

# Exposure to carcinogens and mortality in a cohort of restoration workers of water-damaged library materials following the River Arno flooding in Florence, 4 November 1966

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## KEY WORDS

Paper restorers; flood; exposure; emergency response; flood response; mortality study

## SUMMARY

**Background:** In Florence, Italy, the Arno River overflowed on 4 November 1966 and the rare library collections of the National Central Library in Florence (FNCL) were flooded. A Restoration Centre was immediately set up. For book restoration many toxic chemicals were used, such as chlorinated solvents, ethylene oxide (EtO), formaldehyde, petroleum distillates, and pesticides. The study's aims were: (I) to document the restoration process, (II) to identify the potential chemical exposures, (III) to evaluate the mortality experience of restorers. **Methods:** A small cohort of 168 workers was identified. The restorers were employed in the FNCL's Restoration Centre during the years 1967 – 1976. We excluded 9 subjects from the analysis because no working period data were available. Mortality from all causes, from all cancers, and from cancers of specific sites was compared with that of the Italian general population. Standardized Mortality Rates (SMRs) and their 95% confidence intervals were estimated. **Results:** Restorers were exposed to relatively low levels of several carcinogens. A non-significant excess of cancer mortality was found. Significant increases in brain neoplasm among men and in uterine cancer among women were found. **Conclusions:** The small cohort size hampers interpretation of the results. Larger epidemiology studies on library material restorers are needed in order to evaluate risks in this activity. Recommendations to improve future studies are given.

## RIASSUNTO

«Esposizione ad agenti cancerogeni e mortalità in una coorte di restauratori di materiale librario danneggiato nel 1966 dall'alluvione del fiume Arno». Il 4 Novembre 1966, l'Arno straripò inondando non solo il centro di Firenze ma l'intera città e i comuni limitrofi. La Biblioteca Nazionale Centrale (BNCF) situata in posizione pericolosa: a pochi metri dalle spallette dell'Arno e per giunta sotto il livello del fiume, fu completamente inondata fino a sei metri di altezza, in particolare furono allagati i depositi sotterranei dove erano conservate le collezioni

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*più preziose e antiche. Immediatamente fu allestito un Centro di Restauro. Per il restauro del materiale librario alluvionato sono state usate numerose sostanze tossiche, per esempio solventi clorurati, ossido di etilene, formaldeide, ligroina e pesticidi. Gli obiettivi di questo studio di coorte, che ha riguardato esclusivamente i restauratori/conservatori della BNCF, sono stati: 1) descrivere le fasi lavorative del ciclo di "restauro dei libri alluvionati", i reparti, le mansioni, le sostanze usate e i relativi periodi di uso per stimare livelli di esposizione a sostanze di interesse tossicologico; 2) valutare se la coorte composta da 168 restauratori (97 uomini, 71 donne) presentasse un eccesso di mortalità generale e/o per cause specifiche come quelle tumorali. I restauratori sono stati esposti a bassi livelli di cancerogeni. Lo stato in vita e la causa di morte sono stati accertati per tutti i soggetti al 31/12/2004. La mortalità osservata è stata confrontata con l'attesa in base ai tassi di riferimento della popolazione italiana. L'analisi di mortalità è stata eseguita su 159 soggetti, poiché per nove restauratori mancavano informazioni sul periodo lavorativo. Per gli uomini si è osservato un eccesso di mortalità per "tumori di natura non definita" (2 decessi: ICD-9 = 239.6: tumore dell'encefalo di natura non definita; SMR = 17,39; IC 95% = 2,11-62,83). Per le donne, l'SMR per il tumore dell'utero è risultato significativamente superiore all'unità (2 decessi, SMR = 9,35; IC 95% = 1,14 - 33,79). I risultati sono di difficile interpretazione dato il piccolo numero di soggetti reclutati nello studio. Ulteriori studi di mortalità su lavoratori addetti al restauro/conservazione di beni librari sono necessari per valutare completamente i rischi associati a questa particolare attività lavorativa.*

## INTRODUCTION

The Florence National Central Library (FNCL) is one of the most important libraries in Italy, with about 3,000,000 books (2). On 4 November 1966, the Arno River overflowed its banks, flooding the city of Florence and causing "incalculable damage to life, property, and cultural patrimony" (from <http://www.nyu.edu/gsas/dept/fineart/ifa/Florence/florence.htm>).

