La Medicina del Lavoro Med Lav 2010; *101*, 5: 364-374

Respiratory and nasal symptoms, immunological changes and lung function among petroleum refinery workers

J. Minov, Jovanka Karadzinska-Bislimovska, Kristin Vasilevska*, Lidija Trajceva, Snezana Risteska-Kuc, S. Stoleski, D. Mijakoski

Institute of Occupational Health – WHO Collaborating Center for Occupational Health and GA²LEN Collaborating Center, Skopje, R. Macedonia

* Institute of Epidemiology and Biostatistics, Skopje, R. Macedonia

Key words

Refinery; respiratory effects; immunological changes

Summary

Objective: *To assess adverse respiratory effects and immunological changes among petroleum refinery workers.* **Methods:** *We performed a cross-sectional study including 80 subjects employed in the coking unit of a petroleum refinery (54 males and 26 females, aged 28-56 years, duration of exposure 7-28 years) and an equal number of office workers, matched by sex, age and smoking habits. Asthma and allergic rhinitis diagnosed by a physician, as well as respiratory and nasal symptoms in the last 12 months, were recorded by questionnaire. Evaluation of the subjects under study also included skin prick tests for common inhalable allergens and lung function tests.* **Results:** *We found a similar prevalence of asthma and allergic rhinitis in both examined groups. Prevalence of overall respiratory symptoms was higher among petroleum refinery workers (33.7% vs. 22.5%) with a statistically significant difference for cough (30.0% vs. 13.7%, p=0.018) and wheezing (21.1% vs. 8.6%, p=0.029). Prevalence of overall nasal symptoms was higher among petrol refinery workers (36.2% vs. 23.7%) with a statistically significant difference for runny nose (28.7% vs. 12.5%, p=0.014). We found a similar prevalence of allergic sensitization to common inhalable allergens in both examined groups. The results of lung function tests showed significantly lower value of MEF_{50} (61.9% vs. 67.4%, p=0.019) and MEF_{75} (56.1% vs. 62.9%, p=0.000) among petroleum refinery workers. Respiratory impairment was observed in both smoking and non-smoking petroleum refinery workers.* **Conclusion:** *Our data suggest that workplace exposure among petroleum refinery workers may lead to respiratory and nasal symptoms and lung function impairment.*

Riassunto

«Sintomi respiratori e nasali, alterazioni immunologiche e della funzione respiratoria tra lavoratori di una raffineria di petrolio». *Obiettivo di questo lavoro è quello di valutare l'esistenza di effetti respiratori e di alterazioni immunologiche tra lavoratori di una raffineria di petrolio. È stato condotto uno studio trasversale che comprendeva 80 soggetti impiegati nell'unità di raffinazione del petrolio (54 uomini e 26 donne di età tra i 28 e 56 anni e con anzianità lavorativa tra 7 e 28 anni) confrontandoli con un gruppo dello stesso numero di soggetti addetti a lavori*

Pervenuto il 4.2.2010 - Accettato il 10.5.2010

Corrispondenza: Jordan Minov, MD PhD, Institute of Occupational Health – WHO Collaborating Center and GA²LEN Collaborating Center, Skopje, R. Macedonia, II Makedonska Brigada 43, 1000 Skopje, R. Macedonia - Tel. + 389 2 2639 637
Fax + 389 2 2621 428 - E-mail: minovj@hotmail.com

d'ufficio, appaiati per sesso, età e abitudini al fumo. Sono stati raccolti mediante questionario dati sugli episodi di asma e rinite allergica diagnosticati da un medico nonché sui sintomi respiratori e nasali occorsi negli ultimi 12 mesi. La valutazione clinica dei soggetti esaminati comprendeva inoltre l'esecuzione di prick-test cutanei per i comuni allergeni inalabili nonché prove di funzionalità respiratoria. La prevalenza di asma e rinite allergica è risultata simile in ambedue i gruppi studiati, così come lo stato di sensibilizzazione ai comuni allergeni, mentre quella dei sintomi respiratori risultava più elevata tra i lavoratori di raffineria (33,7% contro il 22,5%) con differenze statisticamente significative per tosse (30,0% contro 13,7%, p = 0.018) e per la presenza di sibili (21,1% contro 8,6% p = 0.029). Anche la prevalenza dei sintomi nasali è risultata più elevata tra i lavoratori di raffineria (36,2% contro il 23,7%) e tale differenza risultava statisticamente significativa per rinorrea (28,7% contro 12,5% p = 0.014). Le prove di funzionalità respiratoria hanno evidenziato un valore significativamente più basso di MEF_{50} (61,9% contro 67,4% p = 0.019) e di MEF_{75} (56,1% contro 62,9% p = 0.000) tra i lavoratori della raffineria. Questa compromissione respiratoria è stata osservata sia nei lavoratori fumatori che in quelli non fumatori. È quindi possibile concludere, sulla base dei dati ottenuti, che l'esposizione sul luogo di lavoro può indurre nei lavoratori di raffineria la compromissione della funzione respiratoria ed una prevalenza di sintomi nasali e respiratori.

Introduction

An oil refinery is an industrial processing plant where crude oil is processed and refined into more useful petroleum products, such as gasoline, diesel fuel, asphalt base, heating oil, kerosene, and liquefied petroleum gas (LPG). Oil refineries or petroleum refineries are typically large sprawling industrial complexes with extensive piping running throughout, carrying streams of fluids between large chemical processing units. In these complexes from a hundred thousand to several hundred thousand barrels of crude oil per day are processed. Because of the high capacity, many of the units are operated continuously at steady state or approximately steady state for long periods of time (months to years). This high capacity also makes process optimization and advanced process control highly desirable (21, 22).

Petroleum refinery workers are potentially exposed to a wide range of petroleum-derived hydrocarbons and chemical substances used in the manufacture of petroleum by-products. Furthermore, the neighborhood near the oil refineries may also be affected by refinery emissions, i.e. regular and irregular or accidental emissions, in which weather conditions play an important role (5, 6). Investigations on adverse health effects (i.e. malignant and non-malignant disorders) due to occupational and environmental exposures to emissions in petroleum refining have been carried out over a period of time, producing somewhat inconsistent results (24, 25, 27, 28).

