REVIEW

Occupational Disease Profile in Taiwan, Republic of China

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Abstract: Lack of knowledge of the exact contents of the materials and improper handling of the toxic chemicals lead to the occurrence of occupational illnesses in the developing countries. However, the incidence of occupational diseases was usually underestimated. This article presents the profile of occupational diseases in Taiwan from two sources, i.e. occupational disease benefit payments of labor insurance and the review of relevant literature. The primarily documented occupational diseases in Taiwan were pneumoconioses. The second most common occupational disease was carbon monoxide intoxication, followed by lead poisoning and noise-induced hearing loss. Less than five percent of occupational diseases were due to the other causes, including decompression syndrome, heat stroke, toxic hepatitis, neurological disorders and hematologic disorders. The number of occupational diseases recognized in Taiwan was considered to be seriously underestimated due to the shortage of occupational medical specialists. Priority in the development of occupational medicine in Taiwan is to educate industrial hygienists and physicians to recognize health hazards in the work environment and to diagnose occupational diseases. Recognition of occupational diseases could subsequently highlight the health hazards in the workplace and prevent workers from overexposure.

Key words: Occupational diseases — Toxic chemicals — Pneumoconioses — Carbon monoxide intoxication — Occupational medical physician

INTRODUCTION

The dominant productive activities in Taiwan early in this century were agriculture and mining. Agricultural workers had many health problems, some of which were
the results of occupational hazards. However, these health problems of agricultural workers were often overlooked because of the misconception that occupational health was concerned mainly with industries only. The agricultural workers are not currently under the protection by the Occupational Safety and Health Law in Taiwan and medical care of agricultural workers were not covered by Farmers’ Health Insurance until 1989. Few reports were available on the magnitude and type of occupational disease among agricultural workers. The most striking feature of occupational health problems in agricultural workers was pesticide poisoning. Organophosphate pesticide was first introduced to Taiwan in 1953\(^1\). Since then, many cases of organophosphate pesticide poisoning were reported for workers engaged in spraying or manufacturing. Parathion, a very toxic pesticide, was widely used in Taiwan. Therefore, most of the reported occupation-related pesticide intoxications were parathion poisoning\(^1-3\). Few of the occupational pesticide poisoning were caused by the other organophosphates, organochlorine or paraquat pesticides. Intentional or accidental intoxication accounts for the largest number of pesticide poisoning cases in Taiwan\(^4, 5\).

Coal mining and gold-copper mining were among the oldest industries in Taiwan. Since 1954, when the first six cases of pneumoconioses were documented in Chinese literature\(^6\), these occupational dust-induced diseases raised the concern of the Department of Labor. Thereafter, many surveys and researches were aimed at dust-induced diseases\(^7-11\). That is to say, pneumoconioses is the oldest occupational disease in Taiwan and the perception of occupational diseases in miners became the cornerstone in the development of occupational health. With the industrial revolution in the early 1960’s, manufacturing, construction and commerce have become the dominant industries in Taiwan. Most of the manpower was transferred from agriculture to those industries. During the process of industrialization, a variety of industries were imported along with many toxic substances from industrialized countries. Lack of knowledge of the exact components of the materials and improper handling of these chemicals lead to uncontrolled exposure to toxic chemicals in the small industries which are most responsible for the occurrence of occupational illnesses in Taiwan. Although occupational injury and accident are the major health hazards in these industries and the occurrence of occupational injuries was much more common than occupational diseases, this article will focus on the occupational diseases only.

**Sources of Information**

There are two available sources that overview the profile of occupational diseases in Taiwan. The first source is the occupational disease statistics from Labor Insurance. The Bureau of Labor Insurance has recorded the number of cases of occupational disease benefit payments issued to insured workers every year since 1981. The number represents the cases actually receiving the benefit payments, not the number of claims. The second source is the review of the literature, particularly the major medical journals which report occupational diseases. The major and oldest local
medical journal in Taiwan is the Journal of Formosan Medical Association. Recently, some of the reports were published in the Chinese Journal of Occupational Medicine.

