Factors Related to the Prevalence of Respiratory Symptoms in Workers in a Petrochemical Complex

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Abstract: Factors Related to the Prevalence of Respiratory Symptoms in Workers in a Petrochemical Complex: Jong PARK, et al. Department of Preventive Medicine, College of Medicine, Chosun University, Korea—This study was performed to evaluate the prevalence of respiratory symptoms in workers in a petrochemical complex and to elucidate the relationship between the prevalence and work-related factors. A questionnaire was distributed to 5,983 male workers working in a petrochemical complex. As for the respiratory symptoms, cough was present in 2.4%, phlegm in 8.1%, wheezing in 2.8% and shortness of breath in 4.7% of the workers. The factors significantly related to respiratory symptoms were smoking history, wearing of protective devices, handling of substances toxic to the respiratory system, and history of atopy or respiratory disease (p<0.05). The substances toxic to the respiratory system were divided into 4 types, ie., dusts, solvents, metals, and vapors. When the analysis was performed to evaluate the effects of exposure to substance type on respiratory symptoms, the odds ratio of cough was 1.96 times higher in those workers exposed to dusts compared with those not exposed, 2.28 times for exposure to metals, 1.52 times for solvents, and 1.55 times for vapors, all showing significant differences (p<0.05). For phlegm, the odds ratio was 1.08 times higher in those workers exposed to dusts compared with those not exposed, 1.94 times for exposure to metals, 1.70 times for organic solvents, and 1.85 for vapors (p<0.05). For wheezing, the odds ratio was 2.38 times for exposure to dusts; for shortness of breath, it was 2.42 times for exposure to dusts, 2.89 times for metals, 2.10 times for organic solvents, and 2.14 times for vapors, all showing significant differences (p<0.05). In conclusion, work-related factors significantly affected the respiratory symptoms in workers working in the petrochemical complex. Especially, these respiratory symptoms were significantly related to exposure to toxic substances and the wearing of protective devices. Thus, safety education and management are needed for these workers. (J Occup Health 2006; 48: 216–222)

Key words: Prevalence, Respiratory symptoms, Related factors, Petrochemical complex workers

Materials chemically very toxic to humans are used in the petrochemical industry and their complex by products show additive or synergic effects in the human body. It is known that air pollutants produced by this industry added with other pollutants become more toxic, causing much damage to the respiratory system1. Research found that the prevalence of acute respiratory symptoms and asthma was higher among children living near petrochemical complexes than those in control areas2, 3. Most studies on respiratory symptoms among petrochemical workers have been epidemiological studies using surveillance systems in large petrochemical processing factories. According to the results of these studies, the prevalence of respiratory disease was second highest among all the diseases investigated4. Respiratory symptoms were related to current status of smoking, hypersensitivity of the trachea, and history of atopy5. The prevalence of respiratory symptoms was high among workers involved in manufacturing petrochemicals compared with internal controls6. Smoking and exposure to sulfur compounds were related to phlegm and wheezing7, 8. The prevalences of acute pulmonary infection and other respiratory diseases were high in petrochemical workers exposed to chlorpyrifos compared with controls9. These studies suggest that respiratory symptoms, such as asthma and chronic bronchitis, among petrochemical workers are related to various work-related factors including exposure to occupational hazardous
This study was conducted among workers at a petrochemical complex more than 20 yr old, at which no study on possible health hazards related to occupational exposure had previously been undertaken. This study was done to evaluate the prevalence of respiratory symptoms among workers at the petrochemical complex and to examine whether work-related factors affected the prevalence of major respiratory symptoms.

**Methods**

The population examined in this study was 11,872 male workers working for 75 different companies as of the end of 1997 in a petrochemical complex in South Chollanamdo Province, Korea. A survey was done by distributing a questionnaire to the workers during the 3 months starting from June 1998. We received 6,349 replies to the questionnaires distributed, (response rate: 53.1%), and 366 incomplete replies were excluded, leaving a total of 5,983 which were analyzed for the study. Women were excluded from this study since the number of female workers was very small.

