A CROSS SECTIONAL STUDY ON THE HEALTH OF FIRE FIGHTERS IN SINGAPORE

Wai-On Phoon,* Choon Nam Ong,* Swee Cheng Foo* and Wisai Plueksawan*

INTRODUCTION

The occupation of fire fighters has hazards probably unmatched by almost any other occupation. Great demands are made on the personnel. Stringent standards of physical fitness and mental alertness are required. Fire fighters are constantly exposed to dangers from fires as well as to chemical and physical hazards. As Phoon pointed out, cardiovascular and respiratory diseases are the main health hazards of firemen. A high incidence of ischaemic heart disease has been observed among the fire fighters. In Singapore, the Fire Brigade faces new and exacting demands due to the increasing complexity of building materials and manufacture processes. The common problem of squatter huts catching fire in the earlier years of this century has largely given place to conflagrations involving modern residential and commercial buildings. The number of fire calls has also increased (from 5,534 in 1977 to over 6,000 cases in 1982). Furthermore, the relatively unfavourable ratio of one fireman to every 3,247 persons in the population has resulted in great demands on fire fighters in Singapore, in comparison with their colleagues in many other countries. For example, this ratio is much higher than that of Hamburg (1:2,474) which is a large sea port like Singapore and has approximately the same population.

Although the fire fighter’s occupational exposures to combustion products can be severe, the respiratory effects of their work have not been studied in Singapore in depth. Therefore, a cross-sectional epidemiological study of fire fighters in Singapore was conducted to determine the association between fire fighting and pulmonary function. In addition, exposure to lead and the potential problems associated with over-exposure to noise were also looked into.

MATERIALS AND METHODS

Population. The study population consisted of 520 uniformed employees of the Singapore Fire Brigade. The main study was carried out during late 1979 and early 1980. During this study period, approximately 650 members were actively fighting fires. The rest were in supportive functions such as maintenance, fire prevention or administration. Studies were conducted in three of the larger fire stations which contained about 70% of the total work force. Amongst these 520 fire fighters, the non-participant rate was about 1%. Nine participants were found unsuitable because they had upper respiratory infection or bronchitis at that time, and this resulted in a final group of 506 firemen being studied.

Data collection. Interviews, pulmonary function measurements and collection of blood samples were conducted during scheduled visits. In order to match the shift rosters in these fire stations, these examinations were usually carried out between 0900 to 1130 hours.

Questionnaire. Age, ethnic group, date of birth, occupational history and related medical history were included in a questionnaire in this study. Information on smoking habits and standardized questions of respiratory systems (modified from the British Medical Research Council (MRC) questionnaire) were also collected from each participant. Interviews were conducted by experienced field investigators.

Pulmonary function measurement. Spirometry, including forced vital capacity (FVC) and forced expiratory volume in one second (FEV₁ₑ) was performed with a waterless spirometer (Vitalo-
table), which was calibrated before and after the
study. The measurements were taken at least
two times with the subject in a standing position.
The highest values of FVC and FEV\textsubscript{1.0} were
recorded and adjusted to be expressed as the body
temperature pressure saturation (BTPS).

Nose clips were not used because a pilot study
with and without nose clips early in the investiga-
tion showed that performance was not appreciably
altered by their use; rather their use tended to
make the subject nervous. The ambient tempera-
ture was recorded for each set of tracings taken
during the survey for BTPS adjustment.

**Level of lead in blood.** An evaluation on the
blood level among 30 fire fighters was conducted
by random sampling in 3 fire stations in Singapore.
The concentration of lead in blood was deter-
mined by using an atomic absorption spectrophotometer
attached with a Delve's system.\textsuperscript{7} Venous blood was used for this study.

**Audiometric test.** A questionnaire was de-
designed which covered information about past
occupational history, military service, medical
history, hobbies and life style to detect possible
causes of hearing loss. The purpose of this study
was explained to the subjects prior to audiometric
testing. Hearing threshold levels at 500 Hz, 1
kHz, 2 kHz, 4 kHz, 6 kHz and 8 kHz single tone
frequencies were determined by an Amplivox 125
audiometer. Each ear was assessed separately.

**Analysis of data.** All data were processed on
the University IBM Computer 4341. SPSS (Sta-
tistical Package for the Social Sciences) programs
were used for statistical analysis.

