'Unione Europea. Si conclude che allo scopo di garantire un'adeguata protezione, non c'è alternativa se non la completa abolizione. L'evidenza di cancerogenicità del crisotilo è praticamente la stessa degli anfiboli, il potere cancerogeno del crisotilo è più basso di quello degli anfiboli, ma le stime del rischio devono essere basate anche sulla durata dell'esposizione (al giorno d'oggi il crisotilo rappresenta il 95% dell'amianto usato a livello mondiale). Il fatto che l'induzione del mesotelioma a causa dell'amianto risulta dalla interazione tra esposizione ambientale e fattori genetici riflette un fenomeno generale nella cancerogenesi e non permette alcuna rivalutazione del ruolo dell'amianto. Il ruolo del SV40 non è ancora chiaro: anche presumendo che le stime del rischio attuale siano corrette (cosa che è discutibile), questo agente interagirebbe con l'amianto solo in una parte dei casi di mesotelioma. La validità dei protocolli che sono stati suggeriti per un "uso controllato" non è stata testata con un'approccio scientifico: sembrano difficili da usare, particolarmente nei paesi che al giorno d'oggi sono i maggiori utilizzatori di amianto.*

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Introduction

Asbestos victims all over the world are in the order of hundreds of thousands per year, and calls for an international ban on all forms of asbestos have been issued by some agencies such as the Collegium Ramazzini (22). All over the world, the commitment of countries in taking measures to protect workers and the population from asbestos risks has varied over a wide range, thus leading to multiple standards, an option which is hardly acceptable on ethical grounds. Following the first prohibition of asbestos use in 1983 in Iceland, many countries in the European Union adopted similar measures.

The European Union Directive 1999/77/EC banned import, export, manufacture and trade of any form of asbestos, thus expanding to chrysotile measures which had been previously taken for the amphiboles.

The Scientific Committee on Toxicology, Ecotoxicology and Environment of the European Commission (CSTEE) provided the scientific basis for this 1999 decision, which was reiterated 4 years later (10). National asbestos bans have been adopted in Argentina, Australia, Chile, Croatia, Gabon, Honduras, Japan, Kuwait, Saudi Arabia, Seychelles and Uruguay (19).

Similarly to Europe, in most countries the amphiboles were the first to be regulated through such a drastic measure, whereas chrysotile was banned at a later stage. Other countries have banned crocidolite or all types of amphiboles but not chrysotile. National bans have been advocated for in additional countries, including those ranking highest among the major producers and/or consumers of asbestos, such as India (37) and Brazil (13, 30).

Inequities have also occurred in the adoption of the 1986 ILO asbestos convention C 162, which binds signing countries to prohibit crocidolite (and not other forms of asbestos): the convention has been adopted by only 27 countries worldwide (23).

Table 1 lists the major asbestos producing countries in 2000, as well as their annual consumption. Among non-asbestos producing countries, major consumers include India, Thailand, Indonesia, South Korea, and Mexico, respectively consuming 125, 121, 55, 29 and 27 thousand tons (42).

Table 1 - *The top 10 producers of asbestos in 2000*

	Production (tons/year x x 1000)	Consumption Tons/year x 1000	Consumption Kg/capita/ year
Russia	752	447	3.4
China	350	410	0.4
Canada	320	5	0.2
Brazil	209	182	1.3
Kazakhstan	179	4	1.8
Zimbabwe	152	12	NA
Greece	32	<5	NA
South Africa	19	13	0.5
India	15	125	0.2
Swaziland	13	<5	

Source: reference 42

Some scientific issues have been used more or less explicitly as justifications for the non-adoption of a ban, and allusions to alternative public health approaches are frequently made in the scientific literature. The weakness of these allegations is highlighted in the present text.

Does the evidence for carcinogenicity of chrysotile rank as high as for the amphiboles?

The rationale for giving a positive answer to this question is illustrated in the following paragraphs. Chrysotile causes lung and pleural (and peritoneal) cancer in humans. Its carcinogenic potency is lower than that of the amphiboles, but this is irrelevant to the question, given that the risk for a population or an individual depends on both potency and exposure, and chrysotile is the most widely used fibre type (95% of all asbestos use worldwide) with the largest number of exposed subjects. The epidemiological evidence is supported by a huge number of long-term experiments in laboratory animals: the "negative" results of some experiments – whose reasons remain to be explained - are largely overwhelmed by the "positive" findings.

Long-term (carcinogenicity) studies in laboratory animals

The 1987 update of previous IARC evaluations (21) stated that chrysotile induces: a. mesotheliomas and lung carcinomas in rats after inhalation, b. mesotheliomas in rats and hamsters following intrapleural administration and c. peritoneal tumours including mesotheliomas in mice and rats following intraperitoneal administration.

Results of studies carried out during the 80s and 90s have been tabulated in some detail in another WHO document (44). They largely confirm the conclusions reached by IARC. A sizable number of properly designed experiments have been published over several decades in which chrysotile was administered to rats through inhalation, intratracheal/intrabronchial injection or intrapleural injection. In most of these studies pulmonary and/or pleural cancer were produced. Samples of chrysotile from different sources were used. In the "positive" experiments, the materials used were indicated as UICC chrysotile B, long fibre chrysotile, short fibre chrysotile, UICC chrysotile A, milled UICC chrysotile B, Canadian chrysotile, Standard Canadian chrysotile, phosphorylated Canadian chrysotile, UICC Canadian chrysotile, UICC Rhodesian chrysotile, long and short asbestos cement chrysotile and Chinese chrysotile. "Calidria" chrysotile did not produce cancer in an inhalation experiment, but produced mesothelioma in 2/32 rats given a single intraperitoneal injection. In one experiment in hamsters, intratracheal application for 6 weeks produced cancer only if associated to administration of benzo(a)pyrene (same result for amosite). Negative results were also found in one long-term inhalation study with *ad hoc* prepared "Coalinga" chrysotile, not contaminated with amphiboles (20). This experiment has not been repeated. "Coalinga" chrysotile differs from other types of chrysotile, since it is intensely milled and results in a fraction composed of fibres that are almost all less than 5 μm in length. "Negative" studies also included one inhalation experiment in monkeys, one in hamsters, and two in baboons (in which a few mesotheliomas were produced in other groups of animals treated with amosite or crocidolite). Experiments in which chrysotile was given orally produced controversial results.

Genotoxicity

Chrysotile has been shown to induce inflammation, oxidative stress and genotoxicity in several *in vivo* and *in vitro* experimental systems, thus indicating its potential to induce direct genotoxicity, although the dose-reponse governing *in vivo* genotoxicity remains unclear (10). In humans, three studies have detected increased levels of DNA damage (8-hydroxyguanine adducts and strand fragmentation) and higher frequencies of SCE in the blood cells of workers occupationally exposed to asbestos (10). In one of these studies (40) exposure was to chrysotile, which in a subsequent study was reported to be contaminated with tremolite (41). A more recent (12) study showed the ability of chrysotile and asbestos cement powder to induce dose-dependent micronuclei and loss of cell viability *in vitro*.

Differences in biopersistence between chrysotile and amphiboles

About ten years ago Churg and Wright (9) pointed out that in human lungs amphibole fibres are present in disproportionately large amounts and chrysotile fibers in disproportionately small amounts compared to the known abundance in the original inhaled dusts. Thus, differences between the amphibole and chrysotile fibre burden in the human species reflect faster clearance of chrysotile fibres rather than failure of chrysotile deposition. Most reports have shown that fibre accumulation is proportional to measured exposure for amphiboles, but this is not generally true for chrysotile. For amphiboles, estimated clearance half-times are measured in years to decades, whereas for chrysotile the available, rather indirect, data suggest that the vast majority of fibers are cleared within months (9).

Observations in man are paralleled by experimental studies. In rats exposed to asbestos through inhalation, several types of chrysotile persisted in the lung parenchyma for a shorter time and produced less inflammatory changes than the amphiboles (2). The significance of this finding in terms of assessment of carcinogenic risk in man is debatable. Since not all fibres inducing inflammation following chronic inhalation are carcinogenic, inflammation does not seem to be the only crucial event in carcinogenicity (10). It has been suggested that biopersistent fibers should be classified as probably or possibly carcinogenic to humans (IARC groups 2A or B), whereas biosoluble fibers should be classified as probably not carcinogenic to humans (14), but the predictive value of clearance tests remains to be assessed.

Epidemiological evidence of carcinogenicity of chrysotile and risk estimates

Studies allowing for an estimate of cumulative exposure to different types of asbestos (crocidolite, amosite, chrysotile and mixed exposures) were included in a series of major pooled analyses (18) Six studies related to cohorts reported to be exclusively exposed to chrysotile, i.e. two cohorts of miners (in Quebec and in Balangero, Italy), one of workers in a cement asbestos plant in New Orleans, one of workers in a plant producing friction material in Connecticut, and two cohorts (respectively men and women) of textile workers in South Carolina. Summary observations from each of these studies are given in table 2.

The data from Balangero included in the meta-analysis are derived from a study whose follow-up ended in 1987 (33). A subsequent study limited to pleural mesothelioma detected 5 cases vs 0.15 expected (38). The quarry produced chrysotile (up to 100.000 tons per year), which was contaminated (0.2-0.5% by weight) with balangeroite (a fibrous magnesium-iron silicate first discovered at Balangero, morphologically similar to amphiboles). Workers in South Carolina were exposed to chrysotile originating from Quebec, subsequently processed and treated with mineral oil to suppress dust, which might have contributed to the production of lung cancer. For this reason, separate pooled risk estimates for lung cancer according to whether the Charleston cohorts are included or excluded from the analysis were produced by Hodgson and Darnton (who believe that exposure conditions comparable to those of the Charleston cohorts are to be considered "exceptional"). Estimates are summarized in table 3.

Hodgson and Darnton point out that all estimates are to be considered with caution because of a number of statistical and other uncertainties. They suggest a non-linear relationship for both mesothelioma and lung cancer and estimate that the risk for lung cancer is proportional to a 1.3 power of the exposure: this means that risks increase more steeply than exposure as exposure rises

Table 2 - *Cohort studies of chrysotile asbestos (from (18), simplified)*

	Balangero Mining	Quebec Mining	New Orleans Plant 2 Cement	Connecticut Friction	South Carolina Men Textile	South Carolina Women Textile
Pleural mesothelioma	2	33	0	0	1	0
Peritoneal mesothelioma	0	0	-	-	1	-
Total expected mortality	225.4	5912.7	397.1	550.7	410.1	299.2
Average cumulative exposure f/ml/y	300	600	22	46	28	26
Mesothelioma risk (*)	0.003	0.001	0.000	0.00	0.013	0.000
Lung cancer deaths observed/expected	19/17.3	587/431.6	42/32.4	49/35.8	74/32.2	38/13.8
Lung cancer risk (**)	0.03	0.06	1.3	0.8	4.6	6.7
95% CI	<0-0.24	0.04-0.08	<0-3.4	0.03-1.80	2.9-6.7	3.6-11.0

* percentage of total expected mortality per f/ml/year, adjusted for age at first exposure
** percentage of expected lung cancer risk per f/ml/year

Table 3 - *Summary estimates of asbestos-induced mesothelioma risk and excess lung cancer risk, different levels of cumulative exposure (in brackets lowest and highest arguable estimate). From reference 18, simplified*

Cumulative exposure (f/ml/ years)		Deaths from mesothelioma x 100,000 exposed	Excess deaths from lung cancer x 100,000 exposed
10	Crocidolite	4000 (2000-8000)	1500 (1000-2500)
	Amosite	650 (300-1300)	NA
	Chrysotile	20 (6-60)\	(a) 50 (up to 300) (b) 1000
1	Crocidolite	650 (250-1500)	85 (20-250)
	Amosite	90 (15-300)	NA
	Chrysotile	5 (1-20)	(a) 2 (up to 30) (b) 100
0.1	Crocidolite	100 (25-300)	4 (<1 – 25)
	Amosite	15 (2-80)	NA
	Chrysotile	Negligible (0-4)	(a) Negligible (0-3) (b) 10

and that extrapolation to low doses using these models gives lower risks than the traditional linear models. On the other hand, at least for lung cancer, it has been suggested that the dose-response line may be steeper at low exposure than at high exposure (16). As for the practical implications of Hodgson and Darnton's estimates (table 3), it is to be noted that a cumulative concentration to 1 f/ml/year corresponds to a 10 year exposure to 0.1 f/ml, which is the current permissible exposure limit in the United States. With these exposure conditions, and even assuming that the South Carolina cohort is not representative of all workplace exposures to chrysotile, the number of cancer cases caused by asbestos would be far from negligible.

IS THE ROLE OF ASBESTOS SURPASSED BY THE ROLE OF GENETIC SUSCEPTIBILITY IN THE CAUSATION OF MESOTHELIOMA?

Most scientists would agree that the reply to this question is definitely negative. However, some terms used in the scientific literature may create confusion. For example, a "peculiar" role of susceptibility has been claimed on the basis of the fact that, even following strong exposures, "only" 10% of exposed subjects develop mesothelioma (8). As a matter of fact, and leaving apart the issue of competitive mortality in occupationally exposed asbestos cohorts, this proportion is not much different from the proportion of smokers developing lung cancer, about which no claims of a predominance of genetic factors would be considered seriously.

Undoubtedly, individual susceptibility is highlighted by the occurrence of mesothelioma in subjects who have experienced only short exposures and/or have been exposed to asbestos pollution of industrial origin in the general environment, which in most instances has not been measured, but is likely to be orders of magnitude smaller than concentrations in traditional work environments. Nevertheless, no reliable indicator of susceptibility is available and no study allows for firm estimates of attributable risks, i.e. the number or proportion of cases which would not have occurred in the absence of the indicator of susceptibility. On the other hand, any attributable risk should be viewed from the very well known perspective that when more factors interact in causing a disease, the sum of the proportional risks attributable to each exceeds 100%. Above all, no study has provided evidence that the "less risky" genotypes or phenotypes are fully protected from asbestos carcinogenicity. For the time being, the potential of studies on the genetics of mesothelioma for the implementation "of new methodologies of primary and secondary prevention" (34) can hardly be envisaged.

Over the last years, the number of investigations on the genetics of asbestos-induced cancer has markedly increased, particularly with regard to pleural cancer and mesothelioma. Entering Medline with the key words "susceptibility", "asbestos" and "mesothelioma" provides (at the end of February 2006) 37 citations, 23 of which have been published since 2001 (the corresponding proportion for "lung cancer" is 14 out of 42).

In industrialized countries, clusters in families represent a tiny proportion of all cases of pleural mesotheliomas. Most, but not all, cases which have been reported can be attributed to previous exposure to asbestos shared by the affected members. The conjecture of a genetic component in the origin of clusters in which no environmental exposure to asbestos could be traced is reasonable. The hypothesis of an autosomal dominant inheritance pattern has been raised (1). A major contribution in this direction has been given by the analysis of a six-generation extended pedigree of 526 individuals with mesothelioma in the area of Cappadocia where a high incidence of mesothelioma consequent to exposure to naturally occurring erionite has been known for decades (35). The credibility of this study has been questioned on methodological grounds. In particular, the proportion of deaths from mesothelioma within the nuclear families with the disease did not differ from what would be expected without genetic clustering, and the occurrence of mesothelioma during the reproductive age speaks against the permanence of a hypothetical autosomal and lethal gene (36).

Endogenous co-factors interacting with asbestos exposure have also been investigated with a molecular epidemiology approach. In one study, genetic instability (expressed by the number of micronuclei in peripheral blood lymphocytes) was found to be more common among mesothelioma patients than in controls (4), but this finding was not confirmed in a subsequent study carried out in the same institution (31).

A number of genotypes have been investigated for their possible roles as modifying factors in the association between asbestos exposure and pleural malignant mesothelioma. More than 10 years ago, Hirvonen et al reported an increased risk in subjects occupationally exposed to asbestos and carrying a homozygous deletion of the *GSTM1* gene or the *NAT2* slow acetylator genotype (17). A subsequent study (31) failed to observe the former association, whereas it found an increased risk for *NAT2* fast acetylators. The latter study also reported an association of mesothelioma with microsomal Epoxide Hydrolase (mEH), which interacts with both *NAT2* and *GSTM1* genes according to a multiplicative model. The postulated role of gene polymorphisms leading to defective DNA repair was examined in a very recent case-control study based on the hypothesis that imperfect repair, as revealed by subtle polymorphic variants, could reduce protection against the insult to DNA provoked by asbestos. The study was addressed to 7 single nucleotide polymorphisms (SNPs) for genes *XRCC1*, *XRCC3*, *XPD*, and *OGGI*. SNPs were chosen because it is known they have an effect on the transcript (aminoacid substitution or possible splice defect). Statistically significant odds ratios of 2.1 were found for the variant XRCC1-399Q (Q homozygotes + Q/R heterozygotes vs R homozygotes) and 4.1 for the variant *XRCC3*-241T (T homozygotes +M/T heterozygotes vs M homozygotes) (11).

As for a possible interaction between asbestos and genetic susceptibility in determining individual lung cancer risk, a pooled analysis of 5 studies on the role of *GSTM1* and 3 studies on *GSTT1* polymorphisms failed to suggest that lung cancer asbestos risk differs according to GSTM1 genotype, whereas no conclusion could be drawn for GSTT1 genotypes because of limited statistical power (39). More recently, the GMO genotype has been postulated to interact with asbestos carcinogenicity for the lung. MPO is known to activate procarcinogens such as benzo[a]pyrene (findings are reviewed in reference 16).

In conclusion, studies on the modifying effect of genetic factors in asbestos carcinogenesis have the potential to clarify action mechanisms but, as yet, this has not been achieved (and is not necessary for implementing the traditional measure of preventing exposure). So far, findings on the associations which have been postulated are either preliminary (i.e. require confirmation from studies carried out independently) or contradictory. Their relevance in terms of public health is limited.

How convincing is the interaction between SV40 and asbestos in the pathogenesis of mesothelioma?

For the time being, the evidence of a contributory causal role of SV40 in the development of asbestos-related mesothelioma is suggestive but remains unproven. This opinion is shared by others (16).