The FNCL, which is situated near the river, was flooded with muddy and oily water. Over a million printed books and all library catalogues were damaged.

Recovery operations began in the weeks immediately following the flood. Volunteers from around the world joined the Florentines to rescue artworks and tens of thousands of books. The helpers earned the nickname "Angels of the Mud".

Early book recovery centres were located in different buildings in the town but in March 1967 the restoration activity started in a new wing of the FNCL and continued there until 1997, when it was moved to a new laboratory in a former convent.

The first group of FNCL restorers were Italian people working under the guidance of technicians from the U.S. Library of Congress and from the British Museum. When the emergency recovery

operations ended, the restoration activity was subcontracted to an external co-operative called Coop-L.A.T (5). In the first months after the flood, the Co-operative's employees worked together with the volunteers. Later, they continued the restoration work alone. In March 1976, the co-operative's workers were hired by the FNCL.

At present, the restoration centre still works mainly on routine operations on the library collections damaged in 1966. Up to now, some 58,000 books from the library's most prestigious collections have been restored, with about 50,000 books still to be tackled.

The aims of this study were (i) to reconstruct the restoration process and assess chemical exposures of persons involved in the process and (ii) to describe the mortality experience of the cohort of restorers and discuss the possible association with the chemical exposures.

## METHODS

### Reconstruction of restoration cycle and exposure assessment

Specific FNCL reports (3, 5) and International technical literature (22, 24) describe the main

phases of restoration process and the chemical products used. In-depth information on the FNCL work cycle and specific practices, especially during the first years of activity, was collected by interviewing all restoration workers and supervisors currently working at FNCL, who remembered the restoration cycle, the substances used, and the specific tasks of workers. Warehouse records supplied information about the type and the annual quantities of chemicals used in the period between May 1971 and April 1993.

No information was available regarding the type and amount of chemicals that were donated to the Library in the first few months following the flood. Therefore the total quantity of chemicals used by the Restoration Centre is unknown but was presumably much higher. A large scale fumigation process with EtO was carried out in the period 1967-1973 in the courtyard of the FNCL by a specialized company. Information was not available on the quantity of the EtO mixture used for the fumigation.

Direct air measurements were not carried out, therefore the historical exposure was estimated via the available documentation on the quantity of chemicals used each year in the period between May 1971 and April 1993 and on the presence or absence of a fume hood. A semi-quantitative score was assigned to each department to identify the exposure profile over time. A map of the Restoration Centre showing where the different restoration departments were located was also available.

### **Cohort identification, follow-up and statistical analysis**

The cohort was defined as all the Italian workers engaged in the Restoration Centre from 1 July 1967 until 1 February 1976. Volunteers and workers engaged in the EtO fumigation operations were not enrolled in the cohort. The cohort members were identified by means of the FNCL personnel office records and via interviews with the restoration workers still at work.

Personal data and occupational history such as dates of the beginning and end of work, as well as specific jobs and tasks, were recorded. The total cohort consisted of 168 restorers. We excluded 9 sub-

jects from the analysis because no working period information were available.

Follow-up and accumulation of person-years began on 1 January 1967 and ended on 31 December 2004. Vital status was ascertained through the Official Register of the municipality of residence. The causes of death were obtained from the Tuscany Mortality Register in which all deaths of persons resident in Tuscany are recorded. For subjects living outside Tuscany, death certificates were obtained from the official Municipal Register or from the Office of the Attorney' of the Italian Republic. Causes of death were coded by a physician who was expert in the field following the International Classification of Diseases (ICD IX).

The Standardized Mortality Rates (SMRs) and their 95% Confidence Intervals (CIs) were calculated according to the Poisson distribution. Because the cohort members came from different regions of Italy, the expected deaths were estimated by applying the Italian population mortality rates specific for sex, age (5-year categories) and calendar period (5-year categories) to the person-years of the cohort. The analysis was carried out using STATA statistical software (version 8.0, Stata Corporation, Collage Station, Texas).

