

A cohort study on the mortality of firefighters

Eva Støttrup Hansen

Abstract

This study was set up to investigate the effect of exposure to combustion effluents on the chronic health of firefighters. A cohort of firefighters was followed up through 10 years with regard to cause specific mortality. Comparisons were made with another cohort of civil servants and salaried employees in physically demanding jobs. After a latency of five years, an excess mortality from cancer was seen for persons aged 30 to 74 (standardised mortality ratio (SMR) 173, 95% confidence interval (95% CI) 104-270). A significant increase in lung cancer was seen in the group aged 60 to 74 (SMR 317, 95% CI 117-691), whereas non-pulmonary cancer was significantly increased in the group aged 30 to 49 (SMR 575, 95% CI 187-1341). It is concluded that inhalation of carcinogenic and toxic compounds during firefighting may constitute an occupational cancer risk. An extended use of respiratory protective equipment is advocated.

Firefighters may be exposed to various toxic substances by inhalation of particulate matter and gases. They are frequently exposed to significant concentrations of carbon monoxide, benzene, sulphur dioxide, hydrogen cyanide, acrolein, aldehydes, hydrogen chloride, nitrogen dioxide, chlorinated hydrocarbons including trichloroethylene, toluene, and dichlorofluoromethane, and to soot.¹⁻³ Also, fighting of fires in industrial plants manufacturing or handling certain toxic chemicals may embody exposure to dioxins and polychlorinated dibenzofurans.⁴

Health surveys of firefighters have indicated an increased prevalence of respiratory symptoms and reduced lung function.⁵⁻⁸ These observations have been corroborated by follow up studies indicating a considerable short term post fire decrement in

parameters of lung function,⁹⁻¹⁰ an accelerated rate of permanent loss of pulmonary function,¹¹⁻¹³ and an increased incidence of respiratory symptoms.¹⁴ Also, an increased risk of lung cancer¹⁵ and heart disease¹⁶⁻¹⁸ has been reported.

The occasional high exposures to toxic and potentially genotoxic substances during firefighting are likely to present a health hazard. This study was conducted to contribute information about possible long term effects of inhaled particulates and gases.

Subjects and methods

The design was that of a historical cohort study in which the exposed part of the cohort was compared with the unexposed part in terms of cause specific mortality through a ten year period of follow up. Firefighters constituted the exposed part of the cohort. The comparison population—namely, the unexposed part of the study cohort—was made up of other specific groups of civil servants and salaried employees.

The members of the study cohort were identified from the files of a nationwide census, which was carried out in Denmark on 9 November 1970. Self reported occupation, trade, industry, and employment on the day of the census were recorded for all Danish inhabitants older than 14.

The cohort included only civil servants and salaried employees, only men aged between 15 and 69, and only persons who were employed on the day of the census. Every public employee with the title "firefighter" or "fireman" was included as an exposed person. As unexposed persons, all men with one of the following employments or job titles were included (proportion of the total comparison group in parentheses): officers and conscripts in the military services (32%); medium and lower state functionaries in the post and telegraph services (24%); in the judicial system including the police force and the prison administration (20%); and in the railway and tramway traffic system (16%); plus male nurses and nursing auxiliaries (6%) and pilots and navigators in civil aviation (1%). A total of 886 exposed and 47 694 unexposed persons were enrolled in the study.

The Danish National Bureau of Statistics has linked the records of the 1970 census with the

Table 1 Follow up data for firefighters and comparison group through 9 November 1970 to 9 November 1980

	Firefighters	Comparison group
No of deaths	57	2383
No of emigrations*	6	1124
No of persons living in Denmark at the closing date	823	44187
Total	886	47694

*Includes those lost to follow up.

Table 2 Mortality of Danish firefighters from 1970 to 1980 by cause of death

Underlying cause of death*	OBS	SMR (95% CI)
Malignant neoplasms (140-209)	21	117 (72-178)
Lung cancer (162)	9	163 (75-310)
Other malignant neoplasms	12	96 (50-167)
Ischaemic heart disease (410-414)	24	115 (74-171)
Other diseases	9	71 (32-134)
External causes	3	61 (13-179)
Total	57	99 (75-129)

OBS = Observed no of deaths.