Polyoma virus SV40 is known to cause cancer in animal models. In many countries it contaminated polio vaccines from 1955-63. Over the last 10 years, several reports have described the presence of the virus in tissue samples of a sizable proportion of mesothelioma cases, as well as in a variety of other human tumors. Vilchez et al (43) carried out a pooled analysis of 15 case-control studies in which the proportion of tissues positive for SV40 in mesothelioma cases was compared to the corresponding proportion in control tissues. The pooled analysis – on a total of 528 mesothelioma specimens and 468 control samples – estimated an odds ratio of 17.9 (95% CI 10 to 28). Among cases, 262 (49%) samples were reported to be positive. Methodological concerns have been expressed about the pooled analysis (28). None of the studies was population-based and criteria for the selection of control samples is not fully clear. The proportion of cases of mesothelioma reporting previous exposure to asbestos is not given. Among the mesothelioma series included as cases, the proportion of "positive" samples ranged between 0 and 100%. Reports of SV 40 in mesothelioma tissue have been questioned also because some of the primers used for detecting the virus DNA included nucleotide sequency which is also present in commonly used laboratory plasmids (24). In spite of these concerns, the strength of the association (a relative risk of 17) is impressive. It should be confirmed on the basis of properly designed case-control studies (the most appropriate design, given the rarity of mesotheliomas) using validated methods to assess the exposure. Even assuming that some mesotheliomas derive from the interaction of SV40 with asbestos, this would not be the case in a conspicuous proportion of cases.

What is the public health relevance of mesothelioma produced by non occupational exposure to asbestos?

It has long been known that non occupational exposure to asbestos entails an increased risk of mesothelioma, both in individuals living with asbestos workers and in those living near asbestos mines, mills and factories manufacturing asbestos products. Some major episodes are mentioned below. Compared to other environmental exposures and to other outcomes, ascertainment of mesothelioma occurrence consequent to non occupational exposure to asbestos is facilitated by the high specificity of the association.

Although in most episodes objective measures of the atmospheric concentration of asbestos exposure have been lacking or limited, it is reasonable to assume that they were lower than those which in the past were encountered in the workplace. A major exception is the dramatic outbreak of mesothelioma in the general population who lived around the crocidolite mine in Wittenoom, Western Australia, where estimates are reliable and indicate past, cumulative exposures for the general population of several ff/ml/y (15).

In general, reports of mesothelioma in asbestos polluted areas of people who were not exposed in the workplace suggests that these people were particularly susceptible to asbestos-caused mesothelioma, but they also raise doubts about the existence of any threshold below which 100% of the exposed population is protected from the effects of asbestos. The message for public health authorities is clear and highlights the need for a ban, including chrysotile, given that some outbreaks of mesothelioma induced by environmental (non occupational) exposure occurred in the vicinity of the Canadian chrysotile mines.

Studies published before 2000 were the object of a review and meta-analysis (51). In most studies, exposure was to crocidolite, but this was not the case for 7 women residing in two chrysotile areas in Quebec, corresponding to a relative risk of 7.6 (6). A previous study in the same area had ascertained 8 cases of mesothelioma consequent to household exposure to dusty clothing (5). In the area of Casale Monferrato, NW Italy, where an asbestos cement factory was active between 1907 and 1985 (and residual products were used in buildings), in recent years the incidence of pleural mesothelioma has been about ten times higher than in neighbouring industrial areas: approximately half the cases occur in persons who had not had opportunities for occupational exposure to asbestos (29). A formal mortality cohort epidemiological study of wives of asbestos cement workers in the same area identified 4 deaths from pleural mesothelioma occurring from 1965-88 vs 0.4 expected, in addition to two incident cases (27).

In Wittenoom, out of a cohort of 4659 former workers who had not been engaged in work related to crocidolite extraction, 27 cases of mesothelioma were identified, corresponding to an annual age-standardized incidence rate of 26 x 100.000 (five times higher than in the general Australian population), with no difference between the two genders. Estimated cumulative exposure exceeded 7 f/ml/years in 20/27 cases and 1058/4481 persons with no mesothelioma. Cases have arisen in subjects whose exposure was as short as 2 months and estimated cumulative exposures as low as 0.5 f/ml (15).

Areas whose population exhibits an excess of mesotheliomas attributable to the natural occurrence of asbestos have been described in different parts of the world, such as New Caledonia because of the presence of tremolite in local outcroppings used as whitewash (25) and the rural county of Dayao in SW China because of the natural presence of crocidolite in the surface soil (26). Recognition of carcinogenicity for the pleura of some asbestiform fibers, such as erionite or fluoro-edenite, was triggered by epidemiological observations, respectively in Capadocia and in Biancavilla, Sicily. Unfortunately, in most of these circumstances estimates of the atmospheric concentration of fibers are lacking: it is likely to have been much lower than in the occupational settings, but this is far from demonstrated. A recent study in California confirmed the association between residential proximity to naturally occurring asbestos and mesothelioma risk and estimated that the odds for mesothelioma decreased approximately 6% for every 10 km farther from the nearest asbestos source, thus being far from negligible even at a long distance from the source (32).

Other effects of asbestos exposure in the general environment, if any, are more difficult to be picked up by epidemiological or clinical studies. However, a recent ecological study has detected an excess of deaths from chronic obstructive pulmonary disease after exposure to fluoro-edenite, a newly discovered naturally occurring amphibolic fiber, already known to cause pleural mesothelioma (3).

Is the proposal for a "Controlled use of asbestos" realistic?

Measures underlying the term have been described by the Canadian delegation at the World Trade Organization introducing asbestos case in 1999-2000 (7). The proposal is addressed to high density products only (according to Canada's senior attorney, asbestos textiles are not manufactured anywhere). The proposal implies that all distributors/manufacturers of asbestos be required to have an import permit and that they will distribute their products only to licensed companies whose workers have been properly trained and licensed. These companies are committed to providing a list of users to the responsible government agency and will police downstream users in cooperation with governments. The manufacturer will provide products cut to specification by properly trained and licensed persons and will police downstream users in cooperation with the government.

The scientific literature does not report any study intended to assess the feasibility of these measures, particularly in developing countries where the consumption of asbestos is highest (table 1). Neither, in those countries, has the potential efficiency of any network intended to control the uses of asbestos been verified. Even in the United States, in the mid 90s, OSHA issued more than 1000 annual citations for violations of the 1994 OSHA asbestos standard, which partly overlaps with the proposal for a "controlled use of asbestos" (7).

Conclusions

At present, asbestos extraction and manufacture is restricted to developing countries. The consequences of occupational and environmental exposure to asbestos in those countries have been investigated to a very limited extent. A quick look at Medline is sufficient to realize that the amount of epidemiological studies intended to measure the consequences of occupational and environmental exposure to asbestos has varied among countries over a wide range and that it does not correspond to the amount of asbestos consumed. Consequences can be predicted through the extrapolation of findings in the traditionally industrialized countries. If current uses continue in the future, and only limited measures of primary prevention are implemented, consequences on the health of workers exposed in the workplace and of populations exposed to a polluted general environment will be dramatic.

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From clinical activities to didactics and research in Occupational Medicine

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Key words
Etiological diagnosis; occupational diseases; health surveillance; fitness for work

Summary
Background: *The daily practice of Occupational Physicians in the mot industrialized countries suggests that the frequency of traditional occupational diseases is progressively lowering, their gravity is decreasing, and the etiological factors are changing. This trend should be quantitatively and qualitatively verified with ad hoc studies. The information is particularly relevant for Academic Institutions where medical students and residents in occupational medicine are trained.* **Objectives:** *To analyse the trends of clinical diagnoses and health surveillance activities conducted in the last 15 years by an Italian Institute of Occupational Health, and to gain information on the most relevant topics to be taught in academic program and to be addressed with future research.* **Methods:** *Data sources were represented by the computerised registration of a) diagnostic activities and b) health surveillance programs, conducted by the Institute of Occupational Medicine of the University of Brescia, a highly industrialized area in Northern Italy. The observation period was from 1990 to 2005. The health surveillance programs regarded workers pulled from an iron foundry, a veterinary institute, a health departments for the assistance of elderly subjects, a nursery schools and a municipal department for road maintenance.* **Results:** *Diagnostic activities were conducted on 9080 subjects, who had been referred for suspected occupational disease. The diagnosis of occupational disease was confirmed for 3759 cases. Multiple diseases were diagnosed in 1554 subjects, yielding the total number of 5721 occupational diseases. The most frequent diagnoses accounted for allergic skin disease (23.4%), followed by pneumoconiosis (20.4%), chronic obstructive pulmonary disease (15.9%), noise hearing loss (7.1%), musculoskeletal disorders (6.9%), respiratory allergies (6.9%), cancer (5.9%), miscellaneous (6.4%). When limited to the last quinquennium, the analysis showed a definite increase of muskuloskeltal disorders, cancer, and, although at a lesser extent, diseases due to psychosocial factors. The analysis of the health surveillance programs regarded 1207 workers, and showed that various non occupational diseases caused limitation to individual work fitness. The most frequent conditions were musculoskeletal disorders (65%) and skin diseases (14%).* **Conclusions:** *The results from these two investigations are important not only for the didactic program run by the Institute, but also because they indicate the most relevant topics to be addressed with future research, at least at a local level.*

Riassunto
«Dalle attività cliniche di Medicina del Lavoro alla didattica e alla ricerca». **Introduzione:** *la pratica quotidiana suggerisce che il numero delle malattie del lavoro tradizionali è in progressivo decremento, che la loro gravità si sta riducendo e che i fattori etiologici stanno cambiando. Queste informazioni sono particolarmente importanti*

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per quegli Istituti che sono coinvolti nella didattica per gli studenti di medicina e per gli specializzandi in medicina del lavoro. **Obiettivi:** *Evidenziare l'andamento delle diagnosi cliniche e dei programmi di sorveglianza sanitaria condotti negli ultimi 15 anni da un Istituto italiano di Medicina del Lavoro, allo scopo di individuare gli aspetti più rilevanti ai fini dei programmi didattici e delle future linee di ricerca.* **Metodi:** *La sorgente dei dati era rappresentata dagli archivi informatizzati riguardanti a) le attività diagnostiche e b) i programmi di sorveglianza sanitaria, condotti dall'Istituto di Medicina del Lavoro dell'Università di Brescia che opera in un territorio altamente industrializzato. Il periodo di osservazione considerato era dal 1990 al 2005. I programmi di sorveglianza sanitaria riguardarono lavoratori impiegati in una fonderia di ferro, in un istituto veterinario, nell'assistenza anziani, in un asilo e nella manutenzione delle strade provinciali.* **Risultati:** *Le attività diagnostiche furono svolte su 9080 soggetti, inviati per sospetta patologia occupazionale. La diagnosi di malattia da lavoro venne confermata per 3759 casi. Diagnosi multiple vennero formulate per 1554 soggetti, producendo un numero totale di 5721 malattie da lavoro. Le diagnosi più frequenti sono risultate a carico di dermatiti allergiche (23,4%), pneumoconiosi 20,4%), broncopneumopatie croniche ostruttive (15.9%), ipoacusie da rumore (7,1%), malattie muscoloscheletriche (6,9%), allergie respiratorie (6,9%) tumori (5,9%), ed altre (6,4%). I dati limitati all'osservazione dell'ultimo quinquennio evidenziano invece un netto aumento di malattie muscolo-schletriche, tumori e, sebbene di entità minore, di malattie da fattori psicosociali. L'analisi dei programmi di sorveglianza sanitaria condotti su 1207 lavoratori, ha indicato che diverse patologie di origine non occupazionale possono limitare le idoneità lavorative. In particolare, le malattie muscoloscheletriche (65%) e le patologie della cute (14%).* **Conclusioni:** *I risultati delle due indagini suggeriscono che questi dati possono essere usati, oltre che per identificare temi di didattica, anche per verificare quali argomenti sono meritevoli di essere sviluppati dalla ricerca.*

Introduction

"Industries multiply, change, renew themselves": Luigi Devoto, the founder of the Clinica del Lavoro, synthesizes in this sentence (written in 1901 in the introduction of the new journal "Il lavoro – Work") several essential concepts that still influence the workers' health (6). In this sentence he identifies the growing industrialization, and therefore the spread of occupational risks, and the continuous transformation and renovation of technological processes, with the consequent changes in occupational risks and diseases. In this dynamic context, the Occupational Physician (OP) must stay abreast of changes occurring both in the medical field and in the industrial technology and working conditions.

Among the OP's activities, two are particularly important: a) those aimed to define the existence of occupational diseases, in other words those aimed to the etiological diagnosis; b) those aimed to the prevention of health effects in workers exposed to homogeneous risks through the health surveillance (HS); in other words, activities aimed to identify susceptible individuals. Whereas the definition of etiological diagnosis can be considered a true clinical activity, the identification of hyper susceptibility is definitely a preventive activity.

The etiological diagnosis

Etiological diagnosis is of utmost importance for the following reasons: the population exposed to various occupational risks represents a high percentage of the adult population - almost all biological organs and systems can be damaged by occupational exposures - occupations causing exposure to various physical, chemical, biological, ergonomical or psychosocial risks are numerous (5). In addition, the correct definition of the etiological factors offers several advantages at the individual level:

– the use of specific treatments (e.g., chelation therapy for metal poisoning, surgical treatment for cumulative trauma disorders), or the use of treatments that can be more effective only after the removal from exposure (e.g., anti-asthmatic drugs in occupational asthma);

– the removal from exposure that may lead to a complete recovery (e.g., of occupational dermatitis);

– early rehabilitation treatment that may interrupt the progression of the diseases (e.g. of musculoskeletal disorders);

– the recognition of a commensurate compensation.

A correct etiological diagnosis has also important advantages at a group level:

– the identification of “sentry events”, that leads to the identification of other workers at risk and/or of the other cases of occupational disease;

– the anedoctal evidence that suggests to hypothesis about the relation between work and disease (e.g., adverse reactions following exposure to new substances).

The procedure leading to the etiological diagnosis may be conditioned by various difficulties:

– occupational diseases show generally very long periods of latency;

– occupational risk factors change in time due to technological innovations, and this causes a reduction of traditional risks and the onset of “unexpected” new risks;

– the clinical picture of various occupational diseases has lost its specificity and may overlap with other non occupational diseases commonly observed in the general population;

– occupational risks may be either causal factors of a disease or contributing factors, and diseases with a multi-factorial origin are gradually increasing: e.g., health effects due to combined chemical exposure, muskuloskeletal diseases, and health alterations related to the work organisation.

Health surveillance and evaluations of fitness for work

Besides the etiological diagnosis, the OP’s activities entail also health surveillance. This includes pre-employment and periodic medical examinations of workers in order to protect their health from the exposure of several risk factors. HS leads to the evaluation of individual fitness for work (FW).

HS aims at the early identification of any health effect. Therefore, the OP must consider the functionality of the various target organs, and also all possible health changes caused or aggravated by the work activity. In addition, each alteration of the wellbeing and health may also interfere with the normal execution of job tasks.

The evaluation of the FW is the final step of both HS and risk assessment. The main goals of health surveillance are the protection of the physical and psychological health of the subjects at work, taking into account their professionalism, and the reduction of conflicts and absenteeism (1, 4).

HS enables the OP also to address two additional problems:

– the identification of working conditions that are risk-free for the majority of workers but can be harmful for susceptible workers (e.g. G6PDH deficiency, or slow acetylators more at risk for bladder cancer);

– the workers follow-up may show that working conditions previously considered as safe, are then recognized as toxic and harmful (e.g. lead and reproductive disorders, silica and cancer).

Trends in Occupational Medicine

To answer the questions about the clinical activities to be carried out by OP, it may be appropriate to evaluate the current trends of occupational diseases. This information is particularly useful for those Institutes involved in didactic activities for post-graduates students specializing in Occupational Medicine (OM) and for undergraduates students in the Medical Schools. These students must learn to suspect the possible existence of occupational diseases and ask the patients “quam artem exerceas?” (“what is your job?”), as Bernardino Ramazzini suggested in his book *De Morbis Artificum Diatriba* at the end of the XVII century.

Different methods are available to identify the new trends of OM in the diagnostic field, didactics and research:

– the examination of specific reviews on the research needs in the fields of occupational epidemiology and, more generally, of OM (2, 11);

– Delphi studies, similar to the valuable paper published by Harrington in 1994 (8) that reports the results of 25 interviews to senior OM practitioners who worked in Universities, and 28 OM practitioners working for industries or governmental institutions, who were asked to declare their research priorities. This method has been subsequently applied in many countries, including Italy (9, 10);

– other less structured studies based on the collection of clinical experiences (3).

METHODS AND SUBJECTS

In this study we have considered two main topics: the formulation of etiological diagnoses, and HS with the consequent evaluation of FW.

We examined these issues from the point of view of an academic Institute of OM, which operates in a large teaching hospital located in a highly industrialized area of Northern Italy with 1.108.000 of inhabitants and 479.000 (43%) subjects involved in various working activities. The Institute's main tasks include: teaching, research and clinical assistance, three tasks which are closely related.

Etiological diagnoses

Data were obtained from the computerized database of the Institute of Occupational Medicine of Brescia, where individual cases were registered. The following variables were considered for each case: diagnostic code of entry, final diagnostic code, referring subjects/stakeholders, e.g. company doctors, general practitioners (GP), the Italian Work Compensation Institute, and Health Inspectors from the Local Public Health. The observation period was 1990-2005.

Starting from the evaluation of the clinical activities performed during the last 15 years, we tried to identify the main topics that deserve particular attention for the teaching programs of post-graduate students specializing in OM and undergraduate medical students. To assess the trend over time, the total observation period was also grouped in three shorter periods of five years each: 1990-1995, 1996-2000, 2001-05.

Health surveillance

In order to apply didactics to practice, the Institute carries out also preventive activities in various public and private institutions, by monitoring about 6.500 workers. In particular, HS and the evaluation of the fitness for work of these subjects are regularly performed.

The results of some of the HS programs conducted by the Institute were considered to identify the diseases that although not necessarily work-related, are particularly frequent in the working population. These diseases must be carefully evaluated by specialist different from OP, but they must be familiar also to post-doctoral students specializing in OM. In fact, these clinical conditions are important for a proper evaluation of FW. The various diagnoses and the evaluations of FW were related to 1207 workers employed in four different work environments: a) an iron foundry (165 workers), b) a veterinary institute for research and treatment of domestic animals (388 workers), c) health departments for the assistance of elderly subjects and nursery schools (533 workers), d) a municipal department for the maintenance of the provincial roads (121 workers). The data on HS include the first medical examination by the OP who closely cooperate with our Institute. They were elaborated using the computerized database of the four sources, considering the coded variables of individual diagnosis and FW.

RESULTS AND DISCUSSION

The diagnostic experience

A total number of 9080 subjects were examined for suspected occupational diseases. They had been referred by company doctors, GPs, the Work Compensation Institute or Inspectors of Local Public Health Units. Moreover, since the Institute is located within a large regional hospital, patients hospitalized in other departments, such as pneumology, dermatology, nephrology, and infectious diseases, were examined by the Institute when there was a suspect of an occupational disease (figure 1).