To our knowledge, a limited number of studies exist assessing adverse respiratory and immunological effects among workers employed in the petroleum refining industry. In the present study we compared prevalence of respiratory and nasal symptoms, allergic sensitization to common inhalable allergens and spirometric measurements between petroleum refinery workers and office workers in order to assess respiratory impairment related to petroleum refining processes.

Subjects and methods

Study design

A cross-sectional study was performed at the Institute for Occupational Health of R. Macedonia, Skopje - WHO Collaborating Centre and GA²LEN Collaborating Centre from November 2007 to February 2008.

Study subjects

We examined 80 full-time petroleum refinery workers (54 males and 26 females) aged 28-56 years working in the coking unit of the oil refinery with a duration of exposure of 7-28 years. In the coking unit 92 workers were employed. The study

sample comprised all workers from this unit who had spent less than 3 years in occupations other than petroleum refining. To reduce the influence of varied environments on examined variables, workers from this unit who had spent over 3 years in occupations other than petroleum refining were not included in the study (12 workers). In addition, 80 office workers employed in public administration and matched to petroleum refinery workers by sex, age, and smoking habits were studied as controls. The control subjects had never been employed in any refinery or in dusty trades.

Petroleum refinery workers were employed as process operators, labourers, maintenance workers and cleaners in the coking unit in which heavy oils were processed into gasoline and diesel fuel. The coking unit consisted of two large closed working areas with a central ventilation system. The work shift lasted 8 hours per day and involved workplace exposure to a number of chemicals, including petroleum-derived hydrocarbons (paraffins, aromatics, naphthenes, alkenes, alkines, dienes, etc), sulphur dioxide, hydrogen sulphide, nitrogen oxides, particulate matter, etc. The process control ensured that exposures were kept within the permissible limits. The protective equipment used during work included protective clothing, gloves, and masks.

Questionnaire

All subjects were interviewed by a physician who filled in the questionnaire. The questionnaire included, among other items, questions on respiratory and nasal symptoms in the last 12 months, as well as questions on asthma and allergic rhinitis diagnosed by a physician. Respiratory symptoms in the last 12 months (cough, phlegm, dyspnoea, wheezing, and chest tightness) were documented using the European Community for Coal and Steel questionnaire (ECCS-87), and the ECRHS questionnaire (7, 12, 13). Nasal symptoms in the last 12 months (sneezing, itching, runny nose, and blocked nose) were also evaluated. Asthma diagnosed by a physician was defined as an affirmative answer to the question: "Has your doctor ever told you that you have asthma?". Allergic rhinitis was defined as answering "yes" to the question: "Has your doctor ever told you that you have hay-fever or any other kind of allergic rhinitis?"

Detailed smoking history, family history of asthma (taking into account first-degree relatives), accompanying disease, and medication taken were also evaluated.

Smoking was classified according to the World Health Organization (WHO) guidelines on definitions of smoking status (31). A "daily smoker" was defined as a subject who smoked at least once a day at the time of the survey, except on days of religious fasting. An "ex-smoker" was defined as a former daily smoker who no longer smoked. Passive smoking or exposure to environmental tobacco smoke (ETS) was defined as exposure of a person to tobacco combustion products from smoking by others (29).

Skin prick tests

None of the subjects took antihistamines for at least one month before the skin prick tests (SPT) were performed. SPT to 10 common inhalable allergens were performed on the volar forearm using allergen extracts (Torlak, Serbia) of birch (5000 PNU), lime (5000 PNU), mixed grass (*Agrostis alba, Alopecurus pralensis, Dactylis glomerata, Festuca pranesis, Phleum pratense, Poa pratensis, Secale cereale, Triticum aestivum,* and *Zea mais*; 5000 PNU), mugwort (5000 PNU), plantain (5000 PNU), mixed fungi (*Alternaria alternata, Aspergilus fumigatus, Mucor, Penicillium notatum, Cladosporium herbarum, Candida albicans*, and *Trychophyton*; 4000 PNU), *Dermatophagoides pteronyssinus* (4000 PNU), dog hair (4000 PNU), cat fur (4000 PNU), and mixed feathers (chicken and duck feathers; 4000 PNU). All tests included positive (1 mg/ml histamine) and negative (0.9% saline) controls. Prick tests were considered positive if the mean wheal diameter 20 minutes after allergen application was at least 3 mm larger than the size of the wheal of the negative control (26).

Spirometry

Spirometry, including measurement of forced vital capacity (FVC), forced expiratory volume in

one second (FEV_1), FEV_1/FVC ratio, maximal expiratory flow at 50%, 75% and 25-75% of FVC (MEF_{50}, MEF_{75} and MEF_{25-75}, respectively), was performed by Ganshorn SanoScope LF8 spirometer (Ganshorn Medizin Electronic GmbH, Germany) recording the best of three measurements. The results were expressed as percentages of the predicted values, according to the European Community for Coal and Steel (ECCS) norms (23).

Statistical analysis

SPSS version 11.0 for Windows was used for data description and analysis. Continuous variables were expressed as mean values with standard deviation and categorical variables as numbers and percentages. The chi-square test (or Fisher's exact test where appropriate) was used for testing differences in the prevalence of respiratory and nasal symptoms, as well as in the prevalence of allergic sensitization to common inhalable allergens. Spirometric measurements were compared using the independent-sample *t*-test. A *p*-value of less than 0.05 was considered statistically significant.

Results

Characteristics of the study subjects are given in table 1.

Prevalence of asthma diagnosed by a physician was similar in both examined groups (5.0% *vs.* 3.7%). Asthma prevalence was similar in both smoking and non-smoking petrol refinery workers and office workers (5.3% *vs.* 4.7% and 4.9% *vs.* 3.4%, respectively).