## RESULTS

**Pulmonary function**

Tables 1 and 2 show the basic characteristics of
506 fire fighters studied. The majority of the
subjects were below 30 years of age, with a mean
of 28.7 years, reflecting the fact that the larger
number of fire fighters were new recruits (Table
2). The same table also shows that the average
length of employment as firemen in the force was
only 7.6 years. Most of the firemen were Malay,
about 30% were Chinese and there were few
Indians. The physiques of Malay and Chinese
firemen were similar, with a mean height of 168
and about 67 kg in weight.

The scatter diagrams of FVC against age (Figs.
1 and 2) show that the FVCs increased up to the
age of 25–30 years for both Chinese and Malay
fire fighters and thereafter decreased slowly.
Similar patterns were found for FEV\textsubscript{1.0} against
age (Figs. 3 and 4). This phenomenon was par-
ticularly obvious in the Chinese ethnic group.
Similar observations have been reported by Malik

### Table 1. Age distribution of fire fighters.

<table>
<thead>
<tr>
<th>Age in years</th>
<th>Chinese (%)</th>
<th>Malay (%)</th>
<th>Indian (%)</th>
<th>Total (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;19</td>
<td>5 (38.1)</td>
<td>7 (9.7)</td>
<td>0</td>
<td>8 (17.6)</td>
</tr>
<tr>
<td>20–24</td>
<td>25 (16.1)</td>
<td>8 (28.3)</td>
<td>1 (20)</td>
<td>34 (24.5)</td>
</tr>
<tr>
<td>25–29</td>
<td>23 (14.8)</td>
<td>81 (23.4)</td>
<td>2 (40)</td>
<td>106 (20.7)</td>
</tr>
<tr>
<td>30–34</td>
<td>19 (12.3)</td>
<td>65 (18.8)</td>
<td>0</td>
<td>84 (16.6)</td>
</tr>
<tr>
<td>35–39</td>
<td>4 (2.6)</td>
<td>18 (5.2)</td>
<td>0</td>
<td>22 (4.3)</td>
</tr>
<tr>
<td>40–44</td>
<td>9 (5.8)</td>
<td>15 (4.3)</td>
<td>1 (20)</td>
<td>25 (4.9)</td>
</tr>
<tr>
<td>45–49</td>
<td>9 (5.8)</td>
<td>15 (4.3)</td>
<td>1 (20)</td>
<td>25 (4.9)</td>
</tr>
<tr>
<td>50–54</td>
<td>7 (4.5)</td>
<td>12 (3.5)</td>
<td>0</td>
<td>19 (3.8)</td>
</tr>
<tr>
<td>55–59</td>
<td>0</td>
<td>8 (2.3)</td>
<td>0</td>
<td>8 (1.6)</td>
</tr>
</tbody>
</table>

**Total** 155 346 5 506

### Table 2. Characteristics of 506 fire fighters studied.

<table>
<thead>
<tr>
<th></th>
<th>Chinese (n=155)</th>
<th>Malay (n=346)</th>
<th>Indian (n=5)</th>
<th>All (n=506)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age (year)</strong></td>
<td>26.74±10.0</td>
<td>29.5±9.4</td>
<td>34.0±10.4</td>
<td>28.7±9.7</td>
</tr>
<tr>
<td><strong>Duration of service (year)</strong></td>
<td>7.1±3.6</td>
<td>9.2±4.8</td>
<td>7.5±3.5</td>
<td>7.6±4.3</td>
</tr>
<tr>
<td><strong>Stature (cm)</strong></td>
<td>168.9±6.1</td>
<td>167.9±5.8</td>
<td>171.4±6.1</td>
<td>168.2±6.0</td>
</tr>
<tr>
<td><strong>Weight (kg)</strong></td>
<td>65.23±9.1</td>
<td>67.6±10.7</td>
<td>72.8±4.2</td>
<td>66.97±10.0</td>
</tr>
</tbody>
</table>

**Smoking habit**

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Smokers</strong></td>
<td>63</td>
<td>201</td>
<td>3</td>
<td>267</td>
</tr>
<tr>
<td><strong>Non-smokers</strong></td>
<td>88</td>
<td>122</td>
<td>2</td>
<td>212</td>
</tr>
<tr>
<td><strong>Ex-smokers</strong></td>
<td>4</td>
<td>23</td>
<td>0</td>
<td>27</td>
</tr>
</tbody>
</table>
et al. in Pakistani workers. On the other hand, there were good positive correlations in height and FVC (Ong, C.N.: Unpublished data). Similar findings were observed for height and FEV1.0. Both FVC and FEV1.0 increased steadily with standing height over the whole age range of 18 to 60 years.

