

# Respiratory mortality among firefighters

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## Abstract

Although firefighters have been shown in some studies to suffer chronic respiratory morbidity from their occupational exposures, an increased risk for dying from non-malignant respiratory diseases has not been documented in any previous retrospective cohort mortality study. In order to assess the possibility that an unusually strong "healthy worker effect" among firefighters might mask this increased risk, a mortality analysis of firefighters was carried out in three cities in relation to the United States population and also to a comparison cohort of police officers. The firefighters were employed between 1945 and 1980 and experienced 886 deaths by 1 January 1984; compared with the United States population they had a significantly reduced risk of dying from all causes (SMR = 82, 95% confidence interval, 77-87), and from non-malignant circulatory diseases (SMR = 81, 95% confidence interval 73-89), but no significant difference in risk of non-malignant respiratory diseases (SMR = 88, 95% confidence interval 66-117). Compared with police, the firefighters experienced a trend toward improved mortality outcomes for all causes investigated (SMR = 82), but they had an excess of deaths from non-malignant respiratory diseases (SMR = 141). The results indicate that firefighters are probably at increased risk for dying from non-malignant respiratory diseases; this increased risk may have been missed in previous studies because of the limitations of using a general reference population.

Firefighters are occupationally exposed to many irritants of the respiratory tract including ammonia, formaldehyde, isocyanates, sulphides, cyanides, and hydrogen chloride.<sup>1,2</sup> Although in recent years improved respiratory protection has become available to protect firefighters from the fire environment, weight and bulk limitations still make adequate

protection difficult. Despite the well described acute respiratory effects of smoke inhalation, studies to date to evaluate chronic sequelae of respiratory morbidity and mortality among firefighters have shown variable and inconsistent findings.

Numerous investigations and case reports have identified the potential for chronic pulmonary dysfunction to follow single episodes of smoke inhalation, whether among non-occupational victims or firefighters themselves. The sometimes delayed respiratory sequelae of acute smoke inhalation have been attributed not only to thermal injury but also to toxic exposures of the tracheobronchial tree with, for example, resultant tracheobronchitis, bronchiolitis obliterans, bronchial stenosis, and bronchiectasis.<sup>3-6</sup>

Prospective evaluation of groups of firefighters after routine and unusual exposure to smoke has provided variable results in terms of acute and persistent abnormalities of pulmonary function. Musk and his colleagues<sup>7</sup> demonstrated acute but reversible decrements in forced expiratory volume in one second (FEV<sub>1</sub>) after exposure to smoke and although Unger and colleagues found no such acute decrement, they found significantly lower baseline values for FEV<sub>1</sub> and forced vital capacity among firefighters compared with non-exposed controls, suggesting dysfunction related to chronic occupational exposures.<sup>8</sup> In addition, chronic changes in pulmonary function attributed to repeated smoke exposure were found in two longitudinal cohort studies of firefighters.<sup>9,10</sup> Follow up studies on the larger of these two cohorts, however, failed to show persistence of the accelerated loss of pulmonary function previously identified.<sup>11-13</sup>

The potential for acute and chronic respiratory morbidity to result in increased mortality among firefighters from non-malignant respiratory diseases has not been documented in any previous retrospective cohort study.<sup>14-17</sup> The three most recent studies,<sup>15-17</sup> however, showed what would be expected from an occupational group with high levels of physical fitness requirements at entry—namely, a "healthy worker effect" as overall mortality was less than predicted for a general reference population. This healthy worker effect is likely to be most pronounced for non-cancer deaths, such as those from non-malignant respiratory and circulatory diseases.

In order to study the potential impact of this effect, and overcome the methodological limitations of some

previous investigators, we performed a standardised mortality analysis of a cohort of firefighters in three north west cities in the United States; comparisons were made not only with the United States population, but also with a cohort of police officers from two of the three cities.

### Methods

To be eligible for inclusion in the study, firefighters had to be men, employed for at least one day after 1 January 1980, and actively employed for at least one day after 1 January 1945 in the fire departments of Seattle and Tacoma, Washington, and Portland, Oregon. Comparable inclusion criteria were achievable for police employed in Portland and Tacoma; Seattle records could not provide complete assessment of the police cohort. Members of the cohorts were followed up and vital status was determined on 1 January 1984; for those cohort members not employed at this date, vital status was determined through department and pension board records, state motor vehicle department records, state death records, and the national death index. Cause of death was coded by a trained nosologist who had no knowledge of cohort membership, using the version of the International Classification of Disease current at the time of death.

SMRs were computed using rates for white men in the United States developed by the National Institute for Occupational Safety and Health for their modified life table analysis program.<sup>18</sup> In order to compare firefighters with police officers, we calculated expected deaths for the firefighters for each five year age and five year period stratum as equal to the firefighter years at risk multiplied by the ratio between observed police deaths and police years at risk. Statistical significance of SMRs compared with the United States population was determined using a two sided Poisson distribution. Mortality risk for firefighters was compared with those for police using Miettinen's exact test for incidence density,<sup>19</sup> and the Mantel-Haenszel chi-squared test for density follow up studies.<sup>20</sup>

### Results

The cohort of firefighters consisted of 4392 men with 102 931 years at risk who experienced 886 deaths; vital status ascertainment was 96%. The cohort of police consisted of 2074 men with 46 280 years at risk who experienced 389 deaths; vital status ascertainment was 95%.