Table 1 - Demographics of the study subjects

Variable	Petroleum refinery workers (No. = 80)	Office workers (No. = 80)
Age in years: Mean (range)	38.2±9.6 (28-56)	39.7±8.1 (27-57)
< 40 years	32 (40.0%)	34 (42.5%)
> 40 years	48 (60.0%)	46 (57.5%)
Process operators	29 (36.2%)	/
Maintenance workers	19 (23.7%)	/
Labourers	22 (27.5%)	/
Cleaners	10 (12.5%)	/
Duration of employment in years: Mean (range)	14.4±5.2 (7-28)	15.9±6.3 (6-27)
Daily smokers	19 (23.7%)	21 (26.2%)
Life-time smokers (years)	13.9±4.6	14.8±6.2
Number of cigarettes per day	15.7±6.7	13.8±6.1
Ex-smokers	5 (6.3%)	7 (8.6%)
Passive smokers	12 (5.0%)	9 (11.2%)
Positive family history for asthma	5 (6.3%)	4 (5.0%)
Accompanying disease		
Arterial hypertension	9 (11.2%)	11 (13.7%)
Diabetes mellitus type 2	6 (7.5%)	7 (8.6%)
Peptic ulcer	5 (6.2%)	4 (5.0%)

Numbers (%) are given, unless otherwise stated

Prevalence of respiratory symptoms in the last 12 months tended to be higher among petroleum refinery workers with a statistically significant difference for cough (30.0% *vs.* 13.7%, p=0.018; chi-square test) and wheezing (21.1% *vs.* 8.6%, p=0.029; chi-square test) (figure 1).

Prevalence of respiratory symptoms in the last 12 months tended to be higher among petroleum refinery workers who smoked as compared with office workers who smoked with a statistically significant difference for wheezing (31.5% *vs.* 14.3%, p=0.026; Fisher's exact test) (figure 2).

Prevalence of respiratory symptoms in the last 12 months was higher in non-smoking petroleum refinery workers than in non-smoking office workers with a statistically significant difference for cough (26.2% *vs.* 10.1%, p=0.019; chi-square test), dyspnoea (16.4% *vs.* 6.8%, p=0.031; Fisher's exact

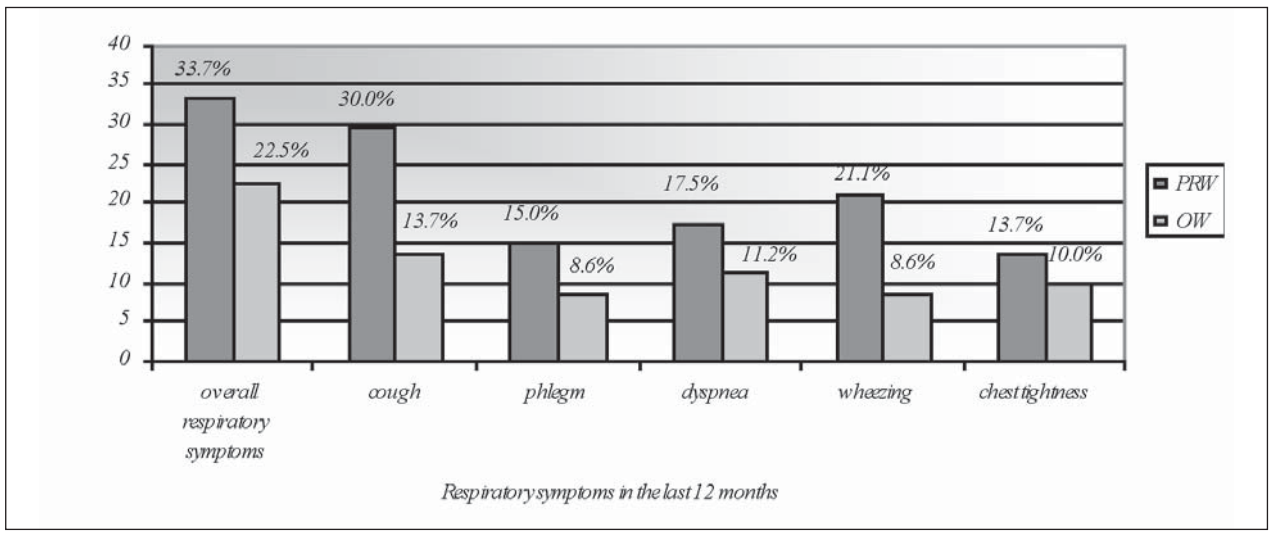

Figure 1 - Prevalence of respiratory symptoms in the last 12 months among petroleum refinery workers and office workers PRW: petroleum refinery workers; OW: office workers

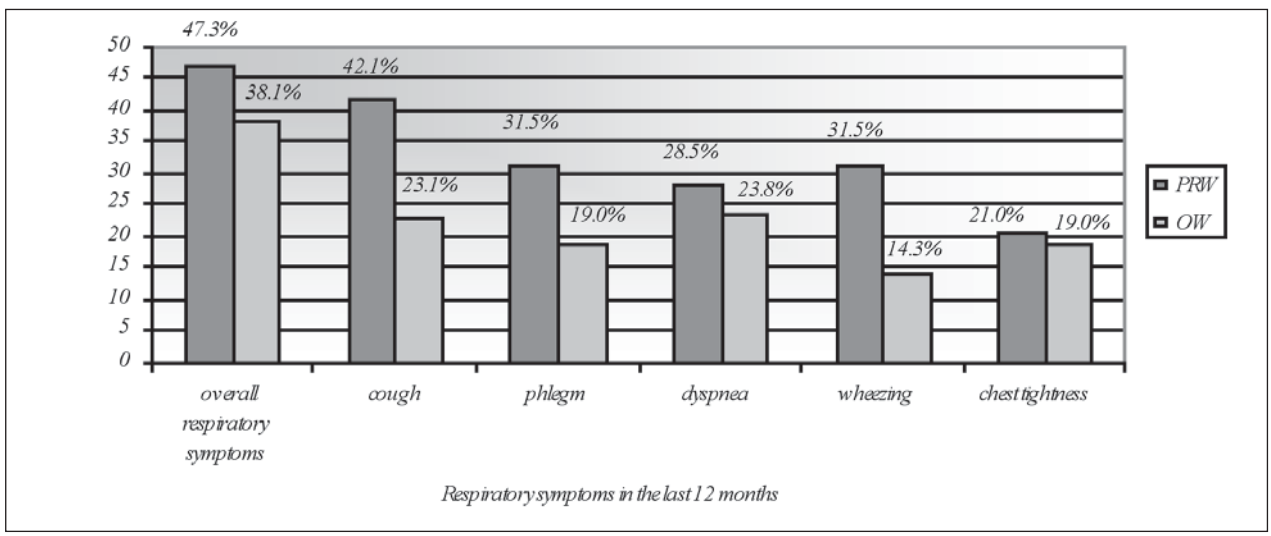

Figure 2 - Prevalence of respiratory symptoms in the last 12 months among petroleum refinery workers and office workers who were smokers. PRW: petroleum refinery workers; OW: office workers