The ventilatory functions of all three ethnic groups are shown in Table 3. The mean value of FVC and FEV1.0 indicated that Chinese firemen have significantly higher ventilatory functions than their Malay and Indian colleagues in the fire service. The adjusted FVC values at 170 cm and age of 30 years for the Chinese and Malys are 4.43 and 4.15 l respectively, while FEV1.0 values are 3.72 for Chinese and 3.49 l for Malay.

![Fig. 1. Scatter diagram of FVC and age for Chinese fire fighters.](image1)

![Fig. 2. Scatter diagram of FVC and age for Malay fire fighters.](image2)

![Fig. 3. Scatter diagram of FEV1.0 and age for Chinese fire fighters.](image3)

![Fig. 4. Scatter diagram of FEV1.0 and age for Malay fire fighters.](image4)

**Table 3. Comparison of ventilatory function for 3 ethnic groups of fire fighters.**

<table>
<thead>
<tr>
<th>Ventilatory function</th>
<th>Chinese $n = 155$</th>
<th>Malay $n = 346$</th>
<th>Indian $n = 5$</th>
<th>Total $n = 506$</th>
</tr>
</thead>
<tbody>
<tr>
<td>FVC (l) Mean±S.D.</td>
<td>4.37±0.70</td>
<td>4.13±0.61</td>
<td>3.72±0.25</td>
<td>4.20±0.65</td>
</tr>
<tr>
<td>FEV1.0 (l) Mean±S.D.</td>
<td>3.74±0.70</td>
<td>3.46±0.62</td>
<td>3.16±0.22</td>
<td>3.54±0.66</td>
</tr>
<tr>
<td>FEV1/FVC (%) Mean±S.D.</td>
<td>85.52±8.3</td>
<td>83.70±8.50</td>
<td>84.92±3.6</td>
<td>84.27±8.5</td>
</tr>
</tbody>
</table>

*Analysis by covariances using height and age as covariates showed that ethnic group difference is highly significant at 0.002. $F=6.161$. $R^2$ when adjusted for age and height=0.414.
Table 4. Multiple correlation of ventilation capacity of Chinese and Malay fire fighters*

Forced Vital Capacity (FVC).

<table>
<thead>
<tr>
<th></th>
<th>Chinese, ( n=153 )</th>
<th>Malay, ( n=343 )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( \text{FVC} = -6.79 + (0.069) \text{Ht} + (-0.017) \text{Age} )</td>
<td>( \text{FVC} = -2.95 + (0.046) \text{Ht} + (-0.024) \text{Age} )</td>
</tr>
<tr>
<td>Multiple correlation coefficient</td>
<td>0.69 S.E. = 0.51</td>
<td>0.68 S.E. = 0.49</td>
</tr>
</tbody>
</table>

Forced Expiratory Volume in 1 second (FEV\(_{1.0}\))

<table>
<thead>
<tr>
<th></th>
<th>Chinese, ( n=153 )</th>
<th>Malay, ( n=343 )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( \text{FEV}_1 = -4.48 + (0.054) \text{Ht} + (-0.031) \text{Age} )</td>
<td>( \text{FEV}_1 = -1.27 + (0.034) \text{Ht} + (-0.034) \text{Age} )</td>
</tr>
<tr>
<td>Multiple correlation coefficient</td>
<td>0.71 S.E. = 0.50</td>
<td>0.68 S.E. = 0.45</td>
</tr>
</tbody>
</table>

*Indians were not considered in this analysis as there were only 5 participants.

Table 5. Ventilatory indices on age.