**OCCUPATIONAL DISEASE STATISTICS FROM LABOR INSURANCE**

Table 1 presents the number of cases of occupational disease benefit payments issued to insured laborers from 1981 to 1992. There were a total of 1,493 cases compensated by benefit payments in these 12 years. 79.7% of these benefit payments were for pneumoconioses, 13.7% for carbon monoxide intoxication, 1.7% (26 cases) for lead poisoning, 1.3% (19 cases) for noise-induced hearing loss and another 3.6% for other occupational diseases. The incidence of occupational diseases in Taiwan was decreasing with the calendar years; it was 67 cases per million in 1981 and declined to 4 per million in 1992. The average incidence rate over these 11 years was 35 per million per year. Compared to the incidence of occupational diseases in developed countries, the reported incidence rate of occupational diseases in Taiwan was extremely low. However, this was not an accurate picture.

<table>
<thead>
<tr>
<th>Year</th>
<th>Grand total</th>
<th>Pneumoconioses</th>
<th>Carbon monoxide intoxication</th>
<th>Lead poisoning</th>
<th>Noise-induced hearing loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>1981</td>
<td>187</td>
<td>185</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>1982</td>
<td>116</td>
<td>113</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1983</td>
<td>156</td>
<td>104</td>
<td>38</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>1984</td>
<td>198</td>
<td>114</td>
<td>82</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1985</td>
<td>228</td>
<td>169</td>
<td>46</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1986</td>
<td>159</td>
<td>120</td>
<td>34</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>1987</td>
<td>157</td>
<td>152</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>1988</td>
<td>111</td>
<td>87</td>
<td>4</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>1989</td>
<td>81</td>
<td>65</td>
<td>0</td>
<td>11</td>
<td>1</td>
</tr>
<tr>
<td>1990</td>
<td>46</td>
<td>35</td>
<td>0</td>
<td>1</td>
<td>7</td>
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<tr>
<td>1991</td>
<td>27</td>
<td>23</td>
<td>0</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>1992</td>
<td>27</td>
<td>23</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
</tbody>
</table>

Total* 1,493 (1,190 (79.7%)) 204 (13.7%) 26 (1.7%) 19 (1.3%)

* Other occupational disease include benzene intoxication (2), nitric acid poisoning (4), decompression disease (11), ethyleneimine poisoning (1), heat stroke (11), n-hexane intoxication (7), metal fume intoxication (11), trichloroethylene intoxication (1), manganese intoxication (1), hypoxia (2), chlorine intoxication (1), pesticide poisoning (1), corneal ulcer (1).
The incidence of occupational diseases in Taiwan was seriously underestimated due to several reasons. First, there is a shortage of qualified occupational medical specialists. The number of occupational health personnel was not sufficient to identify most of the occupational diseases. Second, there were considerable difficulties in evaluating the occupational exposure causing or aggravating diseases since working environmental monitoring data were lacking. Third, the musculoskeletal and connective tissue diseases, which are the most common occupational diseases in the developed countries, were excluded from the occupational diseases benefit payments due to the restricted definition of “occupational diseases” in the workers’ compensation. Most of the musculoskeletal diseases occurred in persons with unduly heavy physical work, i.e. carrying heavy loads and/or inappropriate postures, which were commonly seen in the developing countries.

LITERATURE REVIEW

1. Occupational lung diseases

Pneumoconiosis was the oldest and best known of the occupational lung diseases. Many cases of coal workers’ pneumoconiosis and silicosis were reported in various industries with exposure to coal dusts and silica dusts. However, only three cases of asbestosis was documented in Taiwan and no case of talcosis was known.

<table>
<thead>
<tr>
<th>Table 2. Prevalence of pneumoconiosis in various industries of Taiwan</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<tr>
<td></td>
</tr>
<tr>
<td>Coal miners</td>
</tr>
<tr>
<td>Stone products makers</td>
</tr>
<tr>
<td>Clay products makers</td>
</tr>
<tr>
<td>Glass products makers</td>
</tr>
<tr>
<td>Asbestos products makers</td>
</tr>
<tr>
<td>Steel makers</td>
</tr>
<tr>
<td>Metal products makers</td>
</tr>
<tr>
<td>Machine makers</td>
</tr>
<tr>
<td>Cement makers</td>
</tr>
<tr>
<td>Fire brick makers</td>
</tr>
<tr>
<td><strong>Total</strong></td>
</tr>
</tbody>
</table>