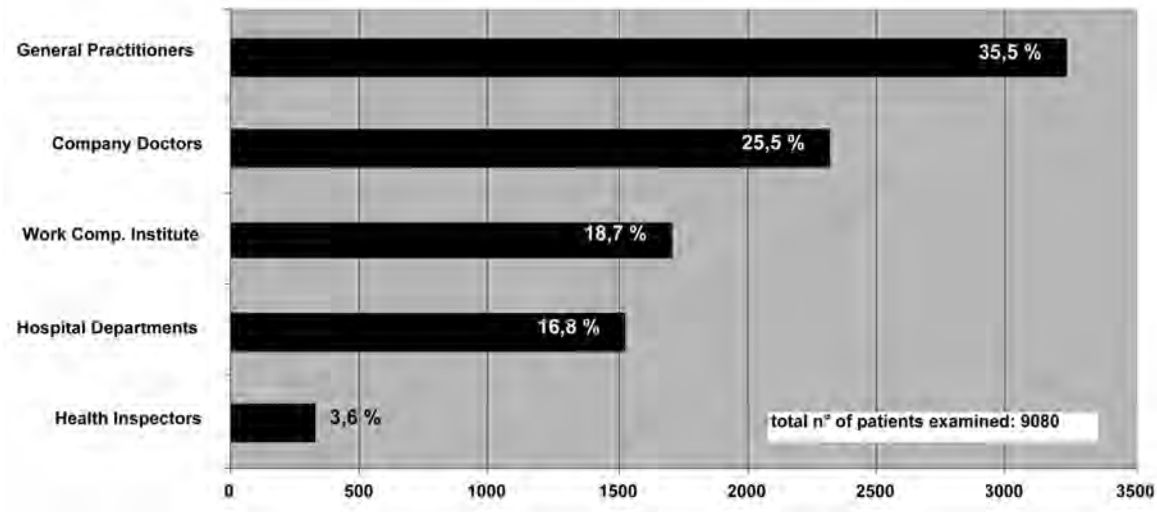

Figure 1 - Referring subjects who have sent to the Institute of Occupational Medicine subjects with a suspect of an occupational diseases (1990-2005)

This close collaboration was the result of an intense informative effort toward the specialists of different hospital departments, on the aspect related OM and occupational diseases.

The main results of this study were the following: in 3759 subjects (41.4%) one or more Occupational diseases (ODs) were diagnosed, yielding a total number of 5721 ODs. The distribution of the diagnoses shows that the most frequent diseases were: skin and respiratory allergies, pneumoconiosis, chronic obstructive pulmonary diseases, noise hearing loss, irritant contact dermatitis, musculoskeletal disorders, cancer (figure 2).

The percentage distribution of the diagnoses in the three quinquennia is reported in figure 3.

The lack of homogeneity among the different ODs in the three quinquennia can probably be explained by the fact that in the first quinquennium the classical ODs were more frequent because the various traditional risk factors were still relevant in the workplaces. Furthermore, these classical risk factors had not been previously recognized due to the absence of an Institute of OM in the Brescian territory. In the second quinquennium, the number of traditional diseases decreased while allergic and irritant skin and respiratory diseases increased significantly. Cancer and musculoskeletal disorders (MSDs) show a definitive trend to a higher frequency. In the last quinquennium, the type and distribution of diagnoses of the patients referred to our Institute changed again and further increase in cancer and MSDs was observed. Diseases due to the exposure to phsychosocial factors started to be recognized in this period, and allow they represent a minor percentage, they appear to represent another increasing tendency.

These preliminary data suggest a few considerations:

– the cases examined in the observation period likely reflect the distribution of ODs in the Brescian area, since the Institute has been the only department of OM in the province;

– the traditional ODs are still quite frequent in this highly industrialized territory, that is located in one of the most advanced countries in occupational prevention;

– it is difficult to maintain that the changes observed in the 3 quinquennia reflect faithfully the evolution of ODs, since they might be influenced by many variables, such as intercurrent enforcement activities, availability of scientific knowledge and information on emerging disease (e.g. low back

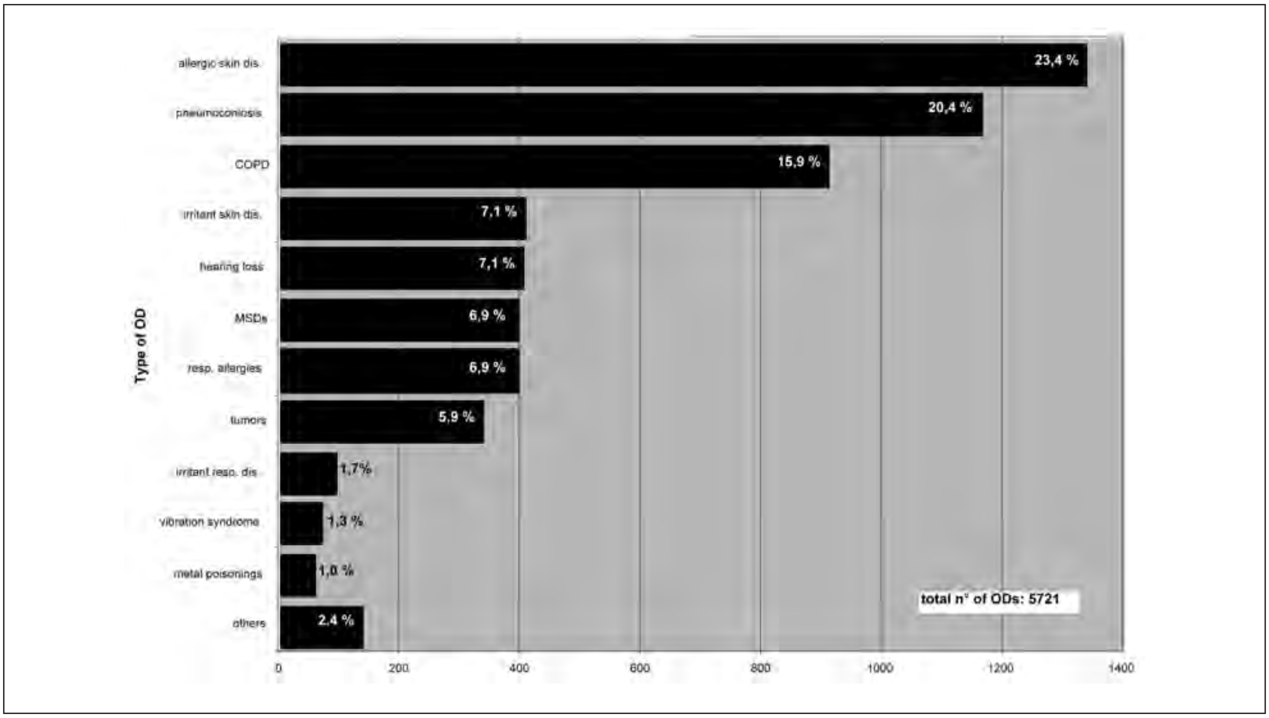

Figure 2 - Distribution of the occupational diseases diagnosed in the period 1990-2005

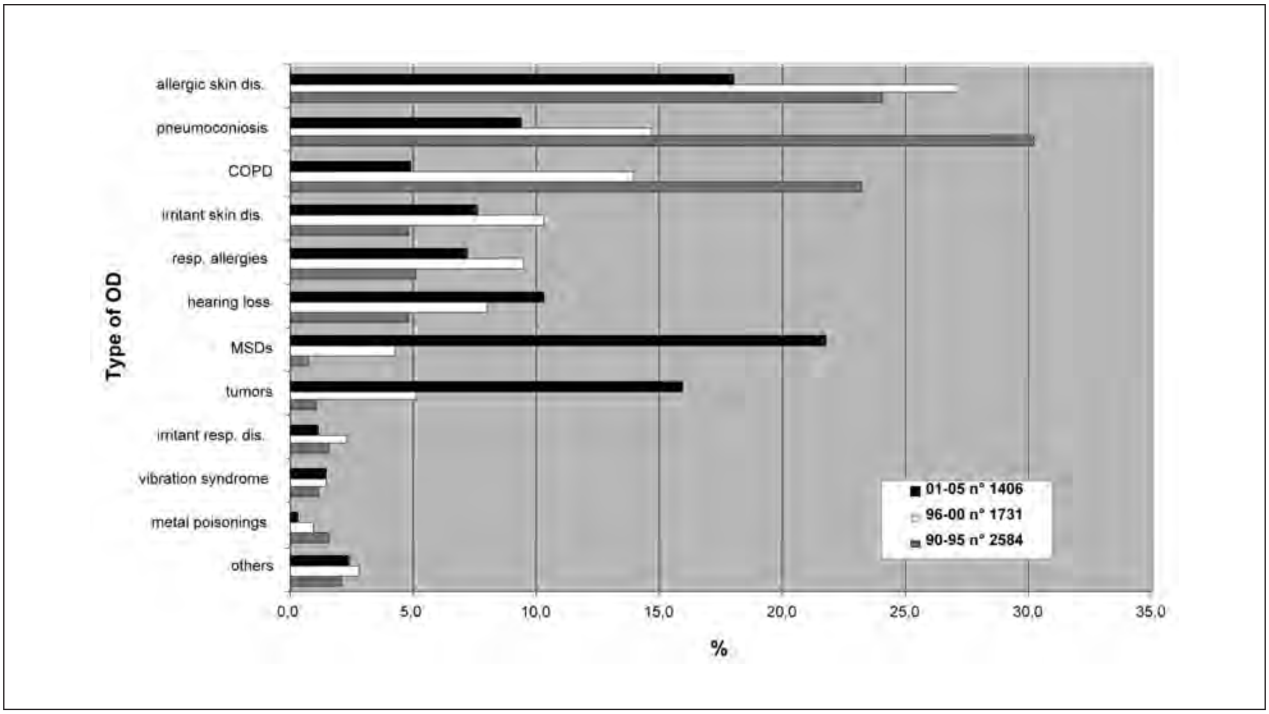

Figure 3 - Percentage distribution of the occupational diseases diagnosed in the three quinquennia

Table 1 - *Evaluation of fitness for work in 1207 workers under health surveillance*

Industry	Full fitness (n= 820)		No fitness (n= 22)		Restricted fitness (n= 365)					
	N.	%	N.	%	N.	%	Occupational diseases		Non Occupational diseases	
Iron	127	77	0	0	38	23	Skin	4	MSDs	17
Foundry							Injuries	1	Eyes	6
									Skin	5
									Others	5
Elderly	319	59	22	6	192	35	MSDs	18	MSDs	143
subjects			MSDs 14				Skin	2	Skin	9
assistance			Psychiatric 6						Allergies	5
and nurseries			diseases						Psychiatric diseases	2
			Others 2						Others	13
Veterinary	316	81	0	0	72	19	Allergies	5	Skin	30
Institute							Skin	1	MSDs	21
for research									Resp. diseases	10
									Others	5
Road	58	48	0	0	63	52	Vibration syndrome	12	MSDs	23
maintenance							Injures	5	Hand-vasc. diseases	11
							MSDs	3	Cardiovasc. diseases	2
							Skin	1	Others	6

pain, carpal tunnel syndrome), an increased awareness among GPs, workers and their representatives;

– these results undoubtedly show what must be taught in our territory both to young doctors in the School of Specialization in Occupational Medicine and to the medical students.

The experience on Health Surveillance

The number of cases for which, after evaluation of FW, it was necessary to state specific limitations for the job task is reported in table 1.

Although the type of job is quite different in the four workplaces, the main causes of restricted FW are due to non-occupational diseases (86%), with the exception of the workers involved in the roads maintenance (table 2).

This preliminary analysis of the four workplaces examined shows that the most common situations emerging form the HS programs are related to MSDs and skin diseases followed by COPD, hand-vascular disorders, allergies and cardiovascular diseases. In the near future, additional data from other workplaces followed by our Institute will be available. Therefore, a more precise definition will

Table 2 - *Causes of restricted fitness for work (365 workers)*

	Diseases	N.%
Occupational diseases (n. 52=14%)		
MSDs	21	40
Vibration syndrome	12	24
Skin	8	15
Injures	6	11.5
Allergies	5	9.5
Non occupational diseases (n. 313=86%)		
MSDs	204	65
Skin	44	14
Hand-vascular disorders	11	3.5
COPD	11	3.5
Allergies	6	2
Heart and vessels	6	2
Eyes	6	2
Others	25	8

be possible of those topics that are not related to occupational diseases, but require a knowledge and competence by the OPs similar to that of the GPs. This result should be obtained with a much greater number of subjects, employed in a variety of different settings, including a great general hospital, a dry-battery factory, a lead shot plant and a metal-mechanical industry.

Research needs

The preliminary results of the two evaluations made by our Institute show that the method used may be useful to identify which didactic is necessary in OM and in the meantime they may be useful to obtain appropriate suggestions for the clinical and preventive organization.

As far as research is concerned, only the results related to the evaluations of the etiological diagnoses might be relevant, provided that the diagnostic procedures take into account the criteria of evidence based medicine (EBM) (7).

On the other hand the results of HS and the consequent evaluation of cases with a restricted FW (which apply to a low number of cases) probably deserve an anedoctical approach, e.g. observing in the follow up if the evaluation was appropriate. This conclusion will be verified in the near future, when the evaluations of the entire case list of 6.500 workers will be completed.

Regarding the research on etiological diagnoses, it will be interesting to evaluate the behaviour of the ODs according to various variables, such as gender, age, length of exposure. Moreover, it will be useful to verify in the three quinquennia the following aspects: a) the possible changes regarding the referring stakeholders, b) the variations of requests from the referring stakeholders (e.g. the increased number of occupational tumors in the last quinquennium was probably determined by the fact that we started to examine the patients from the other department of our hospital only in 2000), c) the degree of concordance between requests and final diagnosis.

Since our data originate form a unique territory, they might merely represent this specific local situation and may not be representative of a larger working population. However, these results suggest that multicentric research should be done in Italy in the near future, using standardized models for the formulation of etiological diagnoses. This seems to be possible in the Lombardy region, where since the 1980's a network of 11 departments of OM, located in the large regional hospitals, has been constituted. The consequent extension of this research to a wider territory should enable a more accurately view of ODs today.

These results should also give suggestions for research activities to be programmed, and the Regional Health Authorities may decide to allocate financial resources based on a more precise picture. The results will yield a more rational use of the available funding.

This type of studies presents a limitation consequent to the high latency time of ODs, which, can be very long especially for cancer. Therefore past exposures, that are generally higher than the current ones, may be the true cause of some of the diseases.

The results of the Delphi studies should be taken into account when programming future research, because they identify the priorities by asking directly the experts opinions. Nevertheless, this type of investigation could not be objective because it largely depends on which respondents were selected. (8)

Maybe the best way to identify the most important topics for future research in OM, should be to consider the results of objectives studies like ours, in addition to the Delphi studies which can take into account the opinions of experts with various backgrounds.

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Acknowledgement: *We would like to acknowledge Angela Carta, M.D. and Luca Belleri, M.D. for their collaboration*

La Medicina del Lavoro Med Lav 2006; *97*, 2: 402-403

Emerging opportunities to prevent occupational lung disease

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Key words
Occupational lung disease; prevention

Summary
In the last decade, newly recognized causes of occupational lung disease include food flavorings, synthetic flock, biocontaminants in metalworking fluid, a chemical in pesticide manufacture, severe acute respiratory syndrome, and avian influenza. In addition, previously recognized associations of lung disease with damp residential environments are now being extended to nonindustrial occupational settings, such as offices and schools. On the horizon are efforts to understand the occupational determinants of chronic obstructive lung disease, only 80% of which is attributable to cigarette smoking. In addition, work is beginning on the substantial burden of work-exacerbated asthma in those workers whose asthma pre-dated their workplace exposures. Recognition of emerging work-related lung diseases depends on understanding that occupational exposure standards are often nonexistent, inadequate, or not enforced. Workers, astute clinicians, and public health surveillance are the reservoirs from which new questions of risk arise. The tool to describe new associations of lung disease with occupational settings is epidemiologic investigation, supplemented by toxicology and laboratory investigations of biologic plausibility, as appropriate. Thus, enhanced communication among workers, other health professionals, and agencies with epidemiologic skills, laboratory capability, and access to workplaces is critical to pursuit of novel opportunities to prevent occupational lung disease. Occupational safety and health professionals can advise risk-based management of controls and preventive measures for emerging lung diseases before compliance approaches based on exposure standards are available. Exposure standards usually require measurable etiologies and defined exposure-response relationships. Prevention of emerging occupational lung diseases is necessary and usually possible without knowing the specific etiology and corresponding safe exposure level.

Riassunto
«Opportunità emergenti per la prevenzione delle malattie polmonari professionali». *Nell'ultimo decennio, nuove cause riconosciute responsabili di malattia polmonare occupazionale comprendono aromi alimentari, flocculati sintetici, biocontaminanti negli oli da taglio nell'industria metallurgica, prodotti chimici nella produzione dei pesticidi, sindrome respiratoria acuta grave e influenza aviaria. In aggiunta, pregresse riconosciute associazioni tra malattia polmonare e ambienti residenziali umidi sono adesso state estese ad ambienti lavorativi non industriali, come uffici e scuole. All'orizzonte ci sono gli sforzi per capire i determinanti occupazionali della broncopneumopatia cronica ostruttiva, soltanto l'80% della quale è attribuibile al fumo di sigaretta. In aggiunta si sta cercando di capire quale sia il peso dell'asma esacerbato dal lavoro in quei lavoratori la cui malattia era precedente all'esposizione lavorativa. Il riconoscimento di malattie polmonari emergenti correlate al lavoro sottintende il capire che i*

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valori di riferimento dell'esposizione professionale sono spesso inesistenti, inadeguati o non rispettati. I lavoratori, i clinici e la sorveglianza della salute pubblica sono i serbatoi da cui emergono nuove domande riguardo al rischio. Lo strumento per descrivere nuove associazioni di malattie polmonari con ambienti lavorativi è la ricerca epidemiologica, aiutata dalla tossicologia e da accertamenti laboratoristici di plausibilità biologica, se appropriati. Perciò, l'aumentata comunicazione tra i lavoratori, tra altri professionisti che operano per la salute, agenzie con capacità di ricerca epidemiologica, competenza di laboratorio, e l'accesso ai luoghi di lavoro è critico per la ricerca di nuove opportunità per prevenire malattie polmonari professionali. I professionisti che operano nell'ambito della sicurezza e salute nel mondo del lavoro possono indirizzare la gestione del rischio e le misure preventive per malattie polmonari occupazionali emergenti prima che gli approcci basati sugli standard di esposizione siano disponibili. Gli standard di esposizione normalmente si basano su elementi misurabili e su ben definite relazioni dose-risposta. La prevenzione delle malattie professionali polmonari emergenti è necessaria e solitamente possibile senza sapere la causa specifica e i corrispondenti livelli di esposizione sicuri.