test) and wheezing (18.0% *vs.* 6.8%, p=0.016; Fisher's exact test) (figure 3).

Prevalence of allergic rhinitis diagnosed by a physician was higher among petroleum refinery workers but statistical significance was not reached (16.3% *vs.* 10.0%). Prevalence of allergic rhinitis was higher but without statistical significance in both smoking and non-smoking petrol refinery workers as compared with smoking and non-smoking office workers (26.3% *vs.* 14.3% and 13.1% *vs.* 8.5%, respectively)

Prevalence of nasal symptoms in the last 12 months was higher among petroleum refinery workers with a statistically significant difference for runny nose (28.7% *vs.* 12.5%, p=0.014; chi-square test), while the difference for blocked nose just missed statistical significance (18.7% *vs.* 8.6%, p=0.056; chi-square test) (figure 4).

Prevalence of nasal symptoms in the last 12 months was higher among petroleum refinery workers who smoked than among office workers who smoked with a statistically significant difference for runny nose (36.8% *vs.* 14.2%, p=0.031; Fisher's exact test) (figure 5).

Prevalence of nasal symptoms in the last 12 months was higher among non-smoking petroleum refinery workers than among non-smoking office workers with a statistically significant difference for runny nose (26.2% *vs.* 11.8%, p=0.041; chi-square test), and blocked nose (16.4% *vs.* 6.7%, p=0.028; Fisher's exact test) (figure 6).

Prevalence of sensitization to common inhalable allergens was similar in both petroleum refinery workers and office workers (31.2% *vs.* 35.0%). Mite sensitization was detected as the most important individual common inhalable allergen among subjects with positive SPT in both groups (21.2% and 25.0%, respectively). A similar prevalence of sensitization to common inhalable allergens was found in both smoking and non-smoking petroleum refinery workers and office workers (31.5% *vs.* 28.6% and 31.1% *vs.* 37.2%, respectively).

Mean values of spirometric parameters were lower among petroleum refinery workers with a statistically significant difference for MEF_{50} (61.9% *vs.* 67.4%, p=0.019; independent-sample t-test) and MEF_{75} (56.1% *vs.* 62.9%, p=0.000; independent-sample t-test), whereas the difference in the mean values of MEF_{25-75} just missed statistical significance (68.6% *vs.* 72.3%, p=0.065; independent-sample t-test) (table 2).

Mean values of spirometric parameters were lower among petroleum refinery workers who smoked as compared with office workers who smoked with a statistically significant difference for MEF_{50} (58.3% *vs.* 64.8%, p=0.000; independent-sample

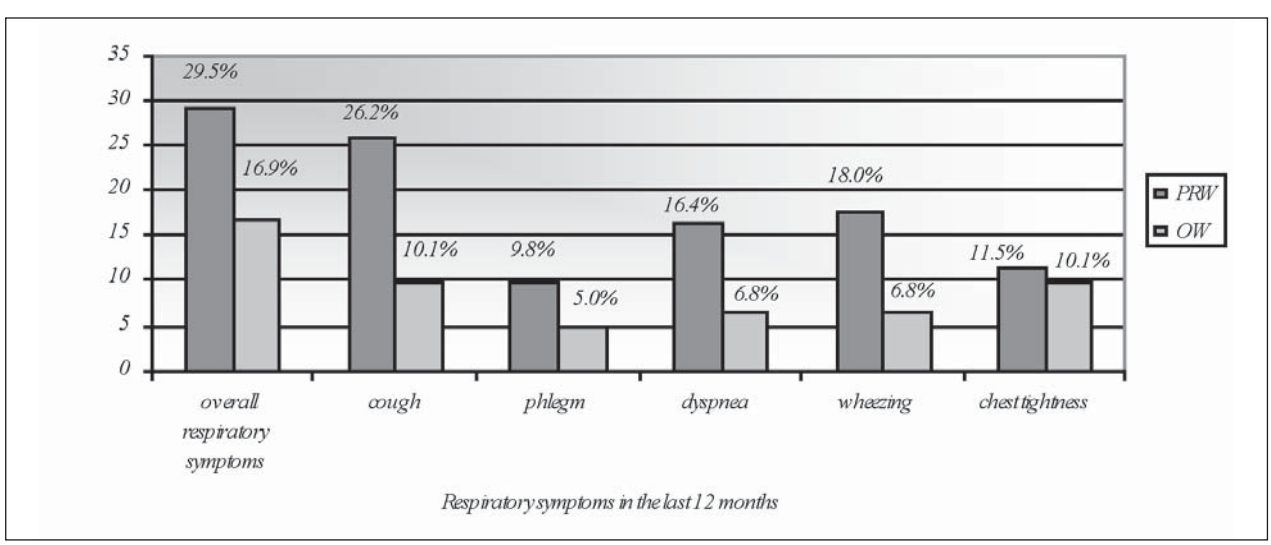

Figure 3 - Prevalence of respiratory symptoms in the last 12 months among non-smoking petroleum refinery workers and office workers. PRW: petroleum refinery workers; OW: office workers