<table>
<thead>
<tr>
<th></th>
<th>(a) FVC</th>
<th>(b) FEV(_{1.0})</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( n )</td>
<td>( \text{Ventilatory function (l)} )</td>
</tr>
<tr>
<td>Hospital staff</td>
<td>101</td>
<td>( 4.08 \pm 0.49 )</td>
</tr>
<tr>
<td>Sedentary workers</td>
<td>134</td>
<td>( 3.88 \pm 0.53 )</td>
</tr>
<tr>
<td>Dock workers</td>
<td>233</td>
<td>( 3.94 \pm 0.42 )</td>
</tr>
<tr>
<td>Fire fighters</td>
<td>153</td>
<td>( 4.43 \pm 0.50 )</td>
</tr>
<tr>
<td></td>
<td>( n )</td>
<td>( \text{Ventilatory function (l)} )</td>
</tr>
<tr>
<td>Hospital staff</td>
<td>101</td>
<td>( 3.20 \pm 0.40 )</td>
</tr>
<tr>
<td>Sedentary workers</td>
<td>134</td>
<td>( 3.25 \pm 0.46 )</td>
</tr>
<tr>
<td>Dock workers</td>
<td>233</td>
<td>( 3.44 \pm 0.39 )</td>
</tr>
<tr>
<td>Fire fighters</td>
<td>153</td>
<td>( 3.72 \pm 0.51 )</td>
</tr>
</tbody>
</table>

Variables have been adjusted to a common stature 170 cm and 30 years of age. Slope coefficient \((d)\) represents age-coefficient per year. The ratio \((c/d)\) represents age at which variable would become zero.

Multiple regression analysis, with ventilatory capacity as the dependent variable, using age and height as independent variables, resulted in the equations shown in Table 4.

Occupational influence on the decline of lung function with age

As there are no validated norms existing for ventilatory functions for the Singapore population as a whole, comparison was therefore made with the observations of various studies conducted previously in Singapore. These studies were mainly made on Chinese subjects, engaged in sedentary, hospital and industrial activities.

The pulmonary functions of these three previous studies, together with the present results are shown in Table 5. It should be noted that fire fighters were found to have higher vital capacities than their counterparts in other sectors.

Inter-group differences were also expressed in terms of regressions of the ventilatory indices on age and are shown in Table 5. According to Cole, the regression equations can be exemplified by:

\[
\text{ventilatory capacity (l)} = \text{constant} - d \times \text{age}
\]

(Where \(d\) is the slope coefficient with age).

Here, the occupation effect has been adopted and used for consideration of all four occupational groups. Two of the respiratory variables (FVC and FEV\(_{1.0}\)) were adjusted to a nominal common stature of 170 cm and 30 years of age in order to standardize all subjects, and the results are sum-

<table>
<thead>
<tr>
<th>Type of work</th>
<th>No. of work places studied</th>
<th>No. of workers studied</th>
<th>Mean (μg/100ml)</th>
<th>S.D.</th>
<th>Percentage of workers higher than 60 μg/100 ml</th>
</tr>
</thead>
<tbody>
<tr>
<td>Secondary lead smelting</td>
<td>1</td>
<td>40</td>
<td>68.33</td>
<td>±12.4</td>
<td>50</td>
</tr>
<tr>
<td>PVC industry</td>
<td>1</td>
<td>34</td>
<td>62.35</td>
<td>±11.8</td>
<td>46</td>
</tr>
<tr>
<td>Storage battery manufacturing</td>
<td>3</td>
<td>265</td>
<td>52.50</td>
<td>±12.8</td>
<td>28</td>
</tr>
<tr>
<td>Ship repairing</td>
<td>2</td>
<td>38</td>
<td>43.10</td>
<td>±8.2</td>
<td>4</td>
</tr>
<tr>
<td>Fire range instructors</td>
<td>1</td>
<td>42</td>
<td>40.80</td>
<td>±9.8</td>
<td>8</td>
</tr>
<tr>
<td>Automobile manufacturing</td>
<td>1</td>
<td>24</td>
<td>34.85</td>
<td>±18.2</td>
<td>3</td>
</tr>
<tr>
<td>Newspaper printing</td>
<td>1</td>
<td>152</td>
<td>28.42</td>
<td>±6.8</td>
<td>—</td>
</tr>
<tr>
<td>Wire splicers</td>
<td>1</td>
<td>24</td>
<td>27.52</td>
<td>±6.4</td>
<td>—</td>
</tr>
<tr>
<td>Paint industry</td>
<td>3</td>
<td>185</td>
<td>26.06</td>
<td>±5.2</td>
<td>—</td>
</tr>
<tr>
<td>Metal workshop</td>
<td>2</td>
<td>68</td>
<td>24.36</td>
<td>±12.8</td>
<td>1</td>
</tr>
<tr>
<td>Electronic industry</td>
<td>4</td>
<td>448</td>
<td>22.85</td>
<td>±5.4</td>
<td>—</td>
</tr>
<tr>
<td>Firemen</td>
<td>3*</td>
<td>30</td>
<td>21.10</td>
<td>±5.2</td>
<td>—</td>
</tr>
<tr>
<td>Sedentary work</td>
<td>6</td>
<td>42</td>
<td>16.42</td>
<td>±3.2</td>
<td>—</td>
</tr>
<tr>
<td>Medical/Auxiliaries</td>
<td>2</td>
<td>22</td>
<td>16.30</td>
<td>±2.7</td>
<td>—</td>
</tr>
</tbody>
</table>

