British Journal of Industrial Medicine, 1978, **35**, 104-108

Mortality among Boston firefighters, 1915–1975*

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ABSTRACT Although the nature of firefighting involves particular health hazards, previous mortality and morbidity studies of firemen have produced inconsistent evidence for an increased risk of mortality from cardiovascular disease, respiratory disease, cancer and accidents. Mortality experience since 1915 has been examined in 5655 Boston firefighters, comprising all male members of the city fire department with three or more years of service. The observed cause of death as stated on the death certificates of 2470 deceased firefighters has been compared with the numbers expected based on rates for the male population of Massachusetts and of the United States of America. Among all firefighters, deaths from all causes were 91% of expected. The standardised mortality ratio (SMR) was markedly reduced (less than 50) for infectious disease, diabetes, rheumatic heart disease, chronic nephritis, blood diseases and suicide. The SMR was 86 for cardiovascular deaths, 83 for neoplastic deaths, and 93 for respiratory deaths. The SMR for accidents was 135 for active firefighters. The results suggest that the survival experience of firefighters is strongly influenced by strict entry selection procedures, ethnic derivation, and sociocultural attributes of membership. While excessive morbidity has been demonstrated in firefighters, there does not appear to be a strong association between occupation and cause-specific mortality.

Although the nature of firefighting in Boston involves particular health hazards, previous mortality and morbidity studies of various firefighting groups have produced inconsistent evidence for an increased risk of death from a cardiovascular, respiratory, neoplastic or accidental cause (Hunter, 1907-1908; Hunter and Rogers, 1920; Hunter, 1927; The Actuarial Society of America and the Association of Life Insurance Medical Directors, 1929; Jenkins, 1930; Whitney, 1934; Registrar General, 1938; Dublin and Vane, 1947; Commonwealth of Massachusetts, 1952; Registrar General, 1957; Mastromatteo, 1959; Guralnick, 1963; Guthrie, 1970; Registrar General, 1971; Committee on Biological Effects of Atmospheric Pollutants, 1972; Peters *et al.*, 1974; Balanof, 1976; Milham, 1976).

To examine the association between this occupation and cause of death we have studied the mortality experience of a large city fire department where records not only covered a period of time sufficient to generate adequate numbers of deaths but also contained accurate information on occupational factors that may be related to cause of death.

*Supported by Research Grant OH 00369 from the National Institute of Occupational Safety and Health and NIEHS Center Grant ES 00002-14.

**Recipient of a Clinical Sciences Fellowship from the National Health and Medical Research Council of Australia

Received for publication 18 August 1977
Accepted for publication 7 November 1977

Methods

DEFINITION OF POPULATION

Subjects were identified from a card index maintained by the Boston Fire Department. Cards were available on all firefighters employed since 1869. From these cards dates of birth, appointment to the department, transfers within the department, promotions, retirement and death were ascertained. Only firefighters employed for more than three years since 1915 were included. Follow-up of firefighters started on 1 January, 1915, or on 1 July of the year of joining the Boston Fire Department and terminated on 1 July, 1975. A total of 5655 subjects, 5640 of whom were white, were included. Of these, 655 died while in active employment and 1815 died following retirement. Only 246 subjects (4·4%) were lost to follow-up.

Death certificates were obtained from the Massachusetts death registry or other US state registries for subjects known to have died. Death certificates were not found for 194 subjects known to be dead (7·9% of all deaths).

All death certificates were coded according to the

seventh revision of the *International Classification of Diseases* (*ICD*) (World Health Organization, 1957). Certificates already coded by this revision of the ICD by the Massachusetts State Department of Health were not revised, but certificates that had been coded by previous or subsequent revisions of the ICD were recoded according to the seventh revision.

ANALYSIS OF THE DATA

The person-years of the study cohort were determined in five-year age-time intervals from 1915-75. Persons lost to follow-up were assumed lost at the time of loss. Expected numbers were calculated for 57 causes of death. To determine these, the number of person-years in each age-time stratum was multiplied by the age and time-specific mortality rates for each cause for all Massachusetts males and for US white males. The expected numbers in each cell were summed over age and time. The measure of association was the standardised mortality ratio (SMR = 100 × observed/expected deaths) (Monson, 1974).