## **RESULTS**

### **Restoration cycle and exposure assessment**

The Restoration Centre in the FNCL was organized into the following main departments (3, 5):

- Specification and pulling: identification of the original book structure, collation, removal and separation of the book jackets - situated on the third floor from 1967 to 1972, and from 1979 to 1997.

- Washing and drying: fixing and washing (treatment with o-phenyl-phenol, water and tylose (methyl-cellulose) or Glutofix (Hydroxyethyl-cellulose), and Chemical Laboratory: cleaning, deacidification, bleaching, and consolidation - both situated on the ground floor (1967-1970): They were later moved to separate rooms in the basement (1970-1997). The chemical laboratory activity terminated in 1989.

- Mould aspiration - located on the second floor (February 1967 - May 1967).

- Mould fumigation (July 1967 until 1973) - located in the courtyard.

- Mending: sticking, gluing, re-binding, final collation - on the ground floor (1967-1973), afterwards in the basement (1973-1997).

- Binding (antique books) - on the ground floor (1967-1970), afterwards in the basement (1970-1997).

- General library bindery for "modern" books (defined as "Valore 5") - located in the basement (1968 - 1997).

- Print and drawing restoration department - located on the ground floor from 1968 to 1989.

- Finishing: polishing, embellishing, gold stamping, decorating and/or lettering, final collation and book inspection from 1970 to 1997.

- Office: compilation of restoration records and files - situated on the mezzanine floor from 1967 to 1997.

The available documentation suggested that FNCL restorers were routinely exposed to many chemicals, some of which are known human carcinogens. There were no local ventilation systems before 1973 when the chemical laboratory and the print and drawing restoration department were equipped with only two fume hoods.

The most important hazardous chemicals were: EtO, formaldehyde, organic solvents and pesticides.

EtO is the most effective mould fumigant for library materials (4, 7); it was commonly used in libraries and archives from the 1950's to the 1980's (1).

The mould fumigation process set up at the Restoration Centre was the first and largest EtO fumigation process in Italy. A mixture of EtO/CO<sub>2</sub> in a concentration of about 1:9 was used to prevent fire and explosion risks. A high-vacuum EtO chamber, of about 18 m<sup>3</sup>, was located outside in the library courtyard and sheltered with a tinfoil shed (6). Figure 1 shows a picture of this fumigation chamber. The EtO operating concentration was 500 g/m<sup>3</sup>. The fumigation subcontracting company was insured and licensed to perform library material sterilization.



**Figure 1** - Florence; FNCL: flooded library materials that were enclosed in plastic bags and treated with EtO inside the fumigator

*Figura 1 - Firenze; Biblioteca Nazionale Centrale di Firenze: il materiale librario alluvionato era avvolto in sacchetti di plastica e trattato con EtO all'interno del fumigatore*

Typical work practices associated with fumigation were: 1) materials loaded in the fumigation chamber; 2) evacuation to about 0.016 atmospheres (atm); 3) introduction of EtO mixture up to a pressure of approximately 0.89 atm. These conditions could vary depending on whether the fumigation was for insects or moulds. The "soak" time for insects was approximately 16 to 20 hours, and for mould was from 5 to 7 days (17).

The chamber contained about 2,000 books each time. Chamber loading was manual. No documentation was available regarding whether the fumigator had a device for air wash cycles or post-treatment aeration before the books were unloaded. This was unlikely and in any case at that time fumigation chambers equipped with a post process air wash system never reached levels of 1 ppm at the end of the air-wash cycles (10, 17, 19).

After the fumigation treatment, the library materials were stacked for aeration for about a month, in a corridor in the basement. This corridor was located near the "Valore 5", the "Old Binding", and the "Washing" departments and near other facilities like the bar and canteen on the premises. The corridor was narrow and poorly ventilated. It had neither natural nor mechanical ventilation.