*Three fire stations in Singapore.

marized in Tables 5 (a) and 5 (b).

The coefficient of age (d) has been considered as the rate of decline in ventilatory function with age. Larger value of ("d") represents a steeper decline in ventilatory function with age. Following this, the FVC for fire fighters can be seen as having greater decline in rate with age than workers who have taken part in previous studies (Table 5 (a)).

A similar finding was shown for FEV_{1.0} (Table 5 (b)). The decline with age for fire fighters was 29%, 63% and 80% faster than dock workers, sedentary workers and hospital staff respectively.

Unfortunately, only one previous study has been conducted on the Malay working population (dock workers). The age coefficients (d) for this group were 0.016 for FVC and 0.024 for FEV_{1.0}. When the age coefficients of Malay fire fighters were considered (extracted from Table 4), the rates of decline with age for both FVC and FEV_{1.0} were also shown to be faster (d for FVC = 0.24, d for FEV_{1.0} = 0.034) than the latter group.

Effect of smoking

Smoking habits could have accounted for the observed differences. There were, however, no significant differences among the three ethnic groups according to current smoking habits and number of cigarettes (Ong, C.N.: Unpublished data).

Fig. 5. Age related average hearing threshold levels at 500 Hz, 1 kHz, 2 kHz, 4 kHz, 6 kHz and 8 kHz test frequencies for 82 fire fighters.

Fig. 6. Hearing threshold for left and right ears for fire fighters with (Yes) and without (No) previous exposure to noise in industries.
Lead in blood

Table 6 shows the level of lead in blood for 14 different groups of workers in Singapore. The mean value of blood lead (Pb-B) for fire fighters approximated that of workers from electronic industries. The range was from 12 to 35 μg/100 ml of blood. The mean blood lead levels for workers from other industrial sectors were generally higher than the fire fighters.

Hearing acuity

Figures 5 (a) and (b) show the hearing threshold of 82 fire fighters for the left and right ears respectively as assessed by audiometry. It is observed that left and right ear hearing threshold levels at 1 kHz and 2 kHz were not greatly different in fire fighters of different age groups. However, there is a prominent upward shift in threshold among young fire fighters of age 20-30 at frequencies of 6 kHz and 8 kHz. This change is pronounced only in the right ear. At frequencies of 500 Hz and 1 kHz hearing threshold levels increased substantially with increasing age of the firemen studied.

Figure 6 shows the possible relationship of previous occupation on audiometric threshold for both left and right ears at different frequencies. Fire fighters with previous exposure to noise show higher thresholds of hearing in both ears than those without any previous exposure. Fire fighters indulging in the hobby of enjoying loud music also show a greater hearing decrement in the ears. Those with military experience were also found to have higher hearing thresholds. This phenomenon was particularly pronounced in the right ear. Possibly, the common habit of firing ammunition with the gun resting nearer the right ear may have contributed to this finding. In addition, it was also found that those with hearing problems at frequencies of 6 kHz were either young fire fighters who had gone through military training or enjoyed spending a lot of their leisure in discotheques.

DISCUSSION

It should be emphasized that the original objective of this study in 1979 was to have a cross-sectional evaluation of the health of fire fighters. It was subsequently hoped that a follow-up could be conducted in 1982 on the same cohort. However, due to the extremely high staff turnover and retirement rates in the Singapore Fire Service (close to 20% a year during 1979-1982), by late 1982 only a relatively small number of fire fighters who were examined in 1979 remained in the service. It is therefore quite likely that results obtained from the present study may be biased in favour of the healthier fire fighters since the less healthy may have left the service. Occupational effects on pulmonary function and hearing are likely to be underestimated.