La Medicina del Lavoro Med Lav 2006; *97*, 2: 404-409

Friday - June, 16 2006 - Semi Plenary

Occupational asthma[1]

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Key words
Occupational asthma; lung disease

Summary
Occupational asthma (OA) is one of the most common forms of occupational lung disease in many industrialized countries, having been implicated in 9 to 15% of adult-onset asthma. Work-related asthma includes: 1. immunologic OA, characterized by a latency period before the onset of symptoms; 2. nonimmunologic OA, which occurs after single or multiple exposures to high concentrations of irritants; 3. work-aggravated asthma, which is pre-existing or concurrent asthma exacerbated by workplace exposures; and 4. variant syndromes. OA is important to recognize clinically, because it has serious medical and socioeconomic consequences. Diagnosis of OA should be confirmed by objective testing early after its onset. Removal of the worker from exposure to the causal agent and early treatment with anti-inflammatory drugs lead to a better outcome. Assessment of the work environment and identification of host factors may provide us with useful information about the mechanisms involved in OA. Another issue concerns strategies for preventing OA which should be implemented.

Riassunto
«Asma professionale». *L'asma professionale (AP) è una delle malattie respiratorie professionali più comuni nei paesi industrializzati, e può spiegare il 9-15% dell'asma che insorge in età adulta. L'asma legata ad esposizioni professionali comprende: 1. AP immunologico, caratterizzato da un periodo di latenza prima della comparsa dei sintomi; 2. AP non immunologico, che si sviluppa dopo esposizioni singole o multiple a concentrazioni elevate di irritanti; 3. Asma che peggiora al lavoro, che e' asma pre-esistente o concomitante, aggravato da esposizioni lavorative; e 4. Varianti. È importante riconoscere clinicamente l'asma professionale, in quanto essa ha importanti conseguenze mediche e socioeconomiche. La diagnosi di AP deve essere confermata con l'uso di tests obiettivi e deve essere precoce. Una prognosi migliore è legata alla rimozione del soggetto affetto dall'esposizione all'agente causale ed alla terapia precoce con farmaci anti-infiammatori quali i glucocorticoidi per via inalatoria. La valutazione dell'ambiente lavorativo assieme all'identificazione dei fattori di suscettibilità individuale possono fornire informazioni utili per la comprensione dei meccanismi patogenetici coinvolti nella malattia. Un altro punto importante riguarda le strategie da adottare per la prevenzione dello sviluppo di asma professionale che vanno aumentate.*

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[1] Supported by the Ministry of University and Scientific Research (60% and 40%), Associazione per la Ricerca e la Cura dell'Asma (ARCA), and by Consorzio Ferrara Ricerche

DEFINITION AND CAUSAL AGENTS

The key element in defining OA is evidence of a direct causal relationship between workplace exposure and the development of asthma (1, 40). Immunologic OA appears after a latency period and encompasses OA that is induced by an IgE mechanism, and OA in which an IgE mechanism has not been found consistently. Immunologic OA is the most common type of OA, accounting for more than 90% of cases. Nonimmunologic OA is characterized by the absence of a latency period and occurs after accidental exposure to high concentrations of a workplace irritant. This clinical entity has been defined as irritant-induced asthma (13, 38), and "reactive airway dysfunction syndrome" (RADS) has been considered as the most definitive form of irritant-induced asthma (6).

Work-aggravated asthma is common and may cause disability and socioeconomic consequences (7, 37). Exposure to cold, dry air, dust, fumes, sprays, and exertion are common in the workplace and may aggravate asthma (39, 37). However, this type of asthma should be distinguished from OA, because the outcome, medical management, and preventive measures differ substantially. Thus, measures not sufficient to prevent the relapse of OA such as the reduction of exposure to the workplace irritants, to environmental allergens, and to tobacco smoke, the optimization of antiasthma therapy and the education of the patient how to use the drugs, often allow workers with work-aggravated asthma to continue working in the same job. It should be underlined that workers with this type of asthma may develop true OA, therefore OA can occur in workers with or without prior asthma. In addition, it should be also emphasized that whereas immunologic OA can be induced only by sensitizers, irritant-induced asthma can be induced by either sensitizers or irritants (3).

VARIANTS

Asthmalike disorders

Asthmalike disorders have been related to exposure to vegetable dusts and can be differentiated from OA on the basis that in these disorders, asthma symptoms may be associated with systemic symptoms, and may occur in naive subjects on first exposure.

Furthermore, increases in non-specific airway responsiveness are often transient and neutrophilic airway inflammation is common (8). These disorders have been associated with exposure to endotoxin.

Eosinophilic bronchitis

This clinical entity is characterized by the presence of cough, sputum eosinophilia, in the absence of airflow limitation or non-specific airway hyperresponsiveness (17). This condition has been described after exposure to acrylates, natural rubber latex, mushroom spores, and an epoxy resin hardener. Recently, it has been shown that, repeated episodes of eosinophilic bronchitis are associated with the development of chronic airflow obstruction, including asthma (36).

CAUSAL AGENTS

Agents that cause immunologic OA with latency encompass more than 300 natural and synthetic substances. They are listed in textbooks (10), review articles (28) and websites (e.g., www.asmanet.com and www.asthme.csst.qc.ca) (44, 45). The agents are categorized in high-molecular-weight (HMW) and low-molecular-weight (LMW) agents. HMW agents are proteins of animal or vegetable origin causing OA through an IgE mechanism, whereas LMW agents include organic and inorganic compounds that usually are not associated with an IgE mechanism. Finally, the most common agents that can induce irritant-induced asthma include chlorine, sulphur dioxide, combustion products, and ammonia.

EPIDEMIOLOGY AND RISK FACTORS

After a review of the published literature on the magnitude of the attributable risk of asthma due to occupation, a median value of 15% (range, 4-58%) among all asthma cases has been recently proposed (2). Epidemiological studies include the cross-sectional study, the population-based study, the randomized control trial, the prospective cohort, the retrospective cohort, the case-referent study, and the case series. All these designs vary regarding advantages, limitations, and information obtained. It should be underlined that most epidemiological studies of OA have been cross-sectional and therefore may underestimate the prevalence of OA because of the workers with the disease who left work.

Exposure is the most important determinant in the development of OA (9), and the higher is the degree of exposure to an occupational agent, the higher is the prevalence of asthma (11). Exposure-response relationships have been reported for several occupational inhaled allergens (4). However, even if the level of exposure is a critical factor for the development of OA (19), only a small proportion of exposed workers will develop OA, suggesting a role for host susceptibility. Among the risk factors for OA, atopy is a predisposing factor in workers exposed to HMW agents, but it is a weak predictor of sensitization and development of OA (23). Other factors such as rhinoconjunctivitis and having a measurable provocative concentration of histamine (PC_{20}) producing a 20% decrease in FEV_1 could be relevant in the development of asthma (15). Cigarette smoking has been associated with the development of OA for few occupational agents such as platinum salts and anhydride compounds (42, 43).

Recently, genetic markers of OA have begun to be examined (29, 35). Of interest are HLA class II molecules, glutathione S-transferase (GST) and N-acetyltransferase genotypes. In OA, genetic studies are facilitated by the ability to characterize with accuracy the phenotype of the affected worker, by the possibility to measure or estimate exposure, and to have controls who work in the same workplace with similar exposure. Asthma is a complex disease caused by interactions over time between genes and environment. Genetic information should be used appropriately, and findings should be replicated in different studies.

Pathophysiology

Immunologic OA

The pathophysiology of immunologic OA usually involves and IgE-dependent mechanism, and is similar to allergic asthma that is unrelated to work (30, 24). Most HMW agents and few LMW agents induce specific antibodies. When the IgE mechanism is involved, HMW agents are recognized by antigen-presenting cells (APC) and mount a CD4 type 2 immunologic response which leads to the production of specific IgE antibodies by interleukin (IL)-4/IL-13-stimulated B cells. When LMW agents induce specific IgE antibodies, they probably act as haptens combining with a body protein to form functional antigens. Binding of IgE to their receptors, Th2 and Th1 cytokines, and other chemokines induce recruitment and activation of inflammatory cells that together with the thickening of the reticular basement membrane are the histopathologic features of OA. Most LMW agents do not induce specific IgE antibodies. In this type of OA, a mixed CD4/CD8 type 2/type 1 immunologic response or induction of γ/δ-specific CD8 may play a role (31).

Irritant-induced asthma

In irritant-induced asthma, epithelium has a central role. Alarm signals from damaged epithelial cells might activate immunocompetent cells. Consequences of the damage in the bronchial epithelium are loss of relaxing factors, exposure of nerve endings, release of inflammatory mediators and cytokines, and secretion of growth factors for epithelial cells, smooth muscle, and fibroblasts (14).

Natural history and long-term consequences

The risk of OA is highest within 1 to 2 years of exposure. The nature of agent and the intensity of exposure affect the rate of developing sensitization and asthma (23). Rhinoconjunctivitis often precedes the onset of asthma due to HMW agents

(26). Subjects with occupational rhinitis have a high risk of asthma (20). Most subjects (about 70%) with OA do not recover even several years after cessation of exposure, and asthmatic workers who continue to be exposed, worsen with time. However, when exposure to natural rubber latex is reduced, workers are able to keep their jobs, improving in symptoms and lung function (41). The duration of exposure and of symptoms, the degree of airway hyperresponsiveness at the time of diagnosis, and the duration of follow-up are determinants of recovery.

Resolution is a slow process and it is still unknown whether the persistence of OA is due to genetic susceptibility or to persistence of an inflammatory process in the airways. In adult-onset asthma, such as OA, both airway inflammation and airway remodelling are present, but it is difficult to estimate their contribution to the chronicity of OA (31). On the other hand, genetic susceptibility may affect the capability of an asthmatic subject to deal with airway inflammation (32).

Diagnosis

Diagnosis of OA should be confirmed by objective testing for asthma as soon as possible (33). Occupational history should be accurate, and the presence of variable airflow limitation or, if lung volumes are normal, of non-specific airway hyporresponsiveness should be also assessed. The monitoring of PEFR is also useful in the investigation of OA (34). Specific inhalation challenge tests with occupational agents should not be considered routine diagnostic tests. Immunologic tests have limited usefulness in the diagnosis of OA and are not diagnostic as a sole investigation. The analysis of induced sputum is a valid method to study airway inflammation (21), and eosinophilia is a reasonably good non-invasive index of airway inflammation (22). Another non-invasive method for assessing airway inflammation is the measurement of exhaled nitric oxide (eNO) (5). The sensitivity of this measurement is high, but its specificity is low.

The physician should be aware of the potential exposures present in different occupations, that the presentation of OA is variable, occurring often during the night, that the absence of airway hyperresponsiveness does not exclude sensitization to an occupational sensitizer, and that incident cases of sensitization and OA have been shown in nonatopic subjects exposed to HMW agents in the occupational setting (16).

Management

Strict exposure control is needed for workplace sensitizers. Removal or substitution of the sensitizers are the best approach. Relocation to jobs with less exposure to the causal agents is successful in few occupational settings, like exposure to natural rubber latex among health professionals. For patients with irritant-induced asthma, further exposure to high concentrations of the irritant should be avoided. Exposure to irritants, tobacco smoke, and environmental allergens should be limited particularly for subjects with work-aggravated asthma. Pharmacologic treatment should be the same as that for nonoccupational asthma and should be optimal. Physicians should support the affected worker in the pursuit of appropriate compensation, since in several countries compensation systems for OA are unsatisfactory.

Prevention and surveillance

Primary prevention is designed to abate hazard before any injury has occurred, and takes into consideration host and environmental factors (12, 18, 24, 25). Secondary prevention aims to identify preclinical changes in the disease, and finally, tertiary prevention aims at the prevention of permanent asthma through an early detection of the disease and an appropriate management (removal from exposure, antiasthma therapy).

Periodic assessment of symptoms and the use of sensitive, specific and reproducible tests for evaluating lung function can help the physician in managing the disease. It should be again underlined that the quick evaluation of causality and the demonstration of a relationship between exposure to the agent in the occupational setting and the occurrence of sensitization and/or asthma are the first step.

Conclusions

Occupational asthma continues to be one of the most common occupational lung diseases. However, many questions regarding occupational asthma and more in general regarding work-related asthma remain unanswered despite recent advances in research in the field.

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La Medicina del Lavoro

Med Lav 2006; *97*, 2: 410-417

Indoor air quality and health in offices and other non-industrial working environments

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Key words

Indoor air; building-related illnesses; sick building syndrome; office work

Summary

Background: *Over the last 30 years, transformation of indoor environments – in particular in office blocks – has been associated with complaints from workers of discomfort, malaise and even diseases termed Building Related Illnesses (BRI) which are classified as specific (e.g. Legionnaire disease, asthma, hypersensitivity pneumonia) or non-specific (e.g. the Sick Building Syndrome).* **Methods:** *A review was made of data from international public health organisations, epidemiological, clinical and experimental studies and congress proceedings from 1990 to 2006 on the topic of indoor air quality and health in modern, non-industrial workplaces.* **Results:** *Studies focused on ventilation, temperature and air humidity and specific pollutants such as Volatile Organic Compounds, particules asbestos fibres, environmental tobacco smoke, radon and biological agents. We can now measure microclimate parameters and many indoor air pollutant levels as well as their effects on health; we can also formulate indications of threshold and guideline values for some of these and make a preventive assessment for toxic emissions from construction and furnishing materials. A stepwise, multi-disciplinary approach – with the specialist in occupational medicine playing a major role – is most suitable for dealing with BRI and the effects of poor indoor air quality on health.* **Conclusions:** *Better criteria are needed to study emission of substances into the indoor environment, adequacy of ventilation, additive or synergistic effects of mixtures of chemicals and toxicity of micro-organism decomposition products. Objective clinical tests to assess the effects of indoor pollutants on health and indices for Indoor Environmental Quality in assessing buildings need to be improved.*

Riassunto

«La qualità dell'aria e la salute negli ambienti confinati e altri inquinamenti lavorativi non industriali». *Il cambiamento degli ambienti confinati, in particolare quello delle postazioni d'ufficio, negli ultimi 30 anni si è associato a lamentele dei lavoratori, come disagio, malessere e spesso malattie chiamate Building Related Illness (BRI) che sono classificate sia come specifiche (malattia dei legionari, asma, polmonite da ipersensibilità) o come non specifiche (sindrome dell'edificio malato). Abbiamo passato in rassegna i dati provenienti da organizzazioni internazionali di salute pubblica, da studi epidemiologici, clinici e sperimentali e da atti di congresso nel periodo compreso tra il 1990 e il 2006, riguardanti la qualità degli ambienti confinati e la salute nei moderni ambienti di lavoro non industriali. Lo studio ha focalizzato la sua attenzione sulla ventilazione, temperatura e umidità dell'aria e su specifici inquinanti quali i composti organici volatili, il particolato, le fibre di asbesto, il fumo di tabacco,*

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il radon e gli agenti biologici. Attualmente è possibile determinare i parametri microclimatici, i livelli di numerosi inquinanti degli ambienti confinati e i loro effetti sulla salute, dare indicazioni riguardo ai valori limite e alle linee-guida per alcuni di questi ed eseguire una valutazione preventiva riguardo le emissioni tossiche provenienti dai materiali edili e di arredamento. Un approccio multidisciplinare, all'interno del quale lo specialista in medicina del lavoro svolga il ruolo principale, sembra essere il più adatto al fine di gestire la BRI e di comprendere gli effetti sulla salute della compromessa qualità dell'aria degli ambienti confinati. Sono necessari metodi più adeguati per lo studio delle emissioni di sostanze negli ambienti confinati, di una corretta ventilazione, dei possibili effetti sinergici o additivi di miscele di sostanze chimiche e della tossicità dei prodotti di decomposizione dei microrganismi. Bisogna migliorare sia i metodi clinici per la messa in luce degli effetti dell'inquinamento che gli indici di qualità degli ambienti confinati nella valutazione degli edifici.

Introduction

Terms such as "indoor environment" or "quality of indoor air" usually refer to confined spaces used for non-occupational activities or non-industrial work – i.e. houses, offices, hospitals, libraries, leisure and social centres (such as cinemas, bars, restaurants, gyms, etc.) or private and public means of transport (25). In developed countries, non-industrial workplaces constitute a large section of the working environment, as about 67% of the population works indoors in the service industry and 27% and 6% are respectively employed in industry and agriculture. In developing countries only 46% of the population is employed in the service industry while 19% works in industry and 35% in agriculture (12). Over the last 30-40 years, working environments in the service industry, especially in offices, have undergone profound changes in the building structures and systems, as well as in the work tools, organisation patterns and work force qualifications. Buildings are often situated in suburban areas, have been constructed using new techniques with light structures and a correspondingly high content of insulating and noise absorbing materials. Air-conditioning systems, with or without humidifiers, are common. Office blocks are often sealed and ventilation reduced to contain energy costs (3). Furniture and furnishings are made of synthetics and new detergents are used for cleaning. Electronic equipment, such as computers, printers, CD readers, photocopying machines, are used almost everywhere.

The profound transformation of indoor environments, especially in office blocks, has gone hand in hand with a rise in complaints from workers of discomfort, malaise, and even diseases, termed "Building Related Illnesses" (BRI). As BRI have spread and as people living in industrialised countries spend 80%-90% of their time working, living or travelling indoors, researchers, politicians and Health Boards have focused on indoor air and its effects on health and well-being of workers and the general population. Indeed, the quality of indoor air, its effects on health and the right to breathe good quality indoor air have assumed the status of a major concern in the modern world.

Indoor air quality

Indoor air is deemed of acceptable quality when "There are no known contaminants at harmful concentrations as determined by cognizant authorities and with which a substantial majority (80% or more) of the people exposed do not express dissatisfaction" (4). However, good quality indoor air cannot be simply defined as lack of harmful effects and reasonable comfort for a limited number of occupants (80%) of the building. Even more sensitive subjects have the right to breathe good quality air, and parameters such as productivity, work or scholastic performance should also be considered. Many factors (14, 25) can reduce the quality of indoor air and impact negatively on health and wellbeing. Sources of pollutants include: air from outside, air-conditioning and ventilation systems, humidifiers, construction materials, furniture and soft furnishings, computers and photocopying machines, the occupants' personal habits and activities. Furthermore, a sub-optimal microclimate, pesticides (anti-wood rot treatments, disinfectants), volatile organic compounds (VOCs), formaldehyde, bacteria, moulds and other micro-organisms, biocides, airborne particulates, artificial mineral fibres, asbestos fibres, gases such as CO,CO_2, NO_2, SO_2, O_3, radon, and tobacco fumes may have a detrimental effect on health. Indeed, indoor concentrations of some of these pollutants are often the same as – or even higher than – concentrations outside and indoor exposure lasts much longer.