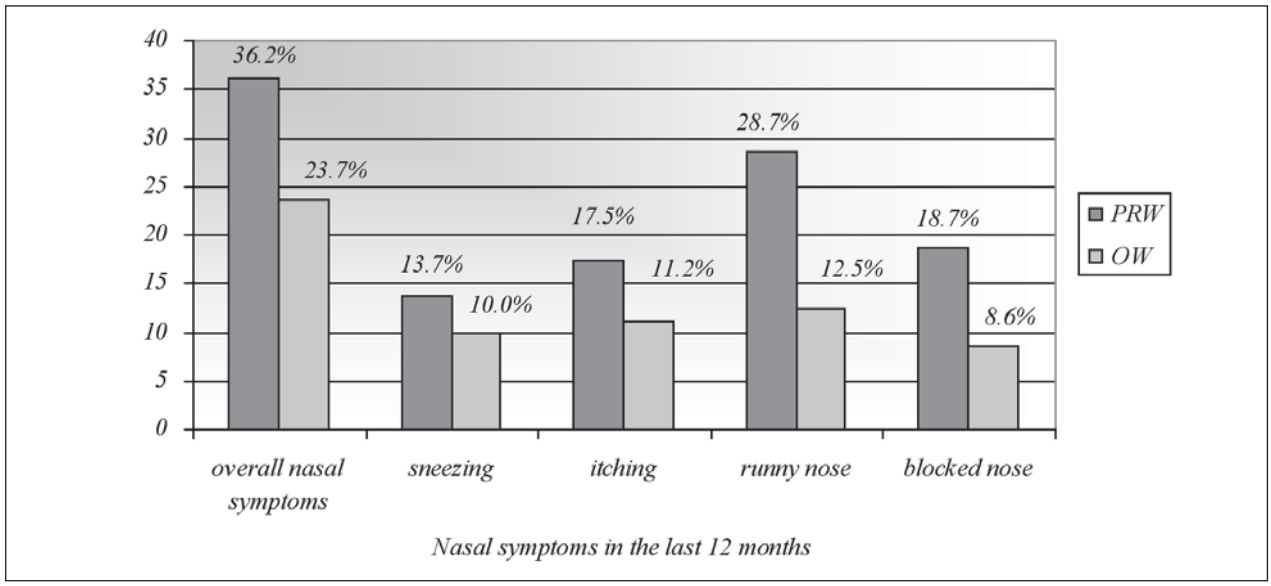

Figure 4 - Prevalence of nasal symptoms in the last 12 months among petroleum refinery workers and office workers PRW: petroleum refinery workers; OW: office workers

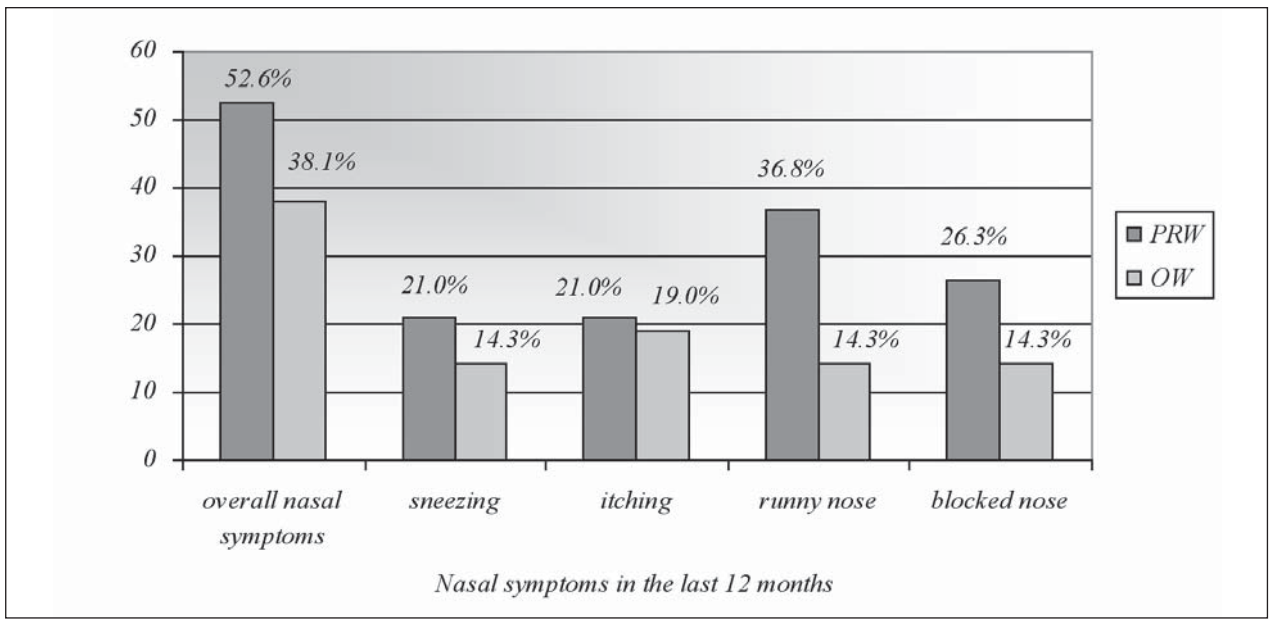

Figure 5 - Prevalence of nasal symptoms in the last 12 months among petroleum refinery workers and office workers who were smokers. PRW: petroleum refinery workers; OW: office workers

t-test), MEF_{75} (52.1% *vs.* 60.7%, p=0.000; independent-sample *t*-test), and MEF_{25-75} (64.3% *vs.* 70.4%, p=0.014; independent-sample *t*-test) (table 3).

The mean values of spirometric parameters were lower in non-smoking petroleum refinery workers than in non-smoking office workers with a significant difference for MEF_{50} (63.4% *vs.* 68.2%, p=0.022; independent-sample *t*-test) and MEF_{75} (57.3% *vs.* 65.1%, p=0.000; independent-sample *t*-test) (table 4).