Sources: Department of Health, Taiwan Provincial Government.
* Direct exposure includes all workers working in the manufacturing processes, whereas indirect exposure includes administrators and clerks working outside the manufacturing processes.
An occupational health program has been conducted to control the health hazards in the coal mining and gold mining industries. Nation-wide surveys of miners were performed once a year by the Department of Health of the Taiwan Provincial Government from 1978 to 1988. The prevalence of coal workers’ pneumoconioses had increased from 5.0% in 1978 to 20.2% in 1988. In Taiwan, silica-containing minerals were mainly used for making pottery, fire bricks, cement, glass and in foundries and the steel industry. The workers of various industries with potential exposure to silica dusts were also screened by chest X-ray by the Department of Health of the Taiwan Provincial Government. The results detailing pneumoconioses prevalence is shown in Table 2. The prevalence of pneumoconioses was high in coal miners, cement workers and fire brick workers. Although the prevalence of pneumoconioses was high in some industries, the progress of pneumoconioses shown in chest X-ray was not severe. Among the pneumoconiotic cases shown in Table 2, most of the X-ray change was limited to category 1 and category 2 of a profusion of small opacities, according to the 1980 Internation Labour Organization classification of pneumoconioses. 6.8 percent was in category 3. Only 2.4 percent of pneumoconiotic changes coexisted with large opacities.

Asbestos has been used in Taiwan for more than 30 years, however, only three cases of asbestosis were documented\textsuperscript{12-14}. Two patients were working as asbestos sheet cutters in a shipyard for 8 and 10 years. The third patient worked in an asbestos cement factory for 8 years. All three cases of asbestosis were confirmed by lung biopsy. However, 4.4 percent of asbestos product workers showed pneumoconiotic changes in the survey conducted by the Department of Health of the Taiwan Provincial Government (Table 2). Based on these results, more cases of asbestosis will be expected to be diagnosed in the near future because of the long latent period of asbestosis\textsuperscript{15}.

In addition to pneumoconioses, occupational asthma and byssinosis were the occupational lung diseases reported in Taiwan. Cases of Toluene diisocyanate (TDI) and Diphenylmethane diisocyanate (MDI)-induced asthma were found in plastic manufacturing workers and “velcro-like” tape manufacturing workers\textsuperscript{16, 17}. All of these cases were confirmed by a provocation test or by detailed clinical evaluations. However, these cases did not apply for benefit payments and they were not included in Table 1. Byssinosis was found in quilt makers and cotton textile workers exposed to cotton dusts. The prevalence of byssinosis among quilt makers was 25.9 percent. Most of them belonged to the grade of C1/2 to C2 in British classification according to Molyneux and Tombleson (1970). Only 1.8 percent was in the grade C3\textsuperscript{18}. A recent epidemiological study showed that byssinosis also occurred among cotton textile workers\textsuperscript{19, 20}. However, the prevalence of byssinosis in cotton textile workers (5.2%) was much lower than that in the quilt makers.

Hypersensitivity pneumonitis is another type of occupational lung disease. However, in addition to five cases of suspected bagassosis\textsuperscript{21}, occupation-related hypersensitivity pneumonitis has never been documented due to ignorance or a lack of confirmation.
test for the precipitin antibody.

Intoxication caused by leakage of toxic gases or vapors in industrial settings has occurred accidentally many times in Taiwan. The documented causative agents include carbon monoxide, carbon dioxide, hydrogen sulfide, ammonia and chlorine. Some of these were fatal accidents. Sporadic cases of irritant-induced pneumonia or pulmonary edema were also reported, for which the causative agents include hydrogen sulfide, chlorine, hydrocarbons, nitrogen dioxide and mercury vapor.

2. Occupational hepatic diseases

Chemically-induced toxic hepatitis may be masked in Taiwan due to the high prevalence of serum hepatitis. However, the cases of toxic hepatitis induced by 1,1,2,2-tetrachloroethane and carbon tetrachloride have been documented in electronic assembly and color printing factories. Dimethyl formamide (DMF)-induced toxic hepatitis was also found in synthetic leather manufacturing workers. Chloroform-induced toxic hepatitis was shown in a pencil sharpener assembly worker. Epidemiologic studies showed that vinyl chloride monomer and mixed organic solvents used in painting and shoe manufacturing may cause hepatic dysfunction.