We estimated that the restorers working in the basement zone were exposed to EtO from 1967 until the end of 1970. In this population, the potential routes of EtO exposure included: (i) inhalation of residual EtO book off-gassing in the basement, (ii) dermal contact with the treated books, and (iii) inhalation of airborne EtO that migrated through doors and windows of the basement.

Formaldehyde was used as disinfectant in all wet restoration phases and was added to fixative solutions (about 3%). It was also contained as a preservative in the adhesives, in the glues, and in the starch pastes.

Pesticides were also used in wet restoration phases. The pesticide routinely used, even up to the present time, was *o*-phenyl-phenol sodium salt (Preventol); from time to time 4-chloro-3-methyl-phenyl-phenol and Chlorbenzide (Mitox) were also used.

Chlorinated solvents (mainly Trichloroethylene (TCE), tetrachloroethylene (PCE), and trichloroethane) and aromatic solvents, including benzene, were used to erase oily stains in the washing department and in the print and drawing restoration department.

Besides the chemical hazards, other hazards were present during restoration, handling, and storage phases and included: bacteria, bacterial toxins, moulds and fungi, mould spore, dust, and possibly pesticide residues (20, 21) from past practices of preservation treatment.

Table 1 shows all chemicals used in quantities of more than 10 kilograms (kg) or 10 litres (L). Table 2 gives a broad exposure pattern.

### Mortality study

Table 3 shows the results of the mortality follow-up. A total of 5254 person-years were accumulated for 159 cohort members. Six subjects (3.8%)

were lost to follow-up; in the mortality analysis we considered the last available observation as the end of the follow-up. There were 41 deaths (25.8%). The average duration of follow-up was 31.5 years for males, and 35.3 years for females.

Table 4 shows the observed and expected number of deaths, the SMRs and their 95% CIs for overall mortality and for selected causes of death, separately for men and women. The SMR for all causes of death was slightly increased for women only but was not statistically significant. An increased risk emerged for malignant cancers for women (SMR=2.16, 95% CI 0.79-4.70), but the excess again was not statistically significant. An excess of neoplasms of unspecified nature (2 brain tumours of "unspecified nature") were observed among males (SMR=10.03, 95% CI=1.22-36.24). Further evidence from clinical records confirmed the malignancy of the two brain tumours.

For females, the SMR for uterine cancer was statistically significant (SMR=11.27, 95% CI=1.37-40.73).

### DISCUSSION AND CONCLUSIONS

Carcinogens are assumed to have no toxicity thresholds and are a potential risk for causing cancer regardless of the level of exposure. This exposure assessment indicates that FNCL restorers were routinely exposed to a large number of chemicals, some of them known or suspected human carcinogens.

The Authors believe that workers in the basement area were exposed to EtO (which is a contaminant and not present in nature) even if concentration levels were lower than those described in the sterilization and fumigation process, because of the insufficient natural ventilation and the large number of stored fumigated books that gave off EtO. In ambient air, EtO primarily breaks down via a photochemical reaction (estimated half-life 211 days: from US-NLM's Toxicology Data Network, Hazardous Substances Data-bank Number: 170; <http://toxnet.nlm.nih.gov/cgi-bin/sis/search/r?dbs+hsdb:@term+@rn+@rel+75-21-8>).

It should be noted that the presence of EtO cannot be detected by humans without monitoring

**Table 1** - Chemicals used in the FNCL Restoration Centre from 27 May 1971 to 8 April 1993 (substances used in quantity of more than 10 Kg or 10 L, sorted by quantity)

*Tabella 1* - Sostanze usate dal Centro di Restauro della FNCL dal 27/5/1971 al 8/4/1993 (sono riportate solo le sostanze usate in quantità superiore a 10 Kg o 10 L, ordinate per quantità decrescenti)