For a long time, public opinion perceived air pollution in urban centres as potentially harmful. Indoor air pollution, even though associated with significant adverse health and socio-economic consequences, is less well known than air pollution and, as a consequence, is under-estimated.

An international consensus document on guidelines for indoor air pollutants would undoubtedly have a positive impact on the health of the general population, but estimating the quality of indoor air is much more complex than determining air quality in a traditional industrial environment (9). A series of fundamental questions needs to be answered before embarking on drawing up guidelines. Which indoor environment will they refer to? Homes? Offices? Schools? Public buildings? Vehicles? What is the underlying principle? Health? Well-being? Who should be safeguarded? Furthermore, if the guidelines are set up as valid household regulations, the general public may not accept them because they are more concerned with outdoor pollution and do not like Government or Health and Social agencies encroaching upon their personal space and privacy.

BUILDING-RELATED ILLNESSES

Reports of building-related illnesses have become more and more frequent over the last 30 years and are associated with the spread of the new indoor work environment, starting in Northern Europe and North America and extending to Southern Europe, South America and Asia. Currently BRI are classified as "specific" or "non-specific" (16). Specific BRI share certain features: the prevalence among the occupants of a building is usually low; the aetiological agent is known and frequently detected in air-conditioning and ventilation systems; once the cause has been removed, there are no new cases. Each disease has a well-defined clinical picture and diagnosis is based on objective clinical and instrumental findings. Pathogenesis is usually immune-allergic, toxic or infective. Once the worker is removed from the workplace for a few days, clinical signs and symptoms do not resolve quickly and may be serious if not treated properly. Specific BRI include infectious diseases (Legionnaires Disease, Pontiac fever, influenza-like illnesses, tuberculosis), immunological disorders (hypersensitivity pneumonia, humidifier fever), allergic disturbances (dermatitis, rhinitis, asthma, contact urticaria), irritative disorders (dermatitis, airways irritation), and intoxications, like carbon monoxide poisoning (which is rare in office blocks).

Non-specific BRI are less clearly defined and the Sick Building Syndrome (SBS) is the best known one (6). Prevalence among the occupants of a building is always over 20% and sometimes reaches 50-60%; irritative symptoms involve the eyes, skin and upper airways mucosa, while the most common general symptoms are headache, lack of concentration, drowsiness and sometimes nausea. Different combinations of these symptoms arise some hours after starting work in the building. All, except cutaneous signs and symptoms, disappear a few hours or 2-3 days after leaving the building. Despite extensive investigation no recurrent objective findings have been detected in outbreaks (18). However, abnormalities in tear film stability have been observed in many subjects, sometimes in association with ocular symptoms, as well as reduced foam formation in the eye and conjunctival hyperemia. Although the earliest reports of the SBS date back to over 20 years ago the aetiology is still unknown (1). In many reports, varying combinations of the following elements often recur: sub-optimal ventilation, low humidity, poor lighting and hygiene, improper maintenance of air conditioning and ventilation systems, and psychosocial factors (6). Discomfort, irritative and general symptoms have also been reported in buildings without any apparent problems. In some cases the severity and frequency of BRI reached levels that required nationwide and international investigations, for instance involving tens of buildings and thousands of workers in Denmark, Finland, Germany, Sweden, United States. The European Union, the Environmental Protection Agency (EPA), the National Institute for Occupational Safety and Health (NIOSH), the North Atlantic Treaty Organization (NATO), the World Health Organization (WHO) have all funded research to assess the relationship between indoor environments and health and to divulge knowledge about the impact of indoor air quality on health and wellbeing (25).

Several experts and researchers in different fields (engineers, architects, system designers, heating and lighting experts, physicians, toxicologists, industrial hygienists, epidemiologists, etc.) are focusing more and more on indoor air quality and BRI. Over the last 20 years, many papers have been published in prestigious journals. Specialized journals have been founded, as well as new, often multi-disciplinary, scientific societies, like the International Society of Indoor Air Quality and Climate (ISIAQ) and the International Academy of Indoor Air Sciences (IAIAS). As early as 1996, the International Commission on Occupational Health (ICOH), established a Scientific Committee on "Indoor air quality and health".

What we know and what we need to know

Some significant progress has been made. Besides measuring microclimate parameters, the levels of many indoor air pollutants can now be determined and their effects on health defined (22). Threshold and guideline values have been proposed for some; toxic emissions from construction and furnishing materials can be preventively estimated. In buildings with problems, strategic interventions can be implemented as well as efficacious health surveillance of occupants, when needed.

Most attention has concentrated on ventilation, temperature and air humidity. Ventilation is defined as the exchange of (presumably polluted) indoor air with (presumably clean, fresh) outdoor air. A ventilation rate equal to or below 10 l/sec per person can aggravate irritative and general symptoms like those found in the SBS. Increasing the ventilation rate to 20 l/sec per person will attenuate them. An interdisciplinary group of European experts (26) found that outdoor air rates below 25 l/sec per person in offices increased the risk of workers developing SBS-like symptoms and absenteeism, thus reducing productivity. Indeed, almost all fieldwork and laboratory studies show that raising the ventilation rate is associated with better performance, particularly when the starting rate is below 20 l/sec/person. When the initial ventilation rate was over 45 l/sec/person any further increase in ventilation was associated with a negligible improvement in performance (24). The American Society of Heating, Refrigerating and Air Conditioning Engineers recently proposed a standard ventilation rate of 8.5 l/sec per person (4) for smoke-free offices, which should be adjusted according to the number of occupants per room.

Several studies have attempted to establish the optimal temperature in air-conditioned offices through experimental observations of the effects of variations in microclimate parameters on occupants' health and wellbeing. At temperatures over 21-22°C, SBS-like symptoms increase, especially the perception of dry air. The effects of changes in humidity levels are more controversial. When humidity is increased, especially in the upper airways, symptoms of dryness can be reduced or increased in some cases, or they may remain unmodified in others. 34-37% air humidity reduces SBS-like irritating and general symptoms. Ocular symptoms are unaffected by changes in humidity. However, an increase in humidity levels increases the perception of odorous and stuffy air (20). Temperature and humidity significantly influence perception of air quality during short exposure periods; air is perceived as being less acceptable and stuffy when temperature and humidity rise and as acceptable when it is cold and dry. When exposure is prolonged for a few hours, perception of air as fresh and acceptable increases if temperature and humidity are low (20°C/40% RH Vs 26°C/60% RH). At low temperatures and low relative humidity levels reducing the ventilation rate from 10 l/sec/person to 3.5 l/sec/person does not significantly reduce wellbeing (8), even though it impacts negatively on the first impression of air quality. Fatigue, headache and lack of concentration are reduced at low temperature and humidity levels, thus accounting in part for the poor performance and loss of productivity associated with higher values.

Techniques for measuring indoor air pollutants date back to the 1960s, when researchers started to determine concentrations of nitrogen oxides, radon and lead in houses. These data were followed by measurement of asbestos fibres and tobacco fume compounds. In the 1980s indoor exposure to sources of toxic VOCs, especially benzene, was found to be higher than outdoor exposure.

Many experimental and field studies defined the effects of several indoor chemical, physical and biological pollutants on health. Commonly found concentrations of VOCs in indoor environments (14, 29), particularly in offices, are associated with irritative symptoms of the eyes, airways mucosa and in some cases the nervous system (irritability, lack of concentration, fatigue). In healthy young volunteers granulocyte-neutrophil counts are increased in nasal lavage fluid and tears and tear film is unstable after exposure to VOCs. Similar irritative findings were reported after controlled exposure set up in a laboratory to emissions from building materials or office machines and during typical work activity in an office (17). Formaldehyde, a common indoor pollutant, can irritate the skin and mucosa even at low concentrations. The International Agency for Research on Cancer (IARC) recently defined it as a definite carcinogenic agent for nasal-pharyngeal tumours in humans; whether it is associated with cancer of the nose and paranasal sinuses and leukaemia is doubtful (10). Long-term effects of VOCs are best exemplified by exposure to benzene, and the consequent risk a of leukaemia in humans has been estimated (2).

Particles are an irritative for the mucosa and eyes and also have adverse cardiovascular effects. Controlled exposure studies showed healthy subjects suffer discomfort, objective ocular abnormalities (tear film instability, epithelial changes and foam formation) as well as disturbances in nasal patency when indoor dust concentrations range from 200 and 700 ?g/m^3. Three hours exposure to a mean concentration of 394 μg/m^3 office particles, with a diameter of less than 20 μm (peak percentage distribution 1-2 μm), produced similar effects in healthy, young non-smokers. Particles can exacerbate asthmatic symptoms. Ultra-fine particles (<100 nm in diameter) trigger an inflammatory reaction in pulmonary alveoli through release of biochemical mediators and impairments in alveolar-capillary diffusion (19). After outdoor exposure (increased incidence of myocardial infarction, ventricular fibrillation, daily cardiovascular mortality rate), with epidemiological findings of outcomes, which are perhaps mediated by interference with coagulation processes, attention has recently focused on the cardiovascular effects of indoor particules exposure. Despite much investigation, threshold values for particles concentrations in indoor air have not convincingly been established (23).

Asbestos, which the IARC classifies as a certain carcinogenic agent for humans (Group I), if found in poorly preserved friable/crumbly construction materials, is another building-related risk factor. Besides causing lung cancer, asbestos has been implicated in pleural mesothelioma (21). Environmental Tobacco Smoke (ETS), one of the major chemical indoor air pollutants, has been extensively studied because of its harmful effects on acute and chronic lung diseases and its role in lung cancer (11). These harmful effects have been well defined in the workplace. In the past few years ETS has been associated with a high incidence of cardiovascular disease in passive smokers (27).

In indoor air, radon is one of the main physical agents associated with a significant risk of lung cancer. Even relatively low concentrations (under 200 Bq/m^3) in houses are associated with a significantly higher relative risk of lung cancer, particularly in smokers (7). Estimates, derived also from exposed miners, appear so convincing that specific regulations have been implemented in many countries, including Italy.

In the indoor environment biological pollutants can cause well-defined diseases such as Legionella Pneumophila pneumonia, viral infections and mycosis. Mites can trigger immune-allergic asthma, eye irritation, rhinitis and pneumonia due to hypersensitivity (16). Mycotoxins produced by some mycetes are associated with irritative symptoms of the skin, eyes and mucosa, fatigue and immune-allergic abnormalities particularly in damp buildings (5). Sources of biological pollutants have been identified in the cooling and humidifying systems of the air-conditioning plant, in the plumbing system and in dust found in rugs, armchairs and fitted carpets.

Despite recent advances, much remains to be defined. Better criteria are needed to study emissions of substances into the indoor environment, the effectiveness of ventilation duct cleaning and adequacy of ventilation levels. New models of exposure should be set-up to take energy, health and financial requirements all into account at the same time. It is also necessary to assess the additive or synergistic effects of mixtures of chemicals their interactions with humidity levels in indoor air and with specific pollutants such as nitrogen oxides, ozone and oxygen free radicals. Investigations should be conducted into micro-organisms, their sources inside and outside the building, and the toxicity of their products such as endotoxins, glucans, polypeptides, allergenic proteins, mycotoxins. The effects of poor quality indoor air on performance and productivity need to be assessed as well as the effectiveness of special ventilation systems (e.g. personal ventilation). Further studies are required into objective tests to determine the health effects of indoor air pollution and of ultrafine particles. Moreover, the effectiveness of indices for Indoor Environmental Quality (IEQ) in evaluating buildings must be determined. A better-defined "IEQ index", that synthesizes the many specific factors correlated with IEQ and is able to identify buildings at high risk of BRI, would be a great aid in prevention and remediation. Although some indices have been proposed e.g. the Indoor Pollutant Standard Index (IPSI) and the Indoor Air Pollutant Index (IAPI), reliability and ease of application require more research.

An ad hoc NIOSH working party has prioritised what still needs to be learnt (15): in-depth knowledge about typical indoor-related respiratory infections, allergies, asthma, and how to encourage implementation of construction practices that take the occupants' health and well-being into account. The WHO (28) has established health-based limits to air pollution and many countries including Germany, Norway and Poland have set up target concentrations for several indoor pollutants (25). Despite this progress, real difficulties exist in establishing acceptable indoor concentrations and the need for guidelines to indoor air pollution is keenly felt as they would serve to improve the health of workers and the general population. Significant improvements in the indoor working environment will be associated with social, health and financial gains. In the United States alone fifteen million workers would benefit; financial gains derived from less absenteeism, greater well-being and increased productivity could amount to many billions of dollars (15).

The role of the Occupational Medicine Specialist

When dealing with problems of indoor air quality and health, prevention and research in the modern non-industrial workplace, a stepwise multi-disciplinary approach is most suitable (13). Any multi-disciplinary team should include all or some of the following: architects, construction and systems engineers, managers of the maintenance squad, specialists in occupational medicine and other health experts, industrial hygienists, and should be led by a recognisably competent professional figure to co-ordinate interpretations and results. Structural aspects, particularly the ventilation system, should be evaluated and eventually adjusted to optimum levels as specified in the building plans. Investigations should start with the simplest and least expensive tests and proceed to the more complex and costly. Efficiency and effectiveness of building maintenance should be checked and improved if necessary. In prevention, in early diagnosis of BRI and in managing an outbreak, the specialist in occupational medicine is one of the principal figures and should be able to recognise the earliest symptoms, make a valid contribution to risk assessment and establish criteria for re-location of workers who are most sensitive to indoor air pollutants or to a sub-optimal microclimate.

As outbreaks of BRI can involve hundreds of people at the same time, some approaches and protocols for managing them have been developed. Besides these investigative procedures, managing a "problem" building, especially if an outbreak of SBS is suspected, requires particular attention and care. Even though disorders are not specific and not severe, they should not be under-estimated or disregarded. Symptomatic workers should be examined at the workplace, not in hospital; employees should be involved from the start, along with workers' representatives and prevention services in order to establish reciprocal trust between occupants of the building and professionals evaluating the situation. Occupants of a building that is under investigation should always be informed of the results of tests. Nevertheless, no definite conclusions should be drawn about the causes of disorders, symptoms or diseases, particularly not at the early stages of the investigation. In fact, it is by no means certain that correction of building-, workplace- or activity-related factors will resolve them. For infections and allergies, which affect a small number of individuals, drug therapy is available. However, most BRI cases are characterized by irritation and general malaise and only some symptoms can be treated. Therefore, as treating an outbreak of BRI may be difficult and expensive, prevention is a key activity in the management of BRI.

Conclusions

With features that clearly distinguish them from traditional industrial plants and artisan workshops, confined, non-industrial workplaces are common in industrialised countries and are rapidly spreading in developing countries. Air-conditioning, inadequate ventilation, unsuitable temperatures, air humidity levels and lighting, release of chemical, physical and biological pollutants from structures, construction materials and furnishings, may all interact synergistically to impair health and well-being. Over the last 30 years most sources of risk have been identified, threshold values have been established for some pollutants and remedial measures provided in many cases. Detecting and managing the risk factors in a building requires a well-defined methodological approach, with a co-ordinated multi-disciplinary expert team. The specialist in occupational medicine plays a major part in early diagnosis of BRI and in prevention of the short- and long-term effects linked to indoor air pollutants.

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The emerging infectious disease

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The 70's represented the *nadir* in regards to the attention put into infectious disease research and the public's general attention in this area.

Smallpox was officially eradicated in 1977. William Beveridge published an article intitled "Influenza, The Last Great Epidemic". Susan Sontag wrote, "Illness as a Metaphor,"and professed that cancer would substitute, in a contemporary metephor, for tuberculosis. Antibiotics, chemotherapy and vaccines created optimism but the reality didn't confirm the expectations. In 1979, with the first descriptions of Legionaires disease, The New England Journal of Medicine published an editorial called "Another new Pneumonia: Pandora's Box Re-opened?" The title turned out to be prophetical. Since then new and re-emerging infectious pathologies have been uninterrupted. Today it is clear that infectious diseases are and will be constant in human history. Microrganisms consitute for 60% of the earth's biomass, and overall it is a biomass that is continually changing and adapting to mutating environmental conditions.

The last 25 years have been characterized by new epidemics and new epidemic risks. The reasons are correlated to microrganisms as well as mutated epidemiological conditions that facilitate the emerging persistant microrganisms. We are not looking at new events here but ones that are constantly being verified during human history. Conversely, we are looking at events that have accelerated during the past quarter of a century. The 20th century has been defined as the "fast century." There have never been so many rapid structural and behavioral changes in the history of humanity, because of this none could expect that there would not be repercussions in the relationship between man and microorganisms. Globalization has determined a stop to the exclusive regionalization of infections. It has even been defined that globalization has rendered an entire planet vulnerable from events that have occasionally taken place in remote and circumscribed areas.

The AIDS pandemic is the most striking example of an infection brought on by a new virus. Human Immunodeficiency Virus, HIV, which differenciated from the Simian Immunodeficiency Virus that developed in limited areas of Western Sub-saharan Africa between the 1930's and the 1950's. The epidemic diffusion was unstoppable. The HIV epidemic has been defined as "behavioral". The infection is exclusively correlated to hygienically incorrect behaviors which became a mass phenomenon. AIDS has demonstrated how these "behavioral" epidemics are so difficult to control.

The SARS-related Coronavirus (Co-SARS) is another new virus that the human species was confronted with and luckily was rapidly extinguished, but it represented an event that will not be forgotten. It remains an example of what could inevitably happen in the future with less favorable outcomes. Co-SARS went from one species to another, specifically from a still unidentified animal resevoir to humans. The outbreak was verified in the district of Fosham in the Chinese province of Guangdong.

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The characteristics of this outbreak were due to socio-economic conditions characterized by high population density and promiscuity, that exist between human beings and different animal species. SARS put these places "on the map" and with that represented a danger for the rest of the world. The diffusion of SARS was associated with one individual index case: Dr. Ly who became infected and then traveled from Guangzhou, the capital of Guangdong, to Hong Kong and there infected 16 other people. These 16 people then diffused the virus in the next 48-72 hours to Ireland, Canada, USA, Germany, Vietnam, Singapore, Bangkok, and Hong Kong.