STATISTICAL CONSIDERATIONS

Because in studies such as this the SMR for all causes tends to be less than 100, we do not consider that testing whether any specific SMR differs significantly from 100 is appropriate. For the reader who is interested in assessing the stability of any SMR, the square root of the expected number is an approximation of the standard error of the expected number under the Poisson assumption.

Results

There were 104 561 person-years of follow-up accumulated by active employees and 38 414 person-years accumulated by retired employees. There was close agreement between the total number of expected deaths based on US and Massachusetts mortality rates (Table 1). The expected number of cancer and circulatory deaths was greater for Massachusetts white males and the expected number of accidental deaths was greater for US white males.

Overall mortality for all firefighters was 91% of that expected for the male population of Massachusetts and 94% of that expected for the white male population of the United States of America. This finding of less than expected mortality is common in mortality studies of occupational groups (McMichael, 1976). The SMR was 104 for all accidents, 86 for circulatory deaths, 93 for respiratory deaths and 86 for cancer. Notably, low SMRs were recorded for diabetes, rheumatic heart disease, chronic nephritis, infectious diseases and suicide. Only eight death certificates indicated suicide as the cause of death, and no suicide was recorded after 1944.

Mortality was not related to age or year of entry, or to age or year of death (Table 2).

The SMR for all accidents was 135 in active subjects (Table 3). Otherwise, active firefighters had fewer deaths than expected. Mortality of retired firefighters was similar to that of Massachusetts males.

SMRs for all causes of death and for accidents in

Table 1 *Observed and expected deaths and Standardised Mortality Ratio* in all 5655 subjects*

ICD No.	*Cause of death*	*Observed*	*Expected*[1]	*Expected*[2]	*SMR*[1]
—	All causes	2470	2720·9	2616·0	91
001-139	Infective	48	115·6	115·0	42
140-205	Cancer	367	427·3	376·4	86
150-159	Digestive	153	191·5	154·2	80
160-165	Respiratory	70	79·6	75·2	88
177-181	Genitourinary	64	69·6	64·1	92
193	Brain and other CNS	8	7·8	7·1	103
200-205	Lymphatic and haemopoietic	22	34·9	27·4	63
—	Other cancer	50	43·9	48·4	114
260	Diabetes	17	43·1	41·2	39
330-334	Vascular disease of CNS	220	268·6	242·8	76
400-468	Circulatory	1058	1196·5	1092·2	86
410	Rheumatic heart disease	17	59·4	55·5	29
470-527	Respiratory	166	177·7	158·5	93
530-587	Gastrointestinal	117	136·9	124·5	85
590-639	Genitourinary	61	124·8	137·4	49
592	Chronic nephritis	33	85·8	78·0	38
800-936	Accidents	138	133·1	160·9	104
979	Suicide	8	41·0	47·6	19
	All other causes	76	56·3	119·5	135
	Unknown cause of death	194	—	—	—

[1]Based on Massachusetts death rates for all males.
[2]Based on US death rates for white males.
*Standardised Mortality Ratio: 100 × observed/expected deaths – not adjusted for 194 deaths of unknown cause.

Table 2 *Standardised Mortality Ratios (and observed deaths) for all causes in all subjects according to selected characteristics**

Characteristic	*Category*	*SMR (Observed deaths)*
Year of entry	< 1920	95 (1630)
	⩾ 1920	84 (840)
Age at entry	< 29	92 (836)
	30-39	93 (881)
	⩾40	88 (753)
Year of death	1915-29	90 (780)
	1930-44	83 (603)
	1945-59	95 (689)
	1960-74	92 (398)
Age at death	<59	87 (349)
	60-69	90 (499)
	70-79	92 (743)
	⩾80	98 (879)

*SMR not adjusted for deaths of unknown cause.