Occupation-related angiosarcoma of the liver was not well documented. But three cases of angiosarcoma in the past were suspected to be related to organic arsenic exposure in the processes of pesticide spraying and glass manufacturing.

3. Occupational renal diseases

Chemically-induced toxic hepatitis usually coexisted with renal dysfunction. Renal failure was also found in the patients of tetrachloroethane and carbon tetrachloride intoxication. Heavy metals, e.g. cadmium and mercury, were also found to cause renal dysfunction in exposed workers.

4. Occupational neurological diseases

Several outbreaks of toxic polyneuropathy have occurred in Taiwan in the last ten years. The causative agents were n-hexane, lead and carbon disulfide. Two outbreaks of n-hexane intoxication have been documented in the interval of 3 years. The first outbreak occurred in the press-proofing factory of the color-printing process, in which n-hexane was used as cleaning solvent. Another outbreak of n-hexane-induced polyneuropathy occurred in a ball manufacturing factory. 11 patients with n-hexane induced polyneuropathy were followed-up for 4 years. Although delayed worsening of sensory and motor functions were noted in the early follow up period, all the patients had completely recovered within 1 to 4 years, including the most severe patient who was initially unable to stand. However, some patients had the residual symptoms of tightness in the legs and muscle cramps.

Carpal tunnel syndrome induced by repeated movements was reported in frozen food processors. The prevalence of carpal tunnel syndrome, diagnosed either by neurological screening tests or electrophysiological tests, was associated with frequency of
repetitive wrist movement. The prevalence of carpal tunnel syndrome in these workers with concomitant exposure to cold temperatures was higher than that in workers without exposure to cold temperature.

Radial nerve palsy was found in soldiers involved in military target shooting training\(^4\). The compression of the radial nerve was due to the special posture in shooting which persists for a long time, causing the radial nerve mononeuropathy.

The central nervous system subdued by occupational exposure can result in acute and chronic toxic encephalopathy. The reported agents which induce toxic encephalopathy in Taiwan include hydrogen sulfide, carbon monoxide, organotin pesticide and mixed organic solvents. The documented organic affective syndrome induced by mixed organic solvents was manifested mainly with symptoms of fatigue, irritability and loss of concentration\(^4\).

A patient of manganese-induced parkinsonism was found in a ferromanganese smelting factory, with the signs of masking face, muscular rigidity and tremors during hand writing. This patient progressively recovered after treatment with levadopa\(^5\), \(^6\).

5. Occupational hematologic diseases

Only few cases of aplastic anemia was documented to be caused by occupational benzene exposure in Taiwan\(^5\), \(^5\), while most cases were reported to be idiopathic. Anemia was usually an early manifestation of lead poisoning. Cases of lead poisoning manifested by anemia have been documented in Taiwan in adults and children. Three cases of methemoglobinemia induced by aniline dye exposure were also reported\(^5\), \(^5\). The blood levels of methemoglobin in these three cases were less than 30% and no treatment was given.

6. Occupational dermatitis

Although occupational dermatitis was considered to be one of the most common occupational diseases, systematic evaluation of the prevalence of occupational dermatitis was lacking in Taiwan. Irritative dermatitis was found in pulp mill workers, factory workers exposed to organic solvents, kerosene\(^5\), antifungal agents and in ball-bearing and paint manufacturing workers\(^5\). Also, fiber glass workers showed contact dermatitis\(^5\), \(^5\). Allergic dermatitis was documented in cement, photogravure, leather workers and certain mechanics\(^5\), \(^5\). Allergic dermatitis caused by epoxy resin was also noted in carbon fiber tennis-racket manufacturing\(^5\).