Avian flu viruses (RNA viruses) are distinguished by their very distinct capacity to mutate. The avian flu virus can acquire the capacity to infect man directly or indirectly with genetic recombination with the human flu virus. Migratory birds can disseminate the pandemic avian flu virus, either mutated or recombinated in remote areas of the world. These epidemics of avian flu among winged animals with sporadic contagions to man are old phenomenons but recently have accelerated. The first known example of this was the Spanish Flu (1918, strain H1N1) followed by H2N2 (1957), H3N2 (1968), H1N1 and H5N1 (1997), H9N2 (1999), H7N7 (2003) and again H5N1 (2003-2006). H5N1, the avian flu that is now in circulation, which could very likely be related to the pandemic virus, is particularly worrisome for its elevated pathogenicity. Places in the far east, such as South China, Thailand, Vietnam, and Laos could be where the flu pandemic had its origin. These being the same places where SARS had its origin. The coincidence is not casual. In these areas there is the largest production of poultry and swine that exists and that are close to large pockets of poverty and promiscuity.

Globalization is a complex phenomenon that touches upon man, animal, and goods. It is basically something that has just begun to have an impact on human society. However, 3% of the world's population now live in countries different from their original country of birth. This means that 175 million people having varying reasons for this exodus: general immigration, nomadism, political refugees, military and diplomatic personnel, NGO employees, crew members, religious pilgrims, company employees, and tourists. The world's tourism flow began with 25 million in 1950 to 166 million in 1970, 500 million in 1993, 664 million in 2000 and will reach an estimated 937 million in 2010.

This phenomenon has opened up a base for a new sector of medicine: Travel Medicine. It is a multi-disciplinary sector that links up with technological, organizational, and complex informational support. Tourists, in fact, are exposed to many different risks depending upon the place and duration spent in that specific place.

The CDC in Atlanta reported a case of Lassa fever in which the patient died after returning to the USA after being in Liberia and Sierra Leone and concluded that "increasing travels result in importation of agents from endemic areas to the USA, posing diagnostic challenges. Clinicians should consider both uncommon and common causes of fever in persons arriving from Africa."

Globalization impacts animals as well as goods. By now there are many examples of negative relapses on infectious pathology. In 2003, there were 11,600 tons of exotic animal meat (monkey, elephant, camel...) illegally imported into Great Britain that were given to ethnic restaurants. In May, 2003 the importation of 800 rodents from Ghana into the USA and a successive infection from prairie dogs that were sold as "pets" provoked 81 cases of monkey smallpox in children.

Microorganisms are only seemingly fragile. They anticipated man's arrival on earth by three million years and have always displayed an ability to adapt. Darwin was correct in saying: "In the fight for survival the one who wins is not the strongest but the one who adapts to the ever changing conditions".

The adaptation to globalization is one of the challenges for human kind at the beginning of the third millenium.

La Medicina del Lavoro

Med Lav 2006; *97*, 2: 420-429

Occupational Health and safety in agriculture: situation and priorities at the beginning of the third millennium

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Key words

Agriculture, occupational health, child labor

Summary

Agriculture is a human activity, which includes a number of different tasks and occupies a huge number of people worldwide. Estimates of World Bank for 2003 suggest that 51% of global population lives in rural areas. ILO estimates that 1.3 billion of workers are engaged in agriculture, and they represent almost a half of the total number of economically active subjects (2,838,897,404). In developed countries, agriculture workers are only a small fraction of the whole work force (up to 9% according to ILO data), while in developing countries, especially in Asia, agriculture workers represent up to the 60% of the total work force. Most agriculture workers reside in Asia, in the Pacific (74%) and in Africa (16%). ILO estimates suggest that half of fatal occupational injuries in the world are attributable to agriculture. This means that around 170,000 agriculture workers die every year as a consequence of occupational injuries. Using the same estimate, half of the fatal accidents could be linked to agricultural activities (more than 130 million). Comparing this estimate with the 6.328.217 people injured in war in 2002 or with the 20-50 million injured victims of road accidents, one has a much clearer picture about the importance of preventing agricultural injuries. In a complicated situation such as occupational health and safety problems in agriculture, it is not so easy to select priorities clearly. But "legalization" of agriculture workers could be a key to solving all the other problems. Actual data on fatal and non-fatal occupational injuries in agriculture show that occupational health and safety issues are among the top priorities for that discipline.

Riassunto

«Sicurezza e salute nell'agricoltura: situazione e priorità nel Terzo Millenio». *L'agricoltura è un'attività che implica lo svolgimento di varie mansioni e impegna un elevato numero di persone in tutto il mondo. La Banca Mondiale stima che, nel 2003, il 51% della popolazione mondiale viveva in aree rurali. L'ILO stima che sono impiegati nell'agricoltura 1,3 miliardi di lavoratori, cioè quasi la metà di tutta la popolazione lavorativa (2.838.897.404). Nei Paesi industrializzati gli agricoltori rappresentano solo una piccola parte della forza lavoro (secondo l'ILO fino al 9%); al contrario, nei Paesi in via di sviluppo, specialmente in Asia, gli agricoltori rappresentano fino al 60% dei lavoratori. La maggior parte dei lavoratori risiede in Asia e nel Pacifico (74%) e in Africa (16%). L'ILO stima che la metà degli infortuni lavorativi mortali nel mondo sono attribuibili all'attività agricola. Ciò significa che circa 170.000 lavoratori agricoli muoiono ogni anno in seguito ad infortuni. In base al medesimo calcolo, la metà di tutti gli incidenti non mortali può essere ricondotta ad attività agricole (più di 130.000). Comparando tali dati con le 6.328.217 persone ferite in guerra nell'anno 2002 o con i 20-50 milioni di persone coin-*

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volte in incidenti stradali, risulta evidente l'importanza che assume la prevenzione degli infortuni agricoli. In una così complessa situazione non è semplice individuare le priorità d'intervento in tema di salute e sicurezza sul lavoro in ambito agricolo. Tuttavia, la "legalizzazione" dei lavoratori agricoli può costituire il punto di partenza per la soluzione di tutti gli altri problemi. I dati attuali sugli incidenti, mortali e non, avvenuti in contesto agricolo, indicano che la salute e sicurezza sul lavoro è senz'altro una delle più urgenti priorità in questo ambito.

Introduction

Agriculture is a key component in human activities since it is mainly addressed at producing food in a world where food demand is growing very quickly. Even in the frame of a deceleration of world population growth (it is estimated that in 2050 the growth rate will have fallen to 0,38% per annum, that is 1/3 of the present situation), several countries, with inadequate food consumption levels, will continue to have rapidly growing populations. The promotion of further increase of food production seems in contrast with the recent shift that emphasizes food quality, food safety, prevention of health and environmental impacts of food production, consumption and trade (3). Nowadays and in the next future, the need of boosting agricultural production has to be considered together with the need of making agriculture and rural development sustainable, in other words ecologically sound, economically viable, socially just, culturally appropriate and based on holistic scientific approach (12). Since agriculture is one of the three most dangerous occupations, besides constructions and mining, improving occupational health, safety and environmental standards for workers and small farmers must be considered as one of the key components of sustainable agriculture. Agricultural workers have some peculiar aspects, in comparison with industrial ones: firstly, they produce food and directly contribute to the well-being of the general population in any country; secondly, their work implies the direct use of land: it is therefore evident that healthy and trained agricultural workers promote the healthiness of millions people and guarantee a sound use of the land against the risks of environmental pollution and disasters.

Current situation in agriculture: an overview

According to the International Labor Organization, in the frame of agricultural activities we can find agriculture, livestock breeding and forestry work. Several tasks and jobs are though identified as "agriculture": tillage of soil, cultivation, including the production of seeds and plants and harvesting; breeding and slaughtering of animals; forestry work and several other activities such as production of hand made food. Even if the proportion of rural population is decreasing, agricultural workers still represent a significant percent of global workforce. According to World Bank data, in 1990 56% of global population lived in rural areas and in 2003 only 51% (more details in figure 1). ILO estimates that 1.3 billion of workers are engaged in agricul-

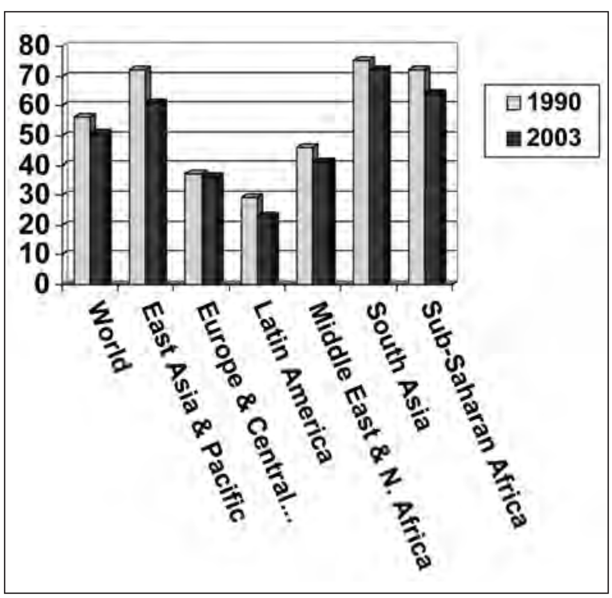

Figure 1 - Rural population (%)

ture (14). According to World Bank data in 2001 there were 2.838.897.404 economically active subjects, agricultural workers represent almost half of total world's workforce (21). The picture significantly varies among different countries: in the developed ones, agricultural workers represent only a small fraction of the total workforce (up to 9% according to ILO data), while in developing countries, especially in Asia, agricultural workers represents up to 60% of the total workforce. Almost 90% of total agriculture workforce lives in two continents: the 74% lives in Asia & Pacific, and the 16% in Africa (14). As for developed countries, in USA and Canada most of agricultural workers are working in middle size (10-50 Ha) and large size (>50 Ha) farms and they are officially registered as agriculture workers. On the contrary, in countries such as Italy (16), Spain, Greece and Portugal most farms are still small sized and family based (<10 Ha), and the number of registered enterprises still exceeds the total number of employees, even with a trend to fusion in bigger enterprises.

Level of agriculture mechanization in developed countries is significantly higher than in developing ones where, when present, is often outdated.

Agricultural workforce

Agricultural workforce is not a homogeneous entity. There are huge differences within this group based, for instance, on type of activities, level of mechanization, specialization, training and type of property, kind of employment relationship. Generally speaking, agriculture workers in developed countries are more specialized and well trained than in developing countries and countries in transition. Such differences cause huge differences in occupational risks.

In developed countries, activities in farms are quite often run by elderly workers. In USA more than half of 1.9 million of farms are operated by people over 55 years of age (4). A similar picture is also observed in many European Countries, were (e.g.: Italy), most of agricultural workers are over 65. Due to the deep knowledge of their work, those workers are generally supposed to be aware of the occupational risks they run; nevertheless, the picture has been changing very quickly in last decades: the recent growing flow of migrant workers, usually coming from developing countries or countries in transition, and the old scourge of illegal work make the situation rather difficult to manage, with regard to occupational health and safety. The migrant workforce often consists in reality of whole families, although formally only the head of the family is employed. In many countries, children of migrant and seasonal workers work with to their parents but do not figure on the payroll. As much work is paid on a "piece-rate" basis, migrant and seasonal workers need their children to work in order to achieve a living wage. Risk communication, together with information and training of agricultural workers, are affected by cultural – not merely linguistic – gaps; moreover, illegal workers, even when autochthonous, do not enter the system of registration of occupational diseases and injuries, making the picture shown by official reporting systems incomplete. In developing countries, the number of registered agricultural workers is even lower than in developed ones, and child and elderly people labor is present as well. Moreover, workers are exposed to significantly higher occupational risks than agriculture workers in developed countries with no knowledge and awareness of the risks.

Working conditions in agriculture differ very much depending on type of employment relationship. Waged agricultural workers are a group distinct from farmers because they do not own or rent the land on which they work nor the tools and equipment they use. Such workers do not form a homogeneous group but they comprise: permanent (full-time) agricultural workers; temporary or casual agricultural workers; seasonal agricultural workers; migrant agricultural workers, piece-rate workers; or workers receiving 'in-kind' payment. Permanent workers usually have better wages, some kind of social and health insurance as well as better housing. Unfortunately, most of agricultural workers are seasonal, casual and temporary, engaged on daily basis. They are involved in lowest-skilled tasks (with lowest wages), in poor working conditions. Most seasonal, casual or temporary workers do not receive any form of social security or unemployment benefit, holidays with pay, or sickness or maternity leave (12). Indeed, many full-time waged agricultural earners lack these same benefits. Usually, those workers do not have any information on occupational risks and do not have contact with occupational health and safety personnel.

Child labor is quite often present in agriculture, especially in developing countries: ILO estimates that at least 250 million children aged between 5 and 14 years work in developing countries, and that almost half of them works on full time basis. According to ILO International Programme on the Elimination of Child Labour, the total number of economically active child population between 5 and 17 years old is estimated 352 million; about 73 million are 5 to 9 years old (one in eight children, roughly 12,2% for that age category) have been working in economic activity in 2000, mostly engaged in unpaid economic activities in the family farm or business. Only a minority were involved in paid work in non-agriculture activities. Having in mind structure of economies in developing countries as well as tradition and social culture, one could estimate that at least two thirds of 250 million children is linked to work in agriculture activities (13).

Occupational risk factors in agriculture

The agricultural workers can be exposed, during their activities, to several risk factors, which include biological agents, such as organic and inorganic dusts an allergens but also contact with plants, animals, insects. Exposure to physical risk factors such as noise, vibrations and ultraviolet light might be very relevant, as well as mobilitation of heavy weights and working in inappropriate postures, or in conditions characterized by repetitive motions. Also exposure to chemical substances can take place; it is worth mentioning that not only pesticides are to be listed in this group, but also other substances such as solvents and gasoline. Usually, the organization of the work might be a treat to the worker's health, in particular a very long working time, quite often starting at the sunrise and ending at the sunset, often under exposure to noxious climatic conditions, due to fact that most of agricultural activities are carried out in the open air.

Finally, other conditions, not directly related to the workplace, can affect agricultural workers' health, that is inappropriate hygiene and water supply.

Evaluating the weight of these risk factors for a single worker is often very complicated, because of multiple tasks on multiple locations carried out by same person, and seasonal work, including urgency of certain tasks.

The above mentioned risk factors significantly affect agricultural workers' health leading to a variety of illnesses ranging from acute poisonings to cancer, hearing loss, musculoskeletal diseases upper limb work-related musculoskeletal disorders due to biomechanical overload, allergies, infections, thermal shocks and injuries.

Injuries

Due to the lack of appropriate registration system in many countries, there are no reliable data on occupational injuries in the sector. ILO estimates suggest that half of fatal occupational injuries in the world are attributable to agriculture (15). Keeping in mind that the estimated yearly number of fatal occupational injuries in the world is 345,719 (11) we can conclude that around 170,000 agriculture workers dies every year due to occupational accidents. No precise data on non fatal injuries in agriculture are available but, assuming that also in this case about half of the total burden of non fatal occupational accidents is caused by agricultural activities, we can estimate that, out of 263,838,111 (11), more than 130 million of occupational injuries yearly could be linked to agriculture. Comparing this estimate with 20,768,000 injured persons in road accidents (22) one has a much clearer picture on the importance of preventing agricultural injuries. Data from Finland indicate that the most of fatal occupational injuries in agriculture are tractor related (18). Canadian results too suggest that most of fatal injuries are agriculture machinery related, showing also a male to female ratio of 11:1 (7). Similarly, results of USA study on fatal injuries in agriculture suggests that male to female ratio in youths is 4:1, with the 45% involving person less than 16 years old (10). In developing countries occupational injuries in agriculture are not so frequently machinery related. For example, in Tanzanian rural areas cuts and stabs are the most frequent injuries, with a gender ratio similar to that found in developed countries (17).

Occupational diseases in agriculture

Data on occupational and work related diseases in agriculture workers are even less certain than data on occupational injuries. First of all, almost all over the world, occupational health structures and services are lacking in rural areas, and the health care of agricultural workers is carried out by rural general practitioners. This means that no health surveillance focused on occupational risks is carried out. General Practitioners often do not have any training in occupational health. In many cases, the observed pictures are typical of works related diseases, in which occupation is one of the aetiological factors, but not the only one. This makes it very difficult to estimate the role of occupational risk factors in the onset of the disease, in particular in the elderly: in these workers, when a chronic-degenerative disease is reported, the effects of age and occupation are very hardly distinguishable and quantified. Also the recognition of other work related health problems is difficult (e.g.: diagnosis of mild and moderate pesticide poisonings), contributing to the above mentioned lack of reliable epidemiological data. In addition, a large proportion of agricultural works is made buy "non official workers". This means that very often diseases are reported as "generic" and not as occupational ones. Moreover, significant differences in regulations and criteria for recognition of occupational diseases among countries (e.g.: different lists of occupational diseases) contribute to the unavailability of veritable data even because registration of occupational diseases is quite often a problem especially in developing countries.

Nevertheless, World Bank estimates that in 2001 there have been 1.687.061 fatal work-related diseases and among them 438.480 deaths caused by dangerous substances (21). Analogue to occupational injuries, one could estimate that half of fatal work-related diseases could be linked to agriculture. So, if we add estimate of fatal occupational injuries in agriculture (170.000) to estimated number of fatal work-related diseases in agriculture (840.000), we could attribute to agricultural activities roughly 1 million of deaths per year.

Apart for fatalities, also the burden of occupational diseases in the sector needs to be estimated: data recorded in the European Union (9) suggest that the most common occupational diseases in the agriculture are musculoskeletal, followed by respiratory diseases, skin diseases and sensory organ diseases (table 1). It is important to underline that allergies as a whole represent a very relevant group. The burden of other diseases, including occupational cancers, is very low. As for infections, the only reported occupational disease is represented by brucellosis. Consistently, official data clearly indicate the most important group of risk factors is represented by the biomechanical and physical ones (table 2).

However, the number of occupational diseases yearly reported is very low (only 1165 in the European Union), and doubts arise on a possible, significant, underreporting of such events. The possible cause of underreporting have been previously listed and can be identified, briefly, in the typical conditions of small size and family enterprises and to the poor training on agriculture of occupational health doctors. Also illegal work can affect this data.