Table 3 *Standardised Mortality Ratios* (and observed deaths) among active and retired firefighters*

ICD No.	*Cause of death*	*Active*	*Retired*
—	All causes	75 (655)	104 (1815)
140-205	Cancer	73 (97)	91 (270)
339	Vascular disease of CNS	63 (33)	89 (187)
400-468	Circulatory	73 (233)	92 (825)
470	Respiratory	83 (51)	101 (115)
530-587	Gastrointestinal	67 (44)	100 (73)
590-639	Genitourinary	34 (13)	57 (48)
800-936	Accident	135 (97)	67 (41)
—	All other causes	37 (45)	118 (104)
—	Unknown causes	— (44)	— (152)

*SMR not adjusted for deaths of unknown cause.

Table 4 *Standardised Mortality Ratios (and observed deaths) for all causes and for accidental deaths in active subjects according to characteristics of survival*

Characteristic	*Category*	*All causes*	*Accidental deaths*
Year of entry	1915-19	73 (317)	125 (39)
	1920-39	70 (140)	99 (16)
	1940-70	74 (198)	140 (42)
Age at entry	⩽ 29	75 (282)	122 (51)
	30-39	75 (269)	138 (36)
	40-65	62 (104)	110 (10)
Year of death	1915-29	55 (122)	96 (19)
	1930-39	78 (139)	94 (15)
	1940-59	78 (231)	114 (26)
	⩾ 1960	76 (173)	262 (37)
Age at death	⩽ 39	51 (68)	85 (20)
	40-49	84 (199)	208 (43)
	50-59	73 (251)	128 (26)
	⩾ 60	73 (137)	99 (8)

*SMR not adjusted for deaths of unknown cause.

active subjects were not related to age of entry into the study (Table 4). The SMR for accidents was greater than 100 for deaths occurring since 1940. The period 1960-75 with an SMR of 262 included two catastrophic fires in which many lives were lost (five lives in an incident on Trumbull Street, in 1964, and nine lives in an incident at the Vendome Hotel in 1972). This is consistent with the trend towards an increase of SMR for accidental deaths in subjects entering the Fire Department since 1940.

Subjects aged 40-49 years at the time of death had the largest excess of accidental deaths. The SMR for firefighters dying accidentally at less than 40 years of age was less than 100. Following the second world war, a large number of new recruits (many in their twenties) were assigned to the South End District which was centrally located, involved great firefighting activity, and included the catastrophes cited above. Recruits hired later were not likely to be assigned to the South End District as there was little turnover. These factors could explain the high accident frequency in the group aged 40-49 years. Similarly, the lowered risk of accidental death in firefighters over sixty years of age may result from non-firefighting assignments and early retirements.

Discussion

In this study of a large City Fire Department, sufficient numbers of observed deaths were generated to produce stable estimates of SMRs and to examine characteristics of survival in city firefighters. Active firefighters have an increased risk of dying accidentally in comparison to the general population, a finding which was anticipated from knowledge of the nature of the occupation, and is in agreement with the 1928 Joint Occupation Study of the Actuarial Society of America (1929) and a study of Chicago city firefighters in 1930 (Jenkins, 1930).

The major reason for conducting this study, however, was to examine mortality patterns for cardiovascular, respiratory and malignant diseases, since other studies have been inconsistent. In the most comprehensive previous study of city firefighters, Mastromatteo (1959) found an excess number of deaths in active and retired firemen from cardiovascular-renal diseases (observed/expected = 1·41). In an earlier study, Dublin and Vane (1947) found a standardised relative mortality index of 125 for deaths from cardiovascular-renal diseases in firefighters. The *Annual Report on the Vital Statistics of Massachusetts for the Year Ending Dec. 31, 1952* (Commonwealth of Massachusetts, 1952) disclosed a higher proportional mortality from cardiovascular-renal diseases in firefighters in comparison with all occupied men. This finding was repeated in the vital statistics of the USA for 1950 (Guralnick, 1963). More recently in the State of Washington, Milham (1976) found no excessive proportional mortality from cardiac diseases but did find an excess of various malignancies and duodenal ulcer.