The survey covered the 3 months from June to August 1998. The questionnaire contained questions regarding 4 respiratory symptoms: cough, phlegm, wheezing and shortness of breath. It also contained questions regarding sociodemographic factors, history of smoking and respiratory symptoms such as bronchitis and asthma, and disease related factors such as history of atopy. The work-related factors investigated were the length of service, use of protective devices, and types of materials toxic to the respiratory system. The types of materials toxic to the respiratory system that workers directly handled were divided into: dusts such as silicate, asbestos, carbon black and welding fumes; metals such as nickel, mercury, zinc, antimony, and aluminum; organic solvents such as alcohol, benzene, toluene, thinner, phenol, xylene, n-hexane and styrene; and vapors such as sulfur dioxide, chlorine, carbon monoxide, acid, ethylene oxide, hydrogen bromide and ammonia. The respiratory symptoms were surveyed using ATS-DLD-78 by the American Thoracic Society, with minor modifications, in which each section contains 4–9 questions. A pretest was performed by letting 50 workers complete the questionnaire before the actual survey was done. Based on the results of the pretest, the content, sentence structure, and question arrangement were modified for the study survey. The study survey was sent to the health manager of each company. The health managers distributed the survey questionnaires to the workers who filled them out, and returned them to the health manager. Abnormal respiratory symptoms were defined when cough and phlegm lasted more than 3 months out of a year. Wheezing was defined positive when wheezing or a whistling-like sound came out of the chest and cough continued. Shortness of breath was defined positive when the subject felt he had a problem feeling shortness of breath when walking, carrying out daily activities, and sleeping.

Analysis was done on the description and frequency of demographic and work-related characteristics and respiratory symptoms. It was done by dividing the respiratory symptoms into two groups: the symptoms present group, and the symptoms absent group. Univariate and multiple logistic regression analyses were performed in order to determine the factors related to respiratory symptoms. Statistical analysis was done using SPSSPC package

**Results**

The distribution of work types showed that the percentage of subjects working in the oil refinery was 9.9% and 12.0% in the target and study groups, respectively; manufacturing organic chemicals, 49.0% and 54.4%, respectively; manufacturing synthetic rubber and plastic, 6.3% and 6.5%, respectively; manufacturing fertilizers, 10.8% and 3.8%, respectively; and others, 24.1% and 23.3%, respectively. The average duration of length of service was 8.34 ± 4.92 yr (Table 1). The average age of the subjects was 35.4 ± 7.7 yr. Non-smoking subjects were 33.2% of the total. Those responding that they handled substances harmful to the respiratory system were 41.6% of the total and those who were in work not requiring protective devices or who

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**Table 1. Representativeness of the study population**

<table>
<thead>
<tr>
<th></th>
<th>Target population (N=11,872)</th>
<th>Study population (N=5,983)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of industry</td>
<td></td>
<td></td>
</tr>
<tr>
<td>oil refinery</td>
<td>1,171 (9.9)</td>
<td>720 (12.0)</td>
</tr>
<tr>
<td>organic chemicals</td>
<td>5,813 (49.0)</td>
<td>3,255 (54.4)</td>
</tr>
<tr>
<td>synthetic rubber and plastic</td>
<td>749 (6.3)</td>
<td>386 (6.5)</td>
</tr>
<tr>
<td>fertilizer</td>
<td>1,283 (10.8)</td>
<td>227 (3.8)</td>
</tr>
<tr>
<td>others</td>
<td>2,856 (24.1)</td>
<td>1,395 (23.3)</td>
</tr>
<tr>
<td>Years in industry (mean ± S.D.)</td>
<td>8.33 ± 5.25</td>
<td>8.34 ± 4.92</td>
</tr>
</tbody>
</table>
wore protective devices during work were 96.8% of the total. Those reporting a history of respiratory disease were 3.6% of the total, and those reporting a history of atopy were 18.5% of the total. The prevalence of respiratory symptoms was 2.4% of the total for cough, 8.1% for phlegm, 2.8% for wheezing, and 4.7% for shortness of breath (Table 2). The results of univariate logistic analysis done to evaluate the factors affecting respiratory symptom awareness showed that the odds ratio for the prevalence of cough was 2.66 times for smokers compared with non-smokers; 2.67 times for those who did not wear protective devices compared with those in work not requiring protective devices or who wore protective devices during work; 1.46 times for those who handled harmful substances compared with those who did not handle harmful substances; 5.02 times for those with a history of respiratory disease compared with those without such a history; and 3.12 times for those with a history of atopy compared with those without such a history (p<0.05). The odds ratio for the prevalence of phlegm was significantly low at 0.80 times for those older than 38.8 yr; and was significantly high at 3.03 times for those exposed to dusts compared with those not exposed, metals 2.28 times, organic solvents 1.52 times, vapors 1.55 times (p<0.05). The odds ratio for the prevalence of wheezing was significantly high for those who were exposed to dusts compared with those not exposed at 2.01 times, those with a history of respiratory disease at 2.44 times, and those with a history of atopy at 2.88 times (p<0.05). The odds ratio for the prevalence of shortness of breath was significantly high for those with a history of smoking at 1.87 times, those who did not wear protective devices at 2.31 times, those who handled harmful substances at 2.06 times, those with a history of respiratory disease at 4.17 times, and those with the history of atopy at 2.17 times (p<0.05) (Table 3).