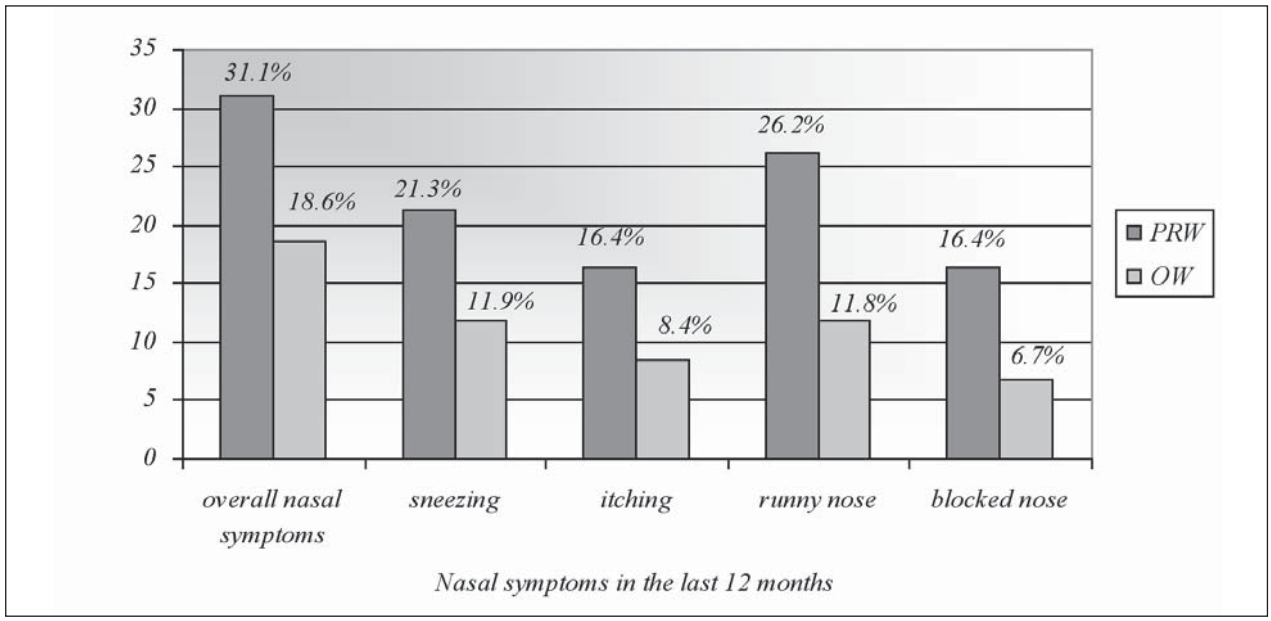

Figure 6 - Prevalence of nasal symptoms in the last 12 months among non-smoking petroleum refinery workers and office workers. PRW: petroleum refinery workers; OW: office workers

Table 2 - Mean values of spirometric parameters in petroleum refinery workers and office workers

Spirometric parameter	Petroleum refinery workers (No. = 80)	Office workers (No. = 80)
FVC (% pred)	88.9±9.6	90.9±9.0
FEV1 (% pred)	83.5±9.1	86.9±7.9
FEV_1/FVC%	74.1±3.8	75.6±4.2
MEF_{50} (% pred)	61.9±8.6	67.4±7.6
MEF_{75} (% pred)	56.1±7.3	62.9±8.1
MEF_{25-75} (%pred)	68.6±10.1	72.3±11.4

Data are expressed as mean value with standard deviation. FVC: forced vital capacity; FEV_1: forced expiratory volume in 1 second; MEF_{50}, MEF_{75}, MEF_{25-75}: maximal expiratory flow at 50%, 75%, and 25-75% of FVC, respectively; % pred: % of predicted value

Table 3 - Mean values of spirometric parameters in petroleum refining workers and office workers who were smokers

Spirometric parameter	Smokers: petroleum refinery workers (No. = 19)	Smokers: office workers (No. = 21)
FVC (% pred)	86.8±8.9	89.1±7.3
FEV1 (% pred)	81.6±8.2	84.1±8.7
FEV_1/FVC%	72.6±4.7	74.1±5.6
MEF_{50} (% pred)	58.3±10.2	64.8±8.1
MEF_{75} (% pred)	52.1±10.9	60.7±11.9
MEF_{25-75} (%pred)	64.3±12.7	70.4±14.2

Data are expressed as mean value with standard deviation. FVC: forced vital capacity; FEV_1: forced expiratory volume in 1 second; MEF_{50}, MEF_{75}, MEF_{25-75}: maximal expiratory flow at 50%, 75%, and 25-75% of FVC, respectively; % pred: % of predicted value

Discussion

Emissions in petroleum refining cover a wide spectrum of reactive chemicals ranging from hydrogen sulfide, sulfur dioxide and nitrogen oxides, isobutane, propylene and butylenes, alkenes, alkynes and benzene, gasoline, kerosene and diesel fuel, to paraffin wax, asphalt and tar. Adverse health effects induced by occupational exposure in petroleum refining have been assessed in a number of epidemiological and experimental studies. The data obtained from these investigations is not always comparable depending on the type of the study and the study population, as well as on the

Table 4 - Mean values of spirometric parameters in non-smoking petroleum refinery workers and office workers

Spirometric parameter	Non-smokers: petroleum refinery workers (No. = 61)	Non-smokers: office workers (No. = 59)
FVC (% pred)	90.3±9.2	92.4±7.5
FEV1 (% pred)	84.8±10.3	87.8±8.1
FEV_1/FVC%	74.8±5.7	76.1±3.9
MEF_{50} (% pred)	63.4±10.7	68.2±8.3
MEF_{75} (% pred)	57.3±8.9	65.1±8.9
MEF_{25-75} (%pred)	69.8±11.3	73.4±9.8

Data are expressed as mean value with standard deviation. FVC: forced vital capacity; FEV_1: forced expiratory volume in 1 second; MEF_{50}, MEF_{75}, MEF_{25-75}: maximal expiratory flow at 50%, 75%, and 25-75% of FVC, respectively; % pred: % of predicted value

type of industrial plant and its size and complexity.