| CAS RN     | Chemical name (synonym)                         | Carcinogenicity Evaluations |      | Quantity Used* |
|------------|---|-----------------------------|------|----------------|
|            |   | EC                          | IARC |                |
| 79-01-6    | Trichloroethylene (TCE)                         | 3                           | 2A   | kg 1,885       |
| 132-27-4   | o-Phenylphenol, sodium salt (Preventol o-extra) | -                           | 2B   | kg 550         |
| 7681-51-9  | Acetic acid                                     | -                           | -    | kg 528         |
| 76-52-9    | Sodium hypochlorite                             | -                           | -    | kg 398         |
| 9002-89-5  | polyvinyl alcohol (Mowiol)                      | -                           | 3    | kg 205         |
| -          | Calzolene Atexal WA HS                          | -                           | -    | kg 125         |
| 67-64-1    | Acetone   | -                           | -    | L 116          |
| 25323-89-1 | Trichloroethane                                 | -                           | 3    | kg 72          |
| 497-19-8   | Disodium carbonate                              | -                           | -    | kg 60          |
| 127-18-4   | Tetrachloroethylene (PCE)                       | 3                           | 2A   | kg 58          |
| 123-91-1   | 1,4-Dioxane                                     | -                           | -    | kg 56          |
| 67-56-1    | Methyl alcohol                                  | -                           | -    | kg 51          |
| 8032-32-4  | Ether of oil (Ligroin)                          | -                           | 3    | L 45           |
| 108-88-3   | Toluene   | -                           | 3    | kg 43          |
| 7772-98-7  | Sodium thiosulfate                              | -                           | -    | kg 41          |
| 50-70-4    | D-glucitol                                      | -                           | -    | L 25           |
| 59-50-7    | 4-chloro-3-methylphenol (Preventol CMK)         | -                           | -    | kg 25          |
| 1330-20-7  | Xylene mixed                                    | -                           | 3    | kg 20          |
| 144-62-7   | Oxalic acid                                     | -                           | -    | kg 20          |
| 546-93-0   | Magnesium carbonate                             | -                           | -    | kg 20          |
| 1305-78-8  | Calcium oxide                                   | -                           | -    | kg 20          |
| 8015-95-1  | Paraffin oils                                   | -                           | 3    | kg 17          |
| 7757-82-6  | Sodium sulphate                                 | -                           | -    | kg 17          |
| 60-29-7    | Diethyl ether                                   | -                           | -    | L 16           |
| 91-17-8    | Decahydronaphthalene                            | -                           | -    | kg 16          |
| 1305-62-0  | Calcium dihydroxide                             | -                           | -    | kg 16          |
| 8006-61-9  | Petroleum distillates b.p. 80-100°C             | -                           | 2B   | kg 15          |
| 7440-44-0  | Active charcoal                                 | -                           | -    | kg 14          |
| 1310-73-2  | Sodium hydroxide                                | -                           | -    | kg 13          |
| 16731-55-8 | Dipotassium disulphite                          | -                           | -    | kg 10          |
| 471-34-1   | Calcium carbonate                               | -                           | -    | kg 10          |
| 50-00-0    | Formaldehyde                                    | 3                           | 1    | L 10           |
| 506-87-6   | Ammonium carbonate                              | -                           | -    | kg 10          |
| 71-43-2    | Benzene   | 1                           | 1    | L 10           |
| 7757-83-7  | Sodium sulphite                                 | -                           | 3    | kg 10          |
| 97-99-4    | Tetrahydrofurfuryl alcohol                      | -                           | -    | L 10           |

CAS RN: Chemical Abstract Service Register Number; Chemical names or Synonym: substance or product name;

EC: European Community; IARC: International Agency for Research on Cancer; kg: kilogram; L: litre;

\* Chemical quantities recorded in warehouse records and used completely

devices until it reaches a concentration higher than 300 ppm for perception (Odour threshold: 470 mg/m<sup>3</sup>).