The results of multiple logistic regression analysis showed that the odds ratio for the prevalence of cough was significantly high at 2.70 times for those with a history of smoking compared with non-smokers, 2.47 times for those who did not wear protective devices compared with those in work not requiring protective devices or who wore protective devices during work, 4.16 times for those with a history of respiratory disease compared with those without such a history, and 2.65 times for those with a history of atopy compared with those without such a history (p<0.05). The odds ratio for the prevalence of phlegm was significantly low for those older than 38.8 yr at 0.78 times, and significantly higher for those with a history of smoking at 2.99 times, those who did not wear protective devices at 2.05 times, those who handled substances harmful to the respiratory system at 2.01 times, those with a history of respiratory disease at 2.44 times, and those with a history of atopy at 2.88 times (p<0.05). The odds ratio for the prevalence of shortness of breath was significantly high for those with a history of smoking at 1.87 times, those who did not wear protective devices at 2.31 times, those who handled harmful substances at 2.06 times, those with a history of respiratory disease at 4.17 times, and those with the history of atopy at 2.17 times (p<0.05) (Table 3).
exposed at 2.38 times. The odds ratio for the prevalence of shortness of breath was 2.42 times high for those exposed to dusts, 2.89 times to metals, 2.10 times to organic solvents and 2.14 times to vapors ($p<0.05$) (Table 5).

**Discussion**

A significant portion of workers in the petrochemical industry might be seriously exposed to substances harmful to the respiratory system as they work in an automated and closed environment. Air pollutants produced by this industry usually become more toxic when mixed with other impurities. Many intermediate byproducts produced during the process of manufacturing are seriously harmful to the body. Workers are exposed to various harmful substances especially during the transportation, processing, raw material processing, intermediate production, and product packaging processes. Petrochemical products typically affect the nervous system, such as peripheral neuropathy, and the respiratory system and cause cancer, allergy, and fungal skin diseases.