Several studies have shown that work in the petroleum industry was associated with a higher risk for developing malignant disease, such as digestive cancer (including rectum), lung cancer and cancer of nasal cavities, lymphoma, skin cancer, etc (28, 27, 2). Several studies have also shown that employees in petroleum refining were at higher risk for development of non-malignant disorders, such as hypertensive disease, diabetes, chronic bronchitis, peptic ulcer, etc (2, 27, 28).

In the present study we compared prevalence of respiratory and nasal symptoms and prevalence of allergic sensitization to common inhalable allergens, as well as spirometric values between a group of subjects working in the coking unit of a petroleum refinery and a group of office workers matched by sex, age and smoking status. Demographic characteristics were similar in both groups. The large proportion of daily smokers and passive smokers found in both groups was similar to that observed in our earlier studies (16, 18). We found a low number of ex-smokers in both groups, which suggested that not enough was being done to encourage people to stop smoking.

We found a similar prevalence of asthma in both examined groups, which was comparable to asthma prevalence in adults aged 20-44 years in Macedonia (13). Prevalence of overall respiratory symptoms was higher in petroleum refinery workers and a statistically significant difference was found for cough and wheezing. Investigating pulmonary symptoms and spirometric values among refinery workers exposed to sour gas plant emissions (most likely hydrogen sulfide and sulfur dioxide), Mostaghni et al. (19) reported a higher prevalence of respiratory symptoms in exposed workers than in controls with the greatest difference for cough and chest tightness. These results are in some way consistent with those reported by Dales et al. (5) for increased respiratory symptoms in children aged 5-13 years and in subjects who had never smoked aged over 14 years who lived downwind from a natural gas refinery. However, in a study including workers with similar occupational exposure Kangas et al. (10) found no increased prevalence of respiratory symptoms between exposed and unexposed employees. In the study on lung health in relation to hydrogen sulfide exposure in oil and gas workers, Hessel et al. (9) reported no difference in the prevalence of respiratory symptoms between workers exposed to low levels of hydrogen sulfide and controls and a significant difference for shortness of breath, attacks of wheezing and wheezing with chest tightness between workers exposed to high hydrogen sulfide concentrations and controls.

The role of smoking as a confounder in respiratory impairment among occupationally exposed workers is confirmed by many studies (3, 6, 14, 15). In order to assess the role of occupational exposure in petroleum refining in the development of respiratory symptoms we performed a separate analysis of prevalence of respiratory symptoms between smoking and non-smoking workers in both groups examined. Our results confirmed the findings of Chan-Yeung & Dimich-Ward (3) that exposure to organic dusts may lead to the development of respiratory impairment and associated respiratory disability independently of any effect due to smoking.

In the present study the prevalence of allergic rhinitis was not significantly higher in petroleum refinery workers, being in the range of the prevalence in adults in Macedonia (4). We found a statistically significant difference in the prevalence of rhinorrhoea and a difference that just missed statis-

tical significance in the prevalence of nasal obstruction between petroleum refinery workers and office workers. Prevalence of nasal symptoms was higher among petroleum refinery workers independently of their smoking status. Occupational exposures are well recognized risk factors for upper airways impairment (1, 20, 30). Excess of nasal symptoms among petroleum refinery workers may be induced by non-specific irritants, such as hydrogen sulfide, sulfur dioxide or nitrogen oxides, and/or by allergic sensitization to some workplace agents.

We found a similar prevalence of allergic sensitization to common inhalable allergens in both examined groups. Furthermore, the prevalence and the pattern of allergic sensitization in both groups were comparable to what we observed earlier among adults in Macedonia (11, 13). A similar prevalence of allergic sensitization to common inhalable allergens in exposed workers and controls was also found in our previous studies on adverse respiratory effects in workers exposed to different types of organic dusts (textile and agricultural workers, bakers and herbal and fruit tea processors) (15, 17).

Spirometric parameters were lower in the petroleum refining workers with a statistically significant difference for MEF_{50} and $MEF_{75,}$ confirming that exposure to dusts, fumes, vapours, or gases can impair ventilatory capacity, predominantly affecting the smaller airways (3, 14, 15, 17). Similar results were reported by Mostaghni et al. (19) in the study investigating pulmonary symptoms and spirometric values among refinery workers working in a sour gas plant. On the other hand, Hessel et al. (9) reported non-statistically significant differences in all spirometric indicators among oil and gas workers exposed to different levels of hydrogen sulfide. Similarly, Dales et al. (5) in the study mentioned above did not report any lung function changes despite the increase in prevalence of respiratory symptoms.

There were some limitations in our study, which should be taken into account when interpreting the results. The non-availability of any measurements of the levels of workplace exposures is the major flaw of the study. Furthermore, neither were skin prick tests for the workplace allergens performed so we could not assess the possible association of sensitization to workplace allergens with respiratory and nasal symptoms and lung function parameters. On the other hand, in a cross-sectional study, as in our investigation, subjects with serious respiratory symptoms or diseases may leave their job so the strength of the association between this exposure and respiratory impairment could be underestimated (healthy worker effect). Therefore, follow-up of the same workers and lung function assessment may provide a clearer picture. The strength of the study is that it investigated both subjective effect markers, such as respiratory and nasal symptoms, and objective measurements, such as sensitization to standard inhalable allergens and lung function.

Conclusion

In conclusion, in a cross-sectional study aiming at assessment of adverse respiratory and immunological effects in petroleum refining we found a similar prevalence of asthma and allergic rhinitis, higher prevalence of respiratory and nasal symptoms, similar prevalence of sensitization to common inhalable allergens, and lower values of spirometric parameters in petroleum refinery workers than in office workers. Respiratory impairment was registered in both smoking and non-smoking petroleum refinery workers. Our study confirms the need for regular medical examinations in order to implement appropriate preventive measures regarding the risks of respiratory impairment among workers employed in petroleum refining.