Around the end of the 1960's, there was contradictory epidemiologic evidence for the carcinogenicity and mutagenicity of EtO and so there was

**Table 2 - FNCL Restoration Center department exposure pattern: qualitatively estimated exposure levels for main chemical agents**  
**Tabella 2 - Matrice mansione-esposizione per il Centro di Restauro: livelli qualitativi di esposizione stimati per le sostanze di maggiore interesse tossicologico**

| Department<br>(work activity, years <sup>A</sup> ) | TCE, PCE and<br>chlorinated solvents <sup>B</sup> | Aliphatic and<br>aromatic solvents <sup>B</sup> | Formaldehyde <sup>C</sup>      | Pesticides <sup>C</sup> | EtO <sup>D</sup>   |
|--|---|---|--------------------------------|-------------------------|--------------------|
| Specification and pulling<br>(1967-1997)           | -   | -   | -                              | -                       | D                  |
| Washing and drying<br>(1967-1997)                  | -   | -   | -                              | + (1967-1997)           | D                  |
| Chemical laboratory<br>(1967-1989)                 | +++ (1967-1973)<br>++ (1973-1989)                 | +++ (1967-1973)<br>++ (1973-1989)               | + (1967-1973)<br>+ (1973-1989) | + (1967-1989)           | + (1970)<br>D      |
| Mending<br>(1967-1997)                             | -   | -   | + (1967-1997)                  | -                       | + (1970)<br>D      |
| Binding and "Valore 5"<br>(1968 - 1997)            | -   | -   | -                              | -                       | + (1968-1970)<br>D |
| Prints and drawings<br>(1968-1989)                 | +++ (1968-1973)<br>++ (1973-1989)                 | +++ (1968-1973)<br>++ (1973-1989)               | ++ (1968-973)<br>+ (1973-1989) | + (1968-1989)           | D                  |
| Mould aspiration<br>(Feb 1967-May 1967)            | -   | -   | -                              | -                       | -                  |
| Restoration office<br>(1967-1989)                  | -   | -   | -                              | -                       | -                  |
| Finishing<br>(1967-1997)                           | -   | -   | -                              | -                       | D                  |
| Mould fumigation with EtO<br>(1967-1973)           | \$  | \$  | \$                             | \$                      | \$                 |

<sup>A</sup> Activity years interval for the specific department in the FNCL building; <sup>B</sup> Inhalatory exposure was the main route;

<sup>C</sup> Inhalatory and dermal exposure were the main routes; <sup>D</sup> Inhalatory exposure was the principal route, but also contact and absorption of EtO through the skin may have been possible in handling newly fumigated books;

<sup>E</sup> Task subcontracted to a specialized company; fumigation chamber operators are not included in the cohort

little concern about its use or the hazard represented by off-gassing EtO after treatment (9, 10, 19). No EtO monitoring practices, like general air sampling, were carried out in the corridor or in surrounding areas to measure airborne EtO concentrations. No breathing zone personal sampling was performed for exposure assessment of restorers who worked in the basement next to the fumigation chamber or next to the corridor. No washing

devices were used to reduce residual EtO from the fumigated materials before they were stored in the corridor. The restoration workers never used Personnel Protective Equipments (PPEs) such as gloves and respirators, nor they did receive hazard information or have access to increased programmes for workplace and medical surveillance.

There were few data concerning exposure of persons employed in sterilization with EtO before

**Table 3** - FNCL Restoration Centre cohort: vital status at the end of the follow-up (1 January 1967 to 31 December, 2004)**Tabella 3** - Stato in vita dei restauratori/conservatori alla fine del follow-up (1/1/1967- 31/12/2004)

|              | Alive (%)   | Dead (%)   | Lost to follow-up | Total subjects | Person-years follow-up |
|--------------|-------------|------------|-------------------|----------------|------------------------|
| Whole cohort | 112 (70.4%) | 41 (25.8%) | 6 (3.8%)          | 159 (100%)     | 5254                   |
| Male         | 60 (37.7%)  | 32 (20.1%) | 3 (1.9%)          | 95 (59.7%)     | 2996                   |
| Female       | 52 (32.7%)  | 9 (5.7%)   | 3 (1.9%)          | 64 (40.2%)     | 2258                   |