It was estimated that 21.2 percent of contact dermatitis in an out-patient clinic was of occupational origin. 338 out of 1,596 out-patients were found to be occupational contact dermatitis in one medical center\(^5\). Among the occupational contact dermatitis, 53.6 percent was categorized as irritative dermatitis, and 46.4 percent as allergic dermatitis. The occupations most often associated with contact dermatitis were electronic, construction, printing, hairdressing and medical personnel. The common allergens frequently noted in these working environments were chromium, nickel, cobalt, formaldehyde, epoxy resin, paraphenylenediamine and eugenol.
7. **Occupational musculoskeletal disorders**

Usually, the musculoskeletal diseases were thought to be the most common occupational diseases. Cases of degenerative arthritis and low back pain were common among load-bearing workers and they were the leading causes of temporary disabilities in many industries in the developed countries. However, musculoskeletal disorders in Taiwan were documented in only one small industry, i.e. a fish docking facility where low back pain occurred among the workers. Information on other industries was lacking.

8. **Occupational cardiovascular diseases**

Identification of occupational risk factors associated with cardiovascular diseases was difficult due to the many factors involved in the causations of the diseases that may be easily confounded or masked by other risk factors. Therefore, cardiovascular diseases were usually not considered as occupational diseases and are not compensated in Taiwan. However, myocardial ischemia accompanied with chest pain was found in factory workers exposed to nitroglycerin in the manufacturing of explosives. Noise may play a role in the development of hypertension, because it has been shown that noise exposure was associated with high blood pressure\(^{64-66}\).

9. **Occupational lead poisoning**

Lead poisoning has been reported in Taiwan in lead battery recycling and tile factory workers\(^{67-71}\). It is characterized by abdominal colic, anemia and neuropathy. Lead encephalopathy has occurred in severe lead poisoning cases, especially in children caused by environmental contaminations\(^{72-74}\). Several epidemiological studies of blood lead levels in a variety of industries have been completed. Workers exposed to red lead, ship scrappers, lead battery manufacturing workers and paint manufacturing workers were potentially exposed to high levels of lead\(^{75}\). The average blood lead levels in these workers was over 40 µg/dl. Another investigation also showed that metal smelting workers and battery manufacturing workers have high blood lead levels. A recent epidemiological study\(^{76}\) found that the mean blood lead levels in lead exposed workers were declining in comparison with those of the previous two studies. Only workers in the lead battery manufacturing factories had mean blood lead level greater than 40 µg/dl. Some of these workers showed very high blood lead levels up to over 100 µg/dl.

10. **Occupational heavy metal poisoning**

One case of mercury intoxication was recently documented in a small glass recycling plant\(^{77}\). This patient manifested hand tremors, sensory deficits, and central nervous system dysfunction, e.g. contraction of visual field. Intoxication was confirmed by data from biological and environmental monitoring. Two cases of mercury vapor induced pneumonitis have been documented in the past\(^{29, 30}\). One occurred in a private laboratory and the other occurred in a jewelry-mercury amalgam shop. Cases of
chromate-induced nasal septal perforation and dermatitis were also recently documented in an electroplating factory\textsuperscript{78}.

11. Occupational cancers

Bowen's disease developed in workers who manufacture paraquat herbicide was the most frequently documented occupational cancer in Taiwan\textsuperscript{79}. One case of lung cancer was documented in a coke oven worker\textsuperscript{80}. In addition, three epidemiologic studies showed that occupational carcinogen exposure and asbestos exposure were associated with lung cancers.

Biological monitoring of the effects of carcinogen exposure in several occupational groups has also been studied. Increased urine mutagenicity was found in coke oven workers and increased sister chromatid exchange was also found in dichlovos exposed workers. Dichlovos (DDVP) is one kind of popular organophosphate insecticide used in Taiwan. Other studies did not reveal the cytogenetic effects on the exposed workers. This includes ethylene oxide exposed gas sterilization workers, pesticide manufacturing or formulating workers, and pesticide spraying farmers.

CONCLUSION

It is believed that the number of occupational diseases in Taiwan will be increasing in the future since the scientific community and the general public have become increasingly aware of and concerned about the health hazards in the workplace. At present, there are six centers of occupational medicine, granted by the Department of Health in Taiwan to train formal occupational medical physicians. However, there is still a shortage of occupational medical specialists in Taiwan. The future goal of the Association of Occupational Medicine in the R.O.C. is to initiate a three month short-term training program and to educate physicians to recognize the potential health hazards and occupational diseases in the working environment. It is urgent that all physicians question their occupational history when seeing patients. A few minutes questioning about patient's occupational history will often discover a large number of occupation-related illnesses.

ACKNOWLEDGMENT

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