Compared with the United States population, the SMR for firefighters for all causes of death was significantly lower, as was the SMR for deaths from non-malignant circulatory disease. Deaths of firefighters from non-malignant respiratory diseases

Table 1 Standardised mortality ratios (SMRs) for firefighters compared with the United States population

	SMR (No observed/ No expected)	95% confidence interval
All causes	82* (886/1084)	77-87
Non-malignant circulatory diseases	81* (389/482)	73-89
Non-malignant respiratory diseases	88 (53/60)	66-117
Malignant neoplasms of the trachea, bronchus, and lung	97 (62/64)	75-126

\*p < 0.01.

were not significantly lower than those for the United States population; nor was there a difference in malignant respiratory tract diseases (table 1). The SMR for all causes of death was persistently reduced across the periods studied (for 1945-59, SMR = 82; for 1960-69, SMR = 87; and for 1970-83, SMR = 78), but increased with increasing age categories (for ages 15-39, SMR = 32; for ages 40-64, SMR = 71; and for ages 65 or older, SMR = 99).

Compared with the United States population, police officers also experienced significantly lower numbers of deaths from all causes and from non-malignant circulatory diseases, and there was no significant difference in mortality from malignant disease of the respiratory tract. Unlike firefighters, police experienced significantly lower numbers of deaths from non-malignant respiratory diseases (table 2) compared with the United States population.

Firefighters had lower death rates from all causes, from non-malignant circulatory diseases, and from cancers of the trachea, bronchus, and lung, but had an excess of deaths from non-malignant respiratory diseases compared with police (table 3). Statistical analysis of adjusted incidence density ratios did not show any significant differences between firefighters and police for deaths from these causes, but Miettinen's unadjusted exact test for incidence density showed a significant excess of deaths from non-

Table 2 Standardised mortality ratios (SMRs) for police compared with the United States population

	SMR (No observed/ No expected)	95% confidence interval
All causes	83* (389/470)	75-91
Non-malignant circulatory diseases	84* (175/209)	72-97
Non-malignant respiratory diseases	48* (12/25)	25-84
Malignant neoplasms of the trachea, bronchus, and lung	109 (29/27)	72-155

\*p < 0.01.

Table 3 Standardised mortality ratios (SMRs) and adjusted incidence density ratios (IDRs) for firefighters compared with police

	SMR (No observed/ No expected)	IDR (95% confidence interval)
All causes	87 (866/1014)	94 (83-105)
Non-malignant circulatory diseases	83 (391/474)	91 (76-109)
Non-malignant respiratory diseases	141 (53/38)	159 (86-296)*
Malignant neoplasms of the trachea, bronchus, and lung	86 (62/72)	92 (72-119)

\*Miettinen's exact test for incidence density (unadjusted): odds ratio 1.98, 95% confidence interval 109-387.

malignant respiratory diseases. The distribution of types of non-malignant respiratory diseases was similar between the two cohorts, with chronic obstructive lung disease or emphysema identified in 62% of firefighters and 58% of police.

The excess of non-malignant respiratory deaths was largely explained by firefighters dying after the age of 40. Table 4 shows the pattern of deaths from this cause by age categories, which also shows an increased SMR for firefighters aged 65 or older compared with the United States population.

## Discussion

As expected, we have shown a strong healthy worker effect in this standardised mortality study of firefighters. This effect is seen as lower risk overall for all causes of death and also for deaths from non-malignant circulatory diseases compared with the general population; that a similar decrement was not seen for deaths from non-malignant respiratory diseases is the first suggestion that deaths from this cause may be actually increased among firefighters. In our study the cohort of police also showed this healthy worker effect but the effect also produced a large deficit in deaths relative to the United States population for non-malignant respiratory diseases. The trend towards a decrease in overall and circulatory disease mortality in firefighters compared with police suggests that between the two, firefighters may be relatively "healthier." Despite this, firefighters appear to have an increased risk for deaths from non-

Table 4 Standardised mortality ratios (No observed/No expected in parentheses) for non-malignant respiratory diseases in firefighters in age groups

	Age (y)		
	< 40	40-64	≥ 65
Firefighters v United States population	40 (1/2.5)	51 (12/23)	116 (40/35)
Firefighters v police	— (1/0)	130 (12/9)	141 (40/28)

malignant respiratory diseases compared with the police reference group. This pattern was also observed in the only other study of which we are aware; a proportional mortality study for New Jersey that compared the distribution of observed with expected deaths for firefighters and police rather than rates.<sup>21</sup>

Caution should be used in interpreting our results given the smaller and therefore relatively unstable numbers generating expected deaths using police as a reference group. The excess of deaths from non-malignant respiratory disease was significant at the 95% confidence level only when an unadjusted analysis of incidence density (which characterises the overall number of cases in relation to the person-years experience contributed by each cohort) was performed. A larger number of deaths would be needed to show this excess at the same confidence level using adjusted rates that are derived within smaller age strata.

Whereas one explanation for our finding could be that the police cohort had unusually low death rates from non-malignant respiratory diseases, we believe this is unlikely.

Personal habits and characteristics such as cigarette smoking, exposure to radiation, diet, and exercise were not measured in this study. The increased risk for death from non-malignant respiratory disease in firefighters is unlikely, however, to be explained by differences in smoking rates between firefighters and police as there was no excess of deaths from other smoking related outcomes—namely, lung cancer and non-malignant circulatory diseases. In addition, there is good evidence from two recent national surveys that smoking rates are comparable between firefighters and police.<sup>22,23</sup>

We believe that the increased risk for respiratory mortality among firefighters shown in our study may have been missed in previous investigations because of the limitations of using a general reference population, and hope that further evaluation of this and other firefighter cohorts will shed additional light on these findings.

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