The epidemiology of cancer in agricultural workers is a very complex issue. Actual results of epidemiological studies have been inconsistent, and a clear picture of the epidemiology of cancer in relation to agricultural exposure has to emerge yet (2). Potential carcinogenic threats in agriculture can be due to different kind of substances and risk factors. In fact, farmers may come in contact with a variety of potential carcinogenic agents, including pesticides, solvents, oils and fuels, dusts, paints, welding fumes, zoonotic viruses, microbes, and fungi (5). However, the results of epidemiological studies suggests that farmers had consistent deficits for cancers of the colon, rectum, liver, nose and bladder, while malignancies showing in some cases excesses in-

Table 1 - *Number and incidence rate (per 100 000 workers) of occupational diseases in agriculture, hunting and forestry in EU countries , EODS obligatory list. - 2003*

Disease	Number of cases, non-fatal, EODS obligatory list	Incidence rate, non-fatal, EODS obligatory list
Infections	29	1.00
Cancers	5	0.02
Neurologic diseases	61	2.02
Diseases of sensory organs	142	5.01
Respiratory diseases	296	10.06
Skin diseases	162	5.08
Musculoskeletal diseases	463	16.05
Unknown	0	0.00
Total	1165	41.06

Table 2 - *Number of occupational diseases in agriculture, hunting and forestry by causative agent in EU countries, EODS obligatory list. - 2003*

Causative agent	Number of cases, non-fatal, EODS obligatory list
Inorganic chemicals	14
Organic chemicals	8
Other chemicals	0
Physical factors	150
Bacteria	27
Viruses	0
Parasites	0
Fungi	74
Plants	56
Animals	92
Other biological agents	0
Biomechanical factors	485
Psychosocial factors	0
Industrial factors and products	85
Other factors	0
Unknown	168
Total	1165

clude Hodgkin's disease, leukemia, non-Hodgkin's lymphoma, multiple myeloma, and cancers of the lip, stomach, prostate, skin (nonmelanotic), brain, and connective tissues. The etiologic factors that may contribute to these excesses in the agricultural environment have not been identified (5).

A recent, large, prospective cohort study (1) of private applicators, commercial applicators, and spouses of farmer applicators conducted in Iowa and North Carolina showed low overall cancer incidence rates, probably as a result of low overall smoking prevalence and other lifestyle factors. On the other hand, the observed slight excess of cancer of the prostate (SIR=1.24) and ovaries (SIR=2.97) among applicators was considered as possibly occupationally related. The excess risk of melanoma observed among spouses (SIR=1.64) was unexpected and did not find any explanation.

Available data for pesticide cancer risk to children, including rural inhabitants, are inconclusive. However, the fact that many of the reported increased risks are of greater magnitude than those observed in studies of pesticide-exposed adults, suggests that children may be particularly sensitive to the carcinogenic effects of pesticides (23).

This finding has to be taken in due account, considering that child labour in agriculture probably brings about occupational exposures of millions of children disseminated in all the corners of the world.

These data confirm that agriculture is one of the most dangerous human activities.

RISK MANAGEMENT IN AGRICULTURE

Based on the above consideration, it is evident the urgent need of sound risk assessment and management activities.

To pose the basis for the development of these activities, it must be taken into account the main characteristics of agriculture, which are similar in any area of the world and may in some cases make very complicated the planning and realization of risk assessment:

– Small size and family based enterprises are usually prevalent. It is worth mentioning that, in most national legislations, a relative or a son is not necessarily considered as a "worker". Therefore, these workers are often ruled out from any OH & Safety program.

– Living and working environments are often overlapped, the same for risk factors.

– The activities done by an agricultural worker significantly vary among seasons, and, in the same season, in a single working day. This makes it very complicated to define "typical" conditions, necessary in any risk assessment activity.

– Several different chemical substances are intermittently used over time (different pesticides, other agrochemicals, such as fertilizers, growth hormones, etc.).

– Occupational exposure to chemical can be affected by meteorological and environmental conditions, since part of the activities is done outdoor, and part indoor.

– Activities often involve elderly and children, also in developed world.

The fact that activities done by agricultural workers may significantly affect either the environment or the quality of the food provided to the population make even more urgent the need of risk assessment and management activities.

Even if agricultural activities are linked to a number of occupational risks, occupational health and safety services are not diffuse. Occupational health and safety services cover only large agriculture holdings in developed countries and to small extent large holdings in developing countries. For all other holdings contacts with occupational health and safety staff are more exception than a rule. It is also important to underline that quite often health surveillance of agricultural workers is carried out by rural general practitioners, which usually do not have enough proper education nor knowledge on occupational risks in agriculture. The most of general practitioners, even in developed countries, have only few hours of occupational health education and none of them focuses on occupational risks in agriculture. The fact that agricultural activities are frequently linked with immigrant work (especially in developed countries) and that those workers are not a part of health system causes that the percent of agriculture workers provided with a proper health surveillance program is very low.

Priorities

In so complicated situation like occupational health and safety problems in agriculture it is not so easy to clearly select priorities. Anyway, "legalization" of agriculture workers could be a key to solving all other problems. It has been already mentioned that only the minority of agricultural workers are registered. Support activity of legalization of agricultural workers carried out by local governments will lead to win-win situation. Both sides will benefit from legalization: owners of agriculture holdings will pay bit more for taxes, insurance, health and safety issues but they will benefit from healthier workforce, less occupational diseases and accidents. Workers will work better in order to keep their job, owing registered holding and production will enable owner to directly reach end-user and to get better price for his products. Also, owners in that case could reach financial market and get support for their ideas for development of production, ordering new machinery etc. At the end, he will earn much more through legal work than now through illegal work. Of course field workers and their families will benefit the most from the fact that they are registered as agriculture workers, beside health and retirement insurance, they will benefit also from occupational health surveillance programs, from better safety measures at workplace and from more less stable employment situation. Local governments will benefit from program of legalization: the number of occupational diseases and injuries in their countries will decrease leading to increased life expectancy. Also due to encouraged owner's agriculture as discipline will be stronger, creating more income and job positions not only in the sector. At the end they will create a positive vicious circle of development in their countries.

In case that local government recognizes the importance of legalization issue in agriculture this will enhance solution for many other problems in that field. Occupational health and safety problems are among those. It is already mentioned that only a few agricultural workers get appropriate information and care from occupational health and safety practitioners. In case that legalization campaign succeeds, owners will be encouraged to provide occupational health and safety service to their workers. This will lead to a better understanding of hazards related to agriculture among workers as well as among agriculture holding owners. Better understanding of hazards will per se decrease risks in agriculture (19). Better understanding of hazards will also lead to introduction of appropriate safety measures, development and implementation of new technologies in agriculture, implementation of adequate personal protection measures, and all those measures will further decrease risks in agriculture.

Increased attention to occupational health and safety in “legal” environment as well as a better recognition of potential hazards in agriculture will lead to a decrease in the use of obsolete pesticides. “Legal” food producers will be encouraged by end-users to produce safe food which will also contribute to decreased use of obsolete and dangerous plant protection products. Local governments will have also possibility to encourage “legal” agriculture to decrease use of those compounds. Those activities will have a number of implications on environmental and occupational safety (20). Improved environmental conditions will lead to improved health of rural population. Improved food safety together with improved environmental conditions will cause positive effect on health of whole population (8). Decreased use of obsolete pesticides together with implementation of modern safety measures will decrease a number of acute and chronic intoxication in agriculture workers. Also, this will significantly decrease number of occupational cancers in that group of workers. All those measures will increase life expectancy in rural as well as in urban areas.

Providing occupational health care for all agriculture workers is among top priorities for third millennium. Nowadays occupational health practitioners are focused on industrial workers and more and more to office workers neglecting agriculture. Comparing risks, occupational injuries and diseases in different industries, office work and agriculture is impossible due to lack of reliable data for agriculture. But comparing of estimates leads us to conclusion that most of occupational health activities are focused on sectors with significantly lower risk than agriculture. There are several explanations for such situation:

– in the past industrial activities had much more inherent risks than agriculture and that lead to focus of occupational health on industry;

– as already mentioned, agriculture workers are very often not registered and there are no legal ground for occupational health activities;

– agricultural activities are dominant source of income in developing countries which have a serious lack of occupational health practitioners;

– as agriculture is rather poor discipline comparing to industry this may have also some influence on occupational health practitioners.

Presence of occupational health practitioners in rural areas could completely change the situation (6). Through their core activities they will improve health of agriculture workers, decrease number of occupational injuries, occupational and work related diseases. They will also be part of occupational health services, in charge not only of health surveillance and preventing activities, but also of data collecting and elaborating: this will create the basis for fulfilling the lack of knowledge on the trend and burden of disease in the sector. Through programs of health promotion, occupational health physicians will affect life of families and communities in rural areas. Better understanding of real magnitude of occupational health problems and challenges of work in rural areas together with legalization of agriculture workers will lead to increased presence of occupational health practitioners in agriculture sector.

Insurance and retirement programs are some of the most important issues for agricultural workers. Legalization of agriculture workers could provide excellent environment for solving problems like compensation in case of occupational disease on injury. As there is limited number of agriculture workers trade unions even in developed countries, the role of local governments is the most important one in this process. They have to encourage employers, holding owners, agriculture workers as well as insurance companies to organize sustainable program for retirement insurance. Also, governments, especially in developing countries, are responsible for developing non-profit insurance schemes and founds for insurance of agriculture as well as other workers in case of occupational disease or injury.

Important part of whole system is labor inspection. As nowadays most of agriculture workers are not registered they are not a subject for labor inspection. Once become "legal" workers, labor inspection will have an important role in monitoring occupational health and safety issues. Labor inspections in agricultural settings can be carried out in two major ways:

– special labor inspection unit for agriculture linked to Ministries of Labor, Agriculture and Health;

– classic labor inspectorate unit linked to Ministry of labor but with specialists for agriculture within the unit.

Both concepts have advantages and disadvantages but nevertheless the most important fact is that agriculture is covered by labor inspectorate. Their role in agriculture overcomes traditional roles of labor inspectors who will have also educational role. As in case of other proposed measures from involvement of labor inspectors in agriculture all parties will benefit. Workers will get more protection, employers will get free advisors, occupational health and safety staff will get supporters for their activities. Local government will get proper information on current problems in that field as well as precise data and unbiased reports on occupational injuries and diseases in agriculture.

Conclusion

Actual data on fatal and non fatal occupational injuries in agriculture indicates that there is great need for increased presence of occupational health and safety professionals and services in agriculture. Legalization of agriculture workforce is among most important prerequisite conditions for preventive actions and improvement of whole situation in rural areas as well in developing countries with strong dependency on agriculture. So, the first step and responsibility for it is on local governments. They have to encourage employers to start process of legalization and to creating a stable environment for development of agriculture. Also, they have to initiate creating agriculture trade unions and to decrease child labor through preventive activities. Local governments are also responsible for developing labor inspection structures appropriate for agriculture and for creating national systems for data collection, aimed at supporting universities and other research centers to collect the set of data adequate to fulfil the uncertainties and the data gap still present in any country.

These goals can be reached only with the creation of occupational rural health experts, able to face the different local problems at their different levels: this task is in the hands of the Universities and other institutions in charge of training and education activities.

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La Medicina del Lavoro

Med Lav 2006; *97*, 2: 430-437

Risk assessment and management of occupational exposure to pesticides in agriculture

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Key words

Agriculture; pesticides; risk assessment

Summary

Nearly 50% of the world labour force is employed in agriculture. Over the last 50 years, agriculture has deeply changed with a massive utilisation of pesticides and fertilisers to enhance crop protection and production, food quality and food preservation. Pesticides are also increasingly employed for public health purposes and for domestic use. Pesticide are unique chemicals as they are intrinsically toxic for several biological targets, are deliberately spread into the environment, and their toxicity has a limited species selectivity. Pesticide toxicity depends on the compound family and is generally greater for the older compounds; in humans, they are responsible for acute poisonings as well as for long term health effects, including cancer and adverse effects on reproduction. Due to their intrinsic toxicity, in most countries a specific and complex legislation prescribes a thorough risk assessment process for pesticides prior to their entrance to the market (pre-marketing risk assessment). The post-marketing risk assessment takes place during the use of pesticides and aims at assessing the risk for exposed operators. The results of the risk assessment are the base for the health surveillance of exposed workers. Occupational exposure to pesticides in agriculture concerns product distributors, mixers and loaders, applicators, bystanders, and rural workers re-entering the fields shortly after treatment. Assessing and managing the occupational health risks posed by the use of pesticides in agriculture is a complex but essential task for occupational health specialists and toxicologists. In spite of the economic and social importance of agriculture, the health protection of agricultural workforce has been overlooked for too many years, causing an heavy tribute paid in terms of avoidable diseases, human sufferance, and economic losses. Particularly in the developing countries, where agricultural work is one of the predominant job, a sustainable model of development calls for more attention to occupational risks in agriculture. The experience of many countries has shown that prevention of health risk caused by pesticides is technically feasible and economically rewarding for the individuals and the whole community. A proper risk assessment and management of pesticide use is an essential component of this preventative strategy.

Riassunto

«Valutazione e gestione del rischio derivante dall'esposizione a pesticidi in agricoltura». *Circa il 50% della forza lavoro mondiale è occupata nel settore agricolo. Negli ultimi 50 anni, le tecniche agricole sono profondamente*

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mutate e prevedono l'utilizzo intensivo di pesticidi e fertilizzanti per aumentare la redditività del suolo, la qualità del cibo e la sua conservazione. Inoltre, gli antiparassitari sono utilizzati per scopi di salute pubblica e in ambiente domestico. I pesticidi sono sostanze chimiche uniche, in quanto sono intrinsecamente tossici nei confronti di diverse specie, sono deliberatamente rilasciati nell'ambiente e presentano una limitata selettività di specie. La tossicità varia a seconda della famiglia del composto ed è generalmente maggiore per i composti di prima sintesi. Nell'uomo l'esposizione a pesticidi è responsabile dell'insorgenza di episodi di avvelenamento acuto e di effetti a lungo termine che includono i tumori e gli effetti avversi sul sistema riproduttore. In considerazione della loro intrinseca tossicità, nella maggior parte dei Paesi sono in vigore complesse e specifiche normative che prevedono l'esecuzione di un accurato processo di valutazione del rischio prima dell'immissione della sostanza sul mercato (risk assessment pre marketing). Il risk assessment post-marketing avviene durante l'uso del pesticida e valuta il rischio per l'operatore esposto. I dati provenienti dalla valutazione del rischio costituiscono la base della sorveglianza sanitaria dell'operatore. L'esposizione a pesticidi in agricoltura avviene nelle diverse fasi di preparazione/applicazione del prodotto e riguarda anche gli astanti e gli operatori che entrano nei campi immediatamente dopo l'applicazione del pesticida. La valutazione e la gestione del rischio per la salute derivante dall'uso di pesticidi in agricoltura è un compito complesso ma essenziale per specialisti in salute occupazionale e tossicologi. Nonostante l'importanza economica e sociale dell'agricoltura, la protezione della forza lavoro impiegata è stata trascurata per troppi anni, determinando l'insorgenza di malattie evitabili, sofferenza umana e perdita economica. In particolare, nei paesi in via di sviluppo, dove l'impiego nel settore agricolo costituisce una delle attività predominanti, un modello di sviluppo sostenibile richiede maggiore attenzione ai rischi occupazionali in agricoltura. L'esperienza di molti paesi ha mostrato che la prevenzione dei rischi per la salute causati dai pesticidi è tecnicamente realizzabile ed economicamente remunerativa per i singoli individui e per l'intera comunità. Un'adeguata valutazione e gestione del rischio derivante dall'uso di pesticidi costituisce una componente essenziale di questa strategia preventiva.

INTRODUCTION

Agriculture represents the largest occupational sector in the world, as nearly 50% of the world labour force is directly or indirectly employed in agriculture. The proportion of the agricultural workforce varies across the continents, ranging from 64% and 61% of the economically active population in Africa and Asia to 24% and 15% in South America and Eastern Europe and to 4-7% of the population in USA and Western Europe.

Agriculture practices have deeply changed in the last century, leading to the development of a sector that heavily depends on biological and physical sciences, engineering and technology and massively employs pesticides and fertilisers in order to enhance crop production, food quality and food preservation. Pesticides are also widely used for public health purposes as well as for domestic applications: according to a 1992 survey, 75 percent of US households used at least one pesticide product indoors during the past year (5).

Pesticides are characterised by a strong geographical variation in their application and use: in the USA and Europe herbicides are mainly applied, while in developing world insecticides are predominantly used. Differently from other chemicals, pesticides are unique compounds as they are deliberately spread into the environment for plant and crop protection, preservation of food products from biodegradation, defence against vector transmitted diseases, and protection from urban and domestic pests. Pesticide toxicity is not totally specific towards weeds and target organisms, but is also exerted towards other species, man included. As a consequence, exposure to these chemicals poses a risk for human health that requires a specific assessment and management.

Occupational exposure to pesticides takes place both at industrial level during their production and formulation, and during their use in agriculture and for public health or domestic use. In this paper, we will focus the attention mainly on the agricultural uses.

The prevention of health risk from pesticides has to take place both before a chemical is put on the market (pre-marketing risk assessment and management) and after its introduction (post-marketing risk assessment and management).

Pre-marketing risk assessment and management deal with the risk of adverse effects from pesticide use for operators, consumers and the environment; post-marketing risk assessment and management evaluate and control the risk during and after the pesticide usage. The introduction of health surveillance programs for the workers exposed to pesticides is also a fundamental element of risk prevention and management.

Pesticide toxicity

Pesticide toxicity is strictly related to the chemical structure of the molecule and is generally higher for the old compounds still present on the market. Newly synthesised molecules are more selectively acting on targets, are active at a lower dose and are in general less persistent in the environment.

Toxic effects of pesticides to mammals (including man) comprise acute effects and long term effects.

Acute toxicity

WHO classifies the pesticides according to the hazard in relation to acute risk to health. The WHO classification is based primarily on the acute oral and dermal toxicity (LD_{50}) to the rat. Presently WHO (7) has classified pesticides as follows: 28 extremely hazardous (Ia), 56 highly hazardous (Ib), 117 moderately hazardous (II), 119 slightly hazardous (III) and 248 unlikely to present acute hazard in normal use (no category). Most of the recently registered compounds are classified as presenting slight or no acute hazard.

Acute effects appear shortly after acute exposure to a single dose or after exposure to multiple doses within a short time. They include a wide range of reactions in different target organs (central nervous system, peripheral nervous system, skin, respiratory tract, kidney, liver, endocrine system, haematopoietic system, etc). Acute poisonings by pesticides represent a major problem in the world. The WHO estimates an annual incidence of unintentional acute poisoning of about 1 million, with an overall mortality rate of about 1% (of which only 1% is in developed countries). The majority of unintentional pesticide poisonings are occupational, although cases occur in the general population due to improper use or storage of pesticides intended for amateur uses or in-house pest control. Population-based studies in 17 countries gave annual incidence rates of unintentional pesticide poisoning of 0.3-18 per 100,000 (2).