The pulmonary function

Records of forced expiration using the Vitalograph provide useful information about the ventilatory function of the lungs. FVC values reflect variations in effective lung volume whereas FEV₁,₉ values give an indication concerning the presence of airway obstruction or otherwise. Both parameters have been widely used to investigate occupational effects on the respiratory system. In the present study, both FVC and FEV₁,₉ values of fire fighters were found to be greater than those of workers from other sectors reported earlier in Singapore. The mean values of age and stature adjusted indices were 16%, 14% and 8% higher than hospital staff, sedentary workers and dock workers, respectively.

The difference in ventilatory function could be accounted for by criteria for preemployment selection and the nature of job. Regular physical activities in the fire service could contribute to the development of larger lung volume. In addition, this study also confirmed an earlier finding that ventilatory function is significantly different between the Malay and Chinese ethnic groups (Table 3).

The findings that FEV₁,₉ is higher than other occupational groups is different from another study which showed that Boston fire fighters had lower FEV₁,₉ values than the predicted values. This difference can be explained by the fact that: (1) a great majority of Singapore fire fighters belong to the younger age groups of about 28 (Table 2), the lung function was just about reaching the maximum (Figs. 1 and 4), whereas the average age of fire fighters in the U.S.A. was about 44. (2) The mean duration of service for the Singapore fire fighters was about 7 years. This is significantly different from Boston firemen who had over 17 years of service experience. It is well known that a short duration of service in fire fighters can be insufficient to induce any marked
change. With a high staff turnover and retirement rates in the Singapore fire service, healthier firemen are likely to remain serving the brigade and being studied, while those being affected dropped out from the service.

A very recent study in Los Angeles showed that the fire fighters initially had higher FEV1,0 and FVC values than those of non-fire fighters in the same service.23) Upon five years of follow-up the fire fighters had greater decline in lung functions than their non-fire fighting colleagues. A major problem encountered in the present study was the difficulty in following-up those subjects who had left the service. However, results obtained from this cross-sectional study showed a faster rate of decline in FVC and FEV1,0 when comparison was made with other occupational groups. A related study conducted on the same cohort of fire fighters in 1980 showed that the most common acute health hazard encountered by Singapore firemen was asphyxiation due to smoke inhalation.24) From the known characteristics of this finding, there is some evidence to suggest that the respiratory function of fire fighters was likely to be affected and subsequently results in a faster decline in age coefficient (d) as shown in the multiple correlation equations (Table 4).

Level of lead in blood

The findings suggest that lead exposure of firemen in Singapore is not appreciable. However, further follow-up studies are required to confirm this tentative conclusion.

Hearing loss

This preliminary survey on hearing of fire fighters revealed that there is an age-related threshold shift (Fig. 5). To determine the contribution of noise exposure on hearing loss in firemen, it would be necessary to control for age and test against years of services. However, the fire service in Singapore accepts new recruits throughout the age range of 18 to 40, and about 20% of these new recruits have already had experience in noisy industries before joining the force. Furthermore, the majority of the fire fighters have a relatively short duration in the fire service. Therefore, this study to date is yet unable to assess the impact of occupational noise on the threshold shift of fire fighters but further observations may provide more definitive answers.

CONCLUSION

This paper presents preliminary findings of a cross-sectional study of firemen in Singapore. The pulmonary function of the subjects was found to be better than that of healthy workers in other studies done in Singapore previously.20~23) However, it has been also observed in this study that firemen tended to have a faster reduction of lung function with advancing years. Audiometric studies did not reveal any definitive impairment of hearing due to occupational noise exposure. In the light of these preliminary findings, it is recommended that utmost care should be taken by the firemen to use respiratory protection equipment whenever there is a possible inhalation hazard. The risk of lead exposure seems to be quite low. However, this and several previous studies on the pulmonary function suggest that proper personal protective equipment should be worn by fire fighters more frequently than is done currently.

Acknowledgement. Our sincere thanks are due to the Ministry of Social Affairs and the Ministry of Home Affairs of Singapore and to Mr. Lim Beng Lock, Director of the Fire Service, and his staff, for their whole-hearted co-operation, to Dr. Camay Lau-Ting, Miss L.E. Lim, Miss B.L. Lee, Miss L.H. Chua, Mr. T.L. Soh and all the field investigators of the Department of Social Medicine and Public Health, National University of Singapore for helping in the project; to Dr. K.C. Lun for assistance with statistical analysis; and to Miss W. Louis for typing the manuscript.

REFERENCES


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