Other studies have not been consistent with these findings. The Registrar General's Decennial Supplement for occupational mortality in England and Wales in 1931 showed a 'probably significant excess' of deaths in firemen from peptic ulcer and buccal cancer (Registrar General, 1938). Subsequent reports (Registrar General, 1957; Registrar General, 1971) did not support this finding nor did these studies show an increase in cardiovascular or accidental deaths. It should be noted that firefighting patterns and techniques do vary with time and place. Other earlier studies (Hunter, 1907-1908; Hunter and Rogers, 1920; Hunter, 1927; Whitney, 1934) were unable to demonstrate excessive cause-specific death rates while the design of more recent investigations has precluded comparison of data (Guthrie, 1970; Balanof, 1976). The present study provides evidence that there is no strong association between the occupation of firefighting *and deaths* from cardiovascular, respiratory, or malignant disease. However, exposures of individual firefighters may vary, and there was no way to determine specific past exposures. It is possible that within our data small subpopulations with excess risk of particular cause of death may exist.

Firefighters are generally considered to be at increased risk of sudden death of cardiac origin. Our results do not show the mode of death in subjects dying from cardiovascular disease: they suggest only that there is no strong association between occupation and death from cardiovascular disease, but do not refute the suggestion that sudden death may be a more common manifestation of cardiovascular disease in firefighters.

Studies of chronic respiratory morbidity have shown that experienced Boston firefighters have a higher rate of chronic nonspecific respiratory disease than new firefighters of the same age (Sidor and Peters, 1974), that there is a chronic effect of firefighting on pulmonary function (Peters *et al.*, 1974) and a protective effect of transfers to less hazardous jobs within the same department (Musk *et al.*, 1977a,b). Other studies (Mitchell *et al.*, 1971) have shown that chronic respiratory disease is underestimated from death certificate information. Excess morbidity, therefore, need not be reflected by excess mortality. Available information on cigarette smoking in current firefighters (Peters *et al.*, 1974; Musk *et al.*, 1977a,b), indicates that it does not differ from that in the general population. Thus, differences in smoking habits between firefighters and the general population do not explain our findings for deaths from malignancy and chronic lung disease.

This and prior studies of firefighters have consistently shown a decrease in mortality rates in firemen from diseases which are likely to be screened out on pre-employment physical examination, for example rheumatic heart disease, chronic nephritis and diabetes. The low SMRs that have been found for these chronic diseases probably result from the selection of healthy applicants for entrance into the Fire Department. *Medical Standards for Public Safety Candidates* (Commonwealth of Massachusetts, 1977) indicates that applicants for employment in the Massachusetts Civil Service, with persistent glycosuria, diabetes requiring insulin, albuminuria, or organic heart disease are rejected.

There may be several explanations for the low death rate for suicide found in this population. A large proportion of the Boston Fire Department comprises individuals of Irish and Italian extraction (Sidor and Peters, 1973) and it appears that Boston residents from these two ethnic groups are less prone to suicide than residents of other origins (Monson, unpublished data). Furthermore, firefighters may be selected on entry for criteria of psychological well-being as well as physical health. Once selected, these men join a closed department where they have financial security and psychological support from a relatively stable workgroup. Research on support groups suggests that this is an important factor in protecting individuals from deleterious effects of stress, including depression and suicide (Caplan, 1974; Durkeim, 1957). It may also be that a career devoted to saving property and lives from fire may lead to a value system where suicide has no place as an alternative. Additionally, there may be a disinclination on the part of physicians to certify death due to suicide in firefighters, even though no incentive for such action appears to exist.

This investigation shows that firefighters on active duty in the Boston Fire Department had an increased risk of dying accidentally, especially if they were in the age bracket 40-49 years. No evidence of an increased number of deaths from cardiovascular disease or malignancy was found for the population as a whole but small subpopulations with excess risk may exist. Our results are also consistent with the notion that mortality from chronic respiratory disease is under-reported by the physician certifying death.

We wish to thank Jane Starkman and Susan Sheridan for their technical and research assistance in writing this paper.

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