No potential conflict of interest relevant to this article was reported

References

1. Bascom R, Shusterman D: Occupational and environmental exposures and the upper respiratory tract. In Naclerio RM, Durham SR, Mygind N (Eds): *Rhinitis: Mechanisms and Management*. New York: Marcel Dekker, 1999: 65-94
2. Blot WJ, Brinton LA, Fraumeni JF, Stone BJ: Cancer mortality in US counties with petroleum industry. Science 1977; *198*: 51-53

3. CHAN-YEUNG M, DIMICH-WARD H: Natural history of occupational lung diseases. Eur Respir Mon 1999; *4*: 46-63
4. CVETANOV V, MILKOVSKA S, RISTESKA-KUC S, et al: Epidemiological characteristics of allergic disease in R. Macedonia. Mak Med Pregled 2003; *56*: 140-141
5. DALES RE, SPITZER WO, SUISSA S, et al: Respiratory health of a population living downwind from natural gas refineries. Am Rev Respir Dis 1989; *139*: 595-600
6. DE HOLLANDER AEM, MELSE JM, LEBRET E, KRAMERS PGN: An aggregate public health indicator to represent the impact of multiple exposures. Epidemiology 1999; *5*: 606-617
7. EUROPEAN COMMUNITY RESPIRATORY HEALTH SURVEY: Variations in the prevalence of respiratory symptoms, self-reported asthma attacks, and use of asthma medication in the European Respiratory Health Survey (ECRHS). Eur Respir J 1996; *9*: 687-695
8. GUIDOTTI TL: Occupational exposure to hydrogen sulphide in the sour gas industry: some unresolved issues. Int Arch Occup Environ Health 1994; *66*: 153-160
9. HESSEL PA, HERBERT FA, MELENKA LS, et al: Lung health in relation to hydrogen sulphide exposure in oil and gas workers in Alberta, Canada. Am J Ind Med 1997; *31*: 554-557
10. KANGAS J, JAPPINEN P, SAVALAINEN H: Exposure to hydrogen sulfide, mercaptan, and sulfur dioxide in pulp industry. Am Ind Hyg Assoc J 1984; *45*: 787-790
11. KARADZINSKA-BISLIMOVSKA J, CVETANOV V, PETROVSKA J, et al: Respiratory symptoms and positive skin prick test in a prospective asthma study in Republic of Macedonia (initial results). Eur Respir J 1999; *14*: 78
12. MINETTE A: Questionnaire of the European Community for Coal and Steel (ECSC) on respiratory symptoms. 1987 - updating of the 1962 and 1967 questionnaires for studying chronic bronchitis and emphysema. Eur Respir J 1989; *2*: 165-177
13. MINOV J, CVETANOV V, KARADZINSKA-BISLIMOVSKA J, et al: Epidemiological characteristics of bronchial asthma in R. Macedonia. Mak Med Pregled 2003; *56*: 156.
14. MINOV J, KARADZINSKA-BISLIMOVSKA J, VASILEVSKA K, et al: Bronchial hyperresponsiveness in workers exposed to organic dusts: effect of smoking. Allergy Hypersensitivity Asthma 2006; *4*: 11-20
15. MINOV J, KARADZINSKA-BISLIMOVSKA J, VASILEVSKA K, et al: Exercise-induced bronchoconstriction in textile and agricultural workers and in bakers. Arh Hig Rada Toksikol 2006; *57*: 379-386
16. MINOV J, KARADZINSKA-BISLIMOVSKA J, VASILEVSKA K, et al: Exposure to environmental tobacco smoke in the workplace in Macedonia: Where are we now? Arh Hig Rada Toksikol 2008; *59*: 103-109
17. MINOV J, KARADZINSKA-BISLIMOVSKA J, VASILEVSKA K, et al: Occupational asthma in subjects occupationally exposed to herbal and fruit tea dust. Arh Hig Rada Toksikol 2007; *58*: 211-221
18. MINOV J, KARADZINSKA-BISLIMOVSKA J, VASILEVSKA K, STOLESKI S: Smoking status in exposed and unexposed workers. Mak Med Pregled 2006; *60*: 128
19. MOSTAGHNI A, NABIPOUR I, DIANAT M, HAMIDI B: Pulmonary symptoms and spirometric values in Kangan sour gas refinery workers. Arch Environ Health 2000; *55*: 297-299
20. ODKVIST LM, EDLING C, HELLQUIST H: Influence of vapours on the nasal mucosa among industry workers. Rhinology 1985; *23*: 121-127
21. Oil refinery. Available at: http://en.wikipedia.org/wiki/Oil_refinery. Assessed at 27.04.2009
22. Oil refining. Available at: http://science.howstuffworks.com/oil-refining.htm. Assessed at 27.04.2009
23. QUAJNER PHH, Ed*:* Standardization of lung function tests – 1993 update. Report of Working Party for the European Community for Steel and Coal. Official Statement of the European Respiratory Society. Eur Respir J 1993; *16* (Suppl): 1-100
24. RICHARDSON DB: Respiratory effects of chronic hydrogen sulfide exposure. Am J Ind Med 1995; *28*: 99-108
25. RUSHTON L, ANDERSON MR: An epidemiological survey of eight oil refineries in Britain. Br J Ind Med 1981; *38*: 225-234
26. The European Academy of Allergology and Clinical Immunology. Position paper: Allergen standardization and skin tests. Allergy 1993; *48* (Suppl 14): 48-82
27. THERIAULT G, GOULET L: A mortality study of oil refinery workers. J Occup Med 1979; *21*: 367-370
28. THOMAS TL, DECOUFLE P, MOURE-ERASO R: Mortality among workers employed in petroleum refining and petrochemical plants. J Occup Med 1980; *22*: 97-103
29. US Department of Health and Human Services. The health consequences of smoking: chronic obstructive pulmonary disease. A report of the Surgeon General. US Department of Health and Human Services, Public Health Service, Office of the Assistant for Health, Office of Smoking and Health. DHHS Publication No. 84-50 205, 1984
30. WELCH AR, BIRCHALL JP, STAFFORD FW: Occupational rhinitis - possible mechanisms of pathogenesis. J Laryngol Otol 1995; *109*: 104-107
31. WORLD HEALTH ORGANIZATION (WHO): *Guidelines for controlling and monitoring the tobacco epidemic*. Geneva: WHO; 1998