There were 75 different work sites at the petrochemical complex examined in this study, including oil refiners’ companies; companies manufacturing basic chemical products, synthetic rubber and plastics, fertilizers,
nitrogen compounds, and non-metalic minerals; and metallurgy, transportation and storage companies. A total of 11,872 workers were working at these companies. The petrochemical complex was set up more than 20 yr ago. During the work process, workers were directly and indirectly exposed to various harmful substances such as acid, base, and sulfur dioxide, which pose health risks. Thus, the postulate set up in this study was that occupational exposure to these substances would pose health risks by inducing respiratory symptoms, and the relationship between respiratory symptoms and work-related factors was investigated.
According to a study of farmers, the prevalence of wheezing was 18.2%, asthma 7.7%, and chronic bronchitis 23.6%. In flour-millers, the prevalence of respiratory symptoms was 54%.\textsuperscript{13} Although the prevalences of cough and wheezing were low compared with the other studies, the prevalence of wheezing among foreign workers processing mussels in New Zealand was 35%.\textsuperscript{14} In the general population in Sweden, the prevalence of shortness of breath and wheezing was 6.1% and chronic cough, 8.1%.\textsuperscript{15} Among New Zealand welders, the prevalence of cough and wheezing was low compared with the prevalence of other respiratory symptoms at 11.3%, though the prevalence of phlegm and shortness of breath was similar with results found in studies done elsewhere. These differences in prevalence of respiratory symptoms were probably due to different epidemiological characteristics. However, in this study, the criteria of respiratory symptoms that the workers felt were defined more strictly. In other words, the low prevalence of respiratory symptoms found in the present study was because only those respiratory symptoms that lasted more than 3 months out of a year were accepted, i.e., only chronic and serious symptoms were the subject of this study.

The work-related factors that showed a significant relationship with the prevalence of respiratory symptoms in the present study were not wearing protective devices and handling of harmful substances when the effects of other factors were controlled. That the prevalence of respiratory symptoms was high when not wearing protective devices was probably because workers were exposed to irritating substances such as dusts, vapors, gases and fumes characteristically seen in a petrochemical complex.\textsuperscript{16, 17} According to the results of this study, the subjects were handling a total of 24 types of substances harmful to the respiratory system. There were some workers who were exposed to a maximum of 6 different substances. Thus, it is crucial to implement preventive measures for handling harmful substances and manage workers to avoid exposure to these substances.

As seen in previous studies, respiratory symptoms in the present study were significantly related to history of smoking, respiratory disease, and atopy\textsuperscript{4, 5, 7, 16–20}. Especially, the histories of respiratory disease and atopy were significantly related to the continuing respiratory symptoms that the subjects felt, suggesting that these factors are important risk factors of respiratory symptoms among workers in a petrochemical complex. Therefore, it is necessary to come up with appropriate measures to manage these workers on a continuous basis. The prevalences of the four respiratory symptoms were high in those who had smoked or who currently smoked compared with non-smokers, suggesting that smoking is an important factor of respiratory symptoms. Among the work-related factors, the length of service was not significantly related to respiratory symptoms, unlike the results of previous studies.\textsuperscript{4, 10}

Dusts, fumes, vapors, and solvents are known to induce occupational pulmonary diseases by irritating the airways. Respiratory symptoms and disease are induced by aldehydes and ammonia irritating the upper airway, chlorine, chlorine oxide and ozone irritating the upper airway and lung, and phosgene irritating the bronchioles and alveoli. In a poor work environment where workers are exposed to irritating chemical substances such as gases, vapors and dusts, mucosa in the eye, nose, and neck is easily irritated. Diisocyanates such as TDI and MDI induce occupational asthma. Metals induce lung disease in which heavy metals such as cobalt and other metals such as beryllium, cadmium, and chrome induce inflammation and calcification.\textsuperscript{21} The prevalence of the four respiratory symptoms examined in this study was significantly high among those workers exposed to dusts, metals, solvents, and vapors compared with those not-exposed, as reported in previous studies.

The limitations of this study were as follows. Firstly, there was the possibility that the healthy worker effect usually seen in studies done in workers could have been present. The healthy worker effect can show differences in how the worker feels depending on various factors such as health status at the time of hiring, size of work place, and type and intensity of work. The finding, that the prevalence of the four respiratory symptoms decreased as the workers’ ages increased, was probably due to the healthy worker effect, possibly because only those older workers with few respiratory symptoms would continue to work at the petrochemical complex. Secondly, this study was a cross-sectional study, so the results of this study cannot be used to establish a causal relationship. This limitation can be overcome by follow up with more subjects. Thirdly, the low response rate might have caused a biased result; the workers who were afraid of being disadvantaged by honest reporting didn’t give an answer. Despite these limitations, the significance of this study lies in the fact that the prevalence of respiratory symptoms among workers in a petrochemical complex was evaluated and we defined various work-related factors related to these symptoms.

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References