**Table 4** - Mortality from selected causes for the FNCL Restoration Centre cohort. Standard: Italian Population**Tabella 4** - Mortalità per alcune specifiche cause di morte osservate nella coorte. Standard: popolazione italiana

| Cause of death                   | Male         |     |      |       |             | Female |      |       |            |
|----------------------------------|--------------|-----|------|-------|-------------|--------|------|-------|------------|
|                                  | ICD-9        | Obs | Exp  | SMR   | 95% CI      | Obs    | Exp  | SMR   | 95% CI     |
| All causes                       | 000-999      | 32  | 30.6 | 1.04  | 0.71-1.47   | 9      | 6.64 | 1.36  | 0.62-2.57  |
| All malignant neoplasms:         | 140-208      | 13  | 10.6 | 1.23  | 0.65-2.10   | 6      | 2.78 | 2.16  | 0.79-4.70  |
| Trachea, bronchus, lung          | 162          | 5   | 3.36 | 1.49  | 0.48-3.48   | 1      | 0.23 | 4.29  | 0.11-23.90 |
| Uterus                           | 179-180, 182 | -   | -    | -     | -           | 2      | 0.18 | 11.27 | 1.37-40.73 |
| Neoplasm of unspecified nature** | 239          | 2   | 0.2  | 10.03 | 1.22-36.24* | -      | -    | -     | -          |
| All circulatory system diseases: | 390-459      | 9   | 11.0 | 0.82  | 0.38-1.56   | 2      | 1.94 | 1.03  | 0.12-3.72  |
| Violence                         | 800-999      | 4   | 2.1  | 1.90  | 0.52-4.87   | -      | -    | -     | -          |

\*  $p < 0.05$ ; \*\* Brain tumor (ICD-9 = 239.6)

ICD-9 = Code of the International Classification of Diseases (9th revision); Obs = Observed numbers of deaths;

Exp = Expected numbers of deaths; 95% CI = 95% Confidence Interval

the late 1970's. Nevertheless those available indicate that direct exposures were relatively high prior to the installation of the industrial hygiene technical controls introduced at the end of 1978, when the first EtO carcinogenicity data were published (11, 18). EtO exposure is causally associated with an increased incidence of stomach cancer, leukemia and Hodgkin's lymphoma in occupationally exposed subjects. The International Agency on Research on Cancer (IARC) classified EtO as a human carcinogen in 1994 (12). It should be stressed that an increased incidence of gliomas was observed in rats (8, 16). It can be assumed that the average concentration levels for the FNCL workers were lower than those described in the sterilization and fumigation process because they were not directly engaged in the fumigation process itself, but were only indirectly exposed.

The fixing tasks in the washing and drying department and in the print and drawing department were carried out with formaldehyde. These operations diminished in time but formaldehyde was always used. Occupational exposure to formaldehyde is associated with excess nasopharyngeal cancer and leukemia (13, 15).

Preventol, the most used pesticide in the restoration centre, was classified as possibly carcinogenic by the IARC (14). Solvents were widely used during the first period of work (1967-1973); later on the use of solvents was reduced and wet cleaning was performed under a fume hood. In the Chemical Laboratory and Print and Drawing department, the restorers were exposed to benzene, which is a strong human carcinogen, and to chlorinated solvents, some of which are probably carcinogenic for humans (23).



Although there were 42 years of follow-up, the number of subjects under study and the number of person-years were small. Given this limitation, results have to be considered with caution. Neither did the entire cohort reveal a pattern for all causes of death differing statistically from that of the general Italian population. However, no "healthy worker effect" was observed. Only the excess of brain tumours was statistically significant in men.

As far as the interest of this study is concerned, even if the limitations of the study (extremely small size of the cohort and lack of quantitative information on exposure) are evident, it is nevertheless the first epidemiological study that considers this particular work; also there is very little information on risks associated with this type of work in the international scientific literature. Larger epidemiology studies on library material restorers are needed in order to fully evaluate the risks associated with this activity.

As a general consideration, we would like to stress the other aspect that makes this study important, that is, the condition of emergency and disaster response under which a large part of the activity was carried out. In this respect the limitations identified in this paper can be taken as a lesson on how to set up better emergency response work practices and exposure assessment in the future. The legacies from library experience brought into being the new profession of book restoration specialist and new preservation technologies and methods for the restoration of cultural library materials and property.

NO POTENTIAL CONFLICT OF INTEREST RELEVANT TO THIS ARTICLE WAS REPORTED

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