Long-term effects

Long-term exposures occur to farmers, professional pesticide users and, to a much lower extent, to the general population via residues in food and water and by environmental exposure due to indoor and outdoor use for pest control. The identification of subjects who have been occupationally or non-occupationally chronically exposed to pesticides is relatively easy, but an accurate qualitative and quantitative identification of exposure is seldom available. Moreover, extrapolation from current data to assess past exposures as well as the risk associated with a given pesticide are difficult since active ingredients and application practices differ and change with time. This is particularly true in the general population where data on exposure and biological monitoring are scanty if not absent. Attention has been focused on carcinogenicity, allergenicity and teratogenicity, and most recently on endocrine disruption and effects on neurological development of pesticides. However, the long time taken for these effects to develop and show clinically detectable signs hampers their identification in population studies.

Occupational long-term effects are in principle the same concerning the general population but in addition also include respiratory and skin effects. As to the risk of increased cancer development in the workers exposed to pesticides, available studies in general show that the overall cancer mortality rate is not higher among pesticide applicators and manufacturers than in the general population. Recently performed reviews on this subject suggest that a clear epidemiological evidence of increased cancer incidence in the exposed working populations is only demonstrated for a minority of pesticides that have been removed from the market since long time in most countries (4, 6).

Pre-marketing risk assessment and management

There is great debate and controversy in the society about the convenience of pesticide use in agriculture, as benefits and advantages for agricultural practice clash with the possibility of development of adverse effects to humans and the environment in general. Occupational exposure to pesticides in agriculture concerns product distributors, mixers and loaders, applicators, bystanders, and rural workers re-entering the fields shortly after treatment. In addition the agricultural use also determines exposure of consumers, due to chemical residues in food and water.

Due to the intrinsic toxicity of pesticides, the need for a strict regulation of their admission to the market and their use in agriculture has been recognised since long time and in most countries a specific and complex legislation prescribes a thorough risk assessment evaluation process prior to their entrance to the market. In general terms, the pre-marketing risk assessment of pesticides aims at reducing the risk for workers, consumers and the environment to a level which must be negligible, minimal or at least acceptable in order to allow their use.

The pre-marketing risk assessment made mandatory by law, shares similar approaches in all countries and is generally based on the requirement that the applicants seeking the authorisation have to demonstrate the "safety" or "acceptability" of the proposed uses to the competent Authority. The founding principles of the risk assessment process in most parts of the world include the "Precautionary Principle" prescribing that, when there is a lack of scientific certainty, precaution should be applied in the risk evaluation.

In the European Union, the registration and authorisation of a pesticide is regulated by the European Council Directive 91/414, which establishes that "*a plant protection products can be authorised only if it does not exert any harmful effects to human health and the environment*". In a similar way, the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) in the USA requires that the proposed use of a pesticide should not pose "*an unreasonable adverse effects on health or the environment*" being this term defined as *"(1) any unreasonable risk to man or the environment, taking into account the economic, social, and environmental costs and benefits of the use of any pesticide, or (2) a human dietary risk from residues that results from a use of a pesticide in or on any food inconsistent with the standard"*. The equivalent legislation in Canada, the Pest Control Products Act (PCPA), defines health and environmental risks as *"the possibility of harm (to human health or the environment, including its biological diversity) resulting from exposure to or use of the product, taking into account its conditions or proposed conditions of registration"*.

In all the legislation schemes above mentioned, the occupational risk to the operators and the workers plays a central role in the risk assessment process. As stated in the European Directive 91/414, the authorisation cannot be granted "*if the level of the operator exposure during pesticide application exceeds the acceptable operator exposure level (AOEL)*".

The overall objective of the operator risk assessment is to assess whether the estimated or predicted operator exposure on a given use is acceptable. The first step of the evaluation consists of the study of the toxicological properties of the active principle in experimental animals and the derivation of an acceptable operator exposure level (AOEL). The AOEL represents the level of exposure at which no harmful effect is expected in operators applying a pesticide according to good agricultural practices (i.e. respecting general hygienic and proper working rules) and is derived from the NOEL obtained in animals divided by an uncertainty factor usually set to 100.

The second step consists of the predictive estimate of the operator exposure level, both in terms of external doses (inhalation and dermal) and internal or absorbed doses. Predicted exposure is generally calculated by means of models that make use of generic exposure databases, under the assumption that exposure level during application of a pesticide is independent of the chemical nature of the pesticide in use and instead dependent on the type of formulation (liquid, wettable powder, etc.), the handled amount per day, the acreage treated, and above all, the technique of application (by hand, by tractor mounted upward sprayers, by tractor mounted downward sprayers, etc.). Thus, predicted exposure is quantified making reference to the application scenarios typical for the cultures to which the pesticide is destined and the operator risk is then defined as the ratio between the predicted exposure and the AOEL. A similar approach is followed for bystanders and agricultural workers re-entering the field after treatment.

In the case of consumer dietary risk assessment, from long-term toxicological studies an acceptable daily intake (ADI) is established, which represents the amount of substance or its residue in or on food that can be ingested every day for all the life without expected adverse health effects. Then daily residue intake by food is calculated using the average regional diet of the population and the consumer risk is defined as the ratio between the predicted dietary exposure and the ADI.

Environmental and ecotoxicological risk assessments are performed through analogous, but more complex, processes that require the modelling of diffusion of the pesticide into the environment, the calculation of predicted concentrations in the environmental media (air, soil, water), and the establishment of toxicity levels for all the different non-target species that inhabit the environment. The predicted level of exposure (acute and long-term) to the pesticide is then calculated for each individual species and the environmental risk is defined as the ratio between toxicity and exposure levels for each species.

The pre-marketing risk assessment of pesticides poses a number of scientific issues and has important limitations that need to be acknowledged. Firstly, the toxicological studies in pre-marketing risk assessment are almost exclusively performed on animals and need to be extrapolated to man, with the consequent uncertainty to this interspecies extrapolation. Secondly, certain effects such as developmental effects and cancer, can only be tested at high doses in animals and a risk extrapolation has to be made from the high experimental doses to the low doses of interest for the human population. Thirdly, the risk assessment is performed for a single pesticide at a time, thus precluding the evaluation of multiple concurrent exposures and their possible interactions. Fourthly, cumulative and aggregated exposures (i.e. exposure from all the different sources) are often difficult to assess.

Among the reasons of possible inaccuracy of the risk assessment results, there is also the suitability of the deterministic models employed to estimate operator exposure. In fact, the generic data base in use contain a limited number of field studies that do not completely represent the variety of scenarios, cultures and exposure conditions typical of all geographical areas. In addition, deterministic models tend to be over-conservative as they are based on the multiplication of serial worst case default assumptions that at the end may lead to unrealistic results. An answer to such limitations could be represented by the introduction of a probabilistic approach in the risk assessment processes, which, making use of distribution of values instead of fixed single values for each variable, allows a more complete and realistic assessment of pesticide risk. This approach can take into account regional and local differences through the introduction of local value distributions obtained by local field surveys. Moreover, the probabilistic risk assessment, yielding a distribution of risk as a result, enables the regulator to choose the desired level of protection (90%, 95%, 99%) and to determine the uncertainty of the assessment at each level of protection selected.

Risk characterisation

The main objective of risk characterisation is the evaluation of the probability and magnitude of the risk to human health. The risk can be classified as negligible, acceptable or not acceptable. The identification of the main factors determining the risk allows the implementation of subsequent possible mitigation measures which can include the substitution with a less toxic compound or the introduction of the use of personal protection equipment to lower exposure.

POST-MARKETING RISK ASSESSMENT OF PESTICIDE USE

Post-marketing risk assessment takes place after a pesticide has been put onto the market. Occupational pesticide exposure takes place in industry for pesticide production and/or formulation and in agriculture and public health for their use.

In industry, workers are exposed to a limited number of pesticides at a time and exposure conditions are relatively constant and easy to measure, thus exposure and risk assessments for pesticides share the same approach common to any other industrial chemical substance.

On the contrary, in agriculture and in public health applications workers use more compounds simultaneously, the work is characterised by a complexity and variety of tasks, and often takes place in open fields. Hence the level of worker exposure is highly variable, depends on the patterns of pesticide use and the techniques and tools of application, is influenced by climate and environmental conditions, and is also determined by factors related to the individual workers, such as proper and constant use of personal protection equipment, worker professional education and habits, and diligent adherence to hygienic practices.

The main job tasks involving pesticide exposure in agriculture include mixing and loading, and spray application, which can occur in open fields or in greenhouses. During mixing and loading workers are exposed to concentrated products, while during open-field applications they are exposed to diluted compounds mainly through the skin; exposure greatly varies according to the culture type, the application techniques, and the personal protection adopted.

Activities performed in treated fields shortly after treatment represent a potential condition of exposure for all agricultural workers, as they can get in contact with dislodgeable pesticide residues remaining on leaves and crops.

Skin contamination represents the main route of exposure to pesticides in open-field applications. Dermal absorption rates commonly vary between 1 and 20% and exceptionally may reach 50-70%, depending on the liposolubility of the compound, the skin permeability, and the presence of skin lesions.

Inhalation exposure occurs in case of exposure to gases, vapours, or fine particulates and represents an important exposure route mainly for greenhouse or indoor applications. Respiratory absorption can take place in alveoli or in nose, pharynx, and bronchi, particularly for lipophylic compounds.

Ingestion does not represent the main route of exposure in agriculture; however pesticides inhaled in the upper airways can reach the mouth and be ingested. Scarce hygienic practices, hand-to-mouth contact, and food consumption in the workplace can also be responsible for a substantial pesticide oral absorption.

There are several methods of occupational exposure assessment in the fields, each one with different degree of precision. They range from the simple estimates of exposure from proxies or the use of generic databases of exposure together with models, to the direct measurements of skin and inhalation exposures. The most accurate way of exposure assessment is represented by the biological monitoring.

When a simple estimate of exposure has to be made, the factors to take into consideration should al least include: the frequency of application, the amount of pesticide employed, the sprayed field dimensions, and the toxicity of the pesticide, as indicated by the WHO classification or the value of the AOEL.

Models using exposure factors derived from generic databases can be used for a quantitative assessment of exposure when data from direct measurements in the field cannot be obtained. Models require the input of values of a number of variables, such as the pesticide dose applied, the dimensions of the treated area, the application tools employed, the culture type, the use of personal protection equipment, and the skin absorption rate of the pesticide. Several models and generic databases are available for use both in Europe and in North America.

Exposure measurement in the field aims at dermal and inhalation exposure assessment. External dermal exposure can be assessed through the measurement of the amount of pesticide deposited on the coverall and the gloves used during the application of the product. Dermal exposure can also be quantified through the determination of pesticide deposition on patches or pads applied on several sections of the operator body underneath the garments (1). Dermal exposure assessment generally provides an accurate estimate of exposure but is rather complex and expensive to perform and cannot be regarded as a routine method of assessment. For assessment of inhalation exposure, the measurement is generally based on personal air sampling. This kind of exposure assessment is recommended for indoor and greenhouse applications, as in this case respiratory exposure has often the same or greater importance than skin exposure.

Internal dose measurement deals with the dosing of the pesticide or its metabolites in body fluids such as plasma or urine. It clearly represents the gold standard method to assess pesticide exposure as it measures the real intake of the compounds. Biological monitoring, however, presents some drowbacks due to the fact that it is complex to perform, analyses are based on laborious and expensive analytical methods, and requires the availability of a specialised laboratory.

After exposure measurement, the results have to be compared with occupational exposure limits. If AOEL values are not available for the compound of interest, the assessor might use other occupational exposure limits, such as f.i. the ACGIH threshold limit values (TLVs). These limits, however, refer to airborne pesticide concentrations that are useful to control respiratory exposure in industry, but are of limited use in agriculture where pesticide exposure mainly takes place via the skin. Biological exposure indicators are available only for a very limited number of pesticides (3) and this further hampers the possibility of biological monitoring application.

Health surveillance of agricultural workers

The purposes of health surveillance are the regular assessment of the health conditions of the workers, the identification of specific contraindications to work, and the early detection of adverse effects due to pesticide exposure. Health promotion should also be an important objective of the health surveillance programme whenever possible (8).

Pre-employment and periodical medical examinations constitute the basic activities of any health surveillance programme. It has to be borne in mind that occupational risk factors in agriculture do not only include pesticides; a number of other risk agents have to be considered, namely noise, vibrations, biological hazards, handling of heavy goods, electrical hazard, fire, microclimate, and finally accidents. When compared to other job sectors, the planning and execution of health surveillance of workers in agriculture is more difficult due to the specific features of the agricultural work, that is characterised by a variety of tasks, regional and seasonal variations, and possible intermittent exposures to a variety of chemical products.

The pre-employment evaluation of agricultural workers aims at several goals: identifying specific health status or personal conditions that could represent a contraindications to work, diagnosing health conditions that could be worsened by exposure to specific risk factors, setting up a baseline evaluation of the worker to be re-evaluated in follow-up examinations.

The objective of the periodical medical examination is to detect as early as possible the development of adverse effects that may have been caused by pesticide exposure and that represent an early sign of disease development. The periodical examination also ought to detect any health change that may compromise the ability to continue the work or that could deteriorate if work is continued.

The schedule of the medical surveillance of workers exposed to chemicals usually is at least annual. However, the periodicity can be varied based on the results of the risk assessment, taking into account the level of exposure to pesticides, the type of the product/formulations employed, and the mode and frequency of application. The periodicity of examination can be personalised for individual workers according to their general health status or, if present, according to the results of the biological monitoring of pesticide exposure.

As a general approach, the medical surveillance of a worker exposed to pesticides should include an accurate collection of the personal, work, and health history, with particular attention to the conditions of specific organ targets, according to toxicity of the used compounds. Routine laboratory tests, including red and white cell counts, platelet counts, liver function tests, and kidney function tests should complete the basic examination. Respiratory function tests, other clinical tests, and specific investigations should be included in the medical surveillance protocols according to the specific target toxicity of the used pesticides or the presence of abnormal findings the nature of which need to be ascertained. Publications that contain guidelines and protocols for the medical surveillance of workers exposed to certain groups of pesticides are available in the literature.

CONCLUSIONS

Assessing and managing the occupational health risks posed by the use of pesticides in agriculture is a complex but essential task for occupational health specialists and toxicologists. In spite of the economic and social importance of agriculture, the health protection of agricultural workforce has been overlooked for too many years, causing an heavy tribute paid in terms of avoidable diseases, human sufferance, and economic losses. Particularly in the developing countries, where agricultural work is one of the predominant job, a sustainable model of development calls for more attention to occupational risks in agriculture. The experience of many countries has shown that prevention of health risk caused by pesticides is technically feasible and economically rewarding for the individuals and the whole community. A proper risk assessment and management of pesticide use is an essential component of this preventative strategy.

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La Medicina del Lavoro Med Lav 2006; *97*, 2: 438-439

The occupational physician in the post-modern world

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The Author shows how historically the world of work has changed and how this change was paralleled by a modified occupational health.

Accordingly, also occupational physicians were forced to decide whether modify their professional behavior or else to stagnate.

These changes were:

– from slave to paid work;

– from work with animals to work with machines;

– from day work to shiftwork;

– from monotonous to repetitive work;

– from dynamic to static work;

– from healthy to unhealthy work;

– from individual to teamwork;

– from polluting to ecologically aware work;

– from anti-ergonomic to ergonomically adequate work;

– from work done to gain money to work done for personal fulfillment;

– from modern (XX Century) to post-modern work (XXI Century).

Post-modernity is a concept that synthesizes the complexity of our social, cultural and economic situation.

These three aspects interact and form a context in which, among other human realities, a company, an association and an occupational health physician may evolve.

Within this new paradigm, the occupational health physician must have her/his professional strategy, that is to define how it will be better for being different.

Being better means defining clear goals, paths and objectives, and identifying adequate tools and skills for translating them into actions.

Being different is the condition of being better.

Making things differently means having routines which take you to the unusual.

A better occupational physician, or a better occupational health organization is that physician or that organization able to develop an organizational structure, to create different processes and to well manage problems and change-related pain of people.

In the post-modernity, companies and organizations must go through a process of change and adaptation or otherwise they will be exiled from this world.

A post-modern occupational physician should be, first and foremost, a professional in the full meaning of the word: an ethical human being, thinking globally and acting locally; he should have a holistic approach, and professional maturity. He should be willing to grow and help others grow. He should know when it is necessary to say YES and when it is necessary to say NO.

Secondly, he should have technical capacity, and adequate training. He should be ready to work in prevention, know how to work in team, and know how to be a leader. He should belong to occupational health associations in all levels, that is, state / national / international associations.

He will give more importance to the people who form a company or an organization, not placing them in opposite sides.

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The solution for the chronic occupational health problems will not come from the knowledge or ideology of the professionals, nor will the solution for the wearing off of the organizations will come from the technological advancement. These solutions will undoubtedly come through internal transformations occurring inside the persons, allowing qualities and virtues of the true professional to arise.

Ethics is a requirement of the post-modern world, and it may and must be extended to occupational health.

ICOH has an ethical code which is very well divulged among its associates.

The Author proposes a trans-disciplinarity orientation to occupational health, since knowledge flows through the different subjects and sciences and transcends the professionals.

Within this new paradigm, the occupational health physician will have a fundamental role, but at one only condition, a pre-requisite: she/he her/himself has to be post-modern.

A post-modern company will be in need of such a post-modern occupational health physician, as well as of her/his occupational health association.

The occupational health physician must never turn her/his back to the risks existing in her/his work.

Maybe the greatest challenge facing an occupational health physician is to change mentally and behaviorally, and also to change her/his way of thinking. The stereotyped narrow-mindedness of the male as well as the female brain must be removed.

Some advices for future occupational health physicians are the following:

– do not set unreal deadlines;
– not all presentations will be successful;
– the traditional hierarchic structure only gets on the way;
– pay attention to the market signs;
– what is good for one professional may not be good for another;
– choose the most adequate tool for each situation;
– not always we are able to implement technical solutions;
– not always we get the results we plan;
– the usage of technical solutions is inevitable. However, difficulties of the people must be considered;
– get used to working under pressure;
– believe in yourself, have confidence;
– go till the end, never give up. Fight.

Alternatively, for those who prefer to fail as occupational health physicians, we have the following advices:

– blame others;
– blame yourself;
– do not set objectives;
– do set the wrong objectives
– choose shortcuts;
– choose the longest way;
– don't worry about small details;
– give up soon;
– the weight of the past;
– the illusion of success.

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– FOGARI R, ORLANDI C: Essential hypertension among workers of a metallurgical factory. In Rosenfeld JB, Silverber DS, Viskoper R (eds): *Hypertension control in the community.* London: Libbey J, 1985: 270-273
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