*Numbers in parentheses refer to the International Classification of Diseases, eighth revision.

Table 3 Mortality of Danish firefighters. Natural causes of death by diagnosis and period of follow up

Underlying cause of death*	First five year period of follow up		Second five year period of follow up	
	OBS	SMR (95% CI)	OBS	SMR (95% CI)
Cancer (140-209)	2	29 (3-103)	19	173 (104-269)
Ischaemic heart disease (410-414)	11	148 (74-265)	13	97 (52-166)
Other diseases	5	103 (33-240)	4	45 (12-116)
Total	18	93 (55-147)	36	108 (76-150)

*Numbers in parentheses refer to the eighth revision of the International Classification of Diseases.

Table 4 Cancer mortality among Danish firefighters during the period 9 November 1975-9 November 1980

Underlying cause of death	Age (y) at 9 November 1975			
	30-49	50-59	60-74	30-74
	SMR (95% CI)	SMR (95% CI)	SMR (95% CI)	SMR (95% CI)
Lung cancer*	0 (0-149)	135 (16-488)	317 (117-691)	220 (95-434)
Non-pulmonary cancer	575 (187-1341)	81 (17-236)	108 (22-317)	150 (75-268)
All cancer sites	439 (142-1024)	96 (31-225)	193 (88-366)	173 (104-270)

*Code No 162 in the eighth revision of the International Classification of Diseases.

National Register of Persons and the National Register of Deaths (publication numbers 37 (1979) and 41 (1985) from the Danish National Bureau of Statistics), making it possible to follow the total census population for ten years. The actual study cohort formed part of the census population and was traced by the use of the existing register linkage. Persons in the study were traced until 9 November 1980, or until death or emigration before that date. Table 1 shows the follow up.

Deceased persons, emigrants, and persons lost to follow up contributed person-years at risk until the day of death, the day of emigration, or the last day of notification in the central register of persons.

The firefighters contributed 8625 person-years and the unexposed civil servants and salaried employees 461 940 person-years at risk to the study.

For deceased persons, information on the underlying cause of death was derived from death certificates. Expected numbers of deaths among the firefighters were calculated from the death rates of the comparison population and the number of person-years at risk accumulated by the firefighters. Separate analyses were performed for each of the two five year periods of follow up.

For statistical evaluation, the observed number of deaths was assumed to follow a Poisson distribution. The death rates of the comparison population were assumed not to be influenced by random variation. A 95% confidence interval (95% CI) for the standardised mortality ratio (SMR) was based on exact Poisson limits for the observed number of deaths.¹⁹

Results

The overall mortality of firefighters did not differ from that of the comparison population. An increased mortality was seen for cancer and ischaemic heart disease but the differences did not reach statistical significance (table 2). None of the deaths in firefighters were ascribed to respiratory diseases (expected number 2.24).

Separate analysis of the two five year periods of follow up showed that the increase in mortality from cancer was confined to the second five year period, whereas an increased mortality from ischaemic heart

disease was manifest within the first five year period only (table 3). Analysis by age indicated an excess risk of lung cancer in the older age groups and of non-pulmonary cancer at younger ages (table 4). The excess mortality from non-pulmonary cancer among firefighters aged 30 to 49 was brought about by five deaths (one stomach cancer, two rectal cancers, one pancreatic cancer, and one cancer with "other localisation"—namely, numbers 170–174 and 190–199 in the eighth revision of the International Classification of Diseases). The excess mortality from ischaemic heart disease seen within the first five year period was most obvious among men aged 40 to 59 (SMR 177, 95% CI 81–336).

Discussion

The results indicate that firefighting is associated with an increased risk of cancer. Also, they corroborate to some extent the hypothesis that firefighting is associated with an increased risk of dying from ischaemic heart disease.

Regarding potential bias in the study, attempts have been made to minimise this by using a hand picked comparison group for the firefighters. As was the case with the firefighters, the members of the comparison group were civil servants and salaried employees. They were selected to have no occupational exposure to combustion effluents or to any other known carcinogens. Furthermore, the occupational groups for comparison were selected to resemble the group of firefighters in terms of work related demands on physical strength and fitness, social class, geographic distribution, and stability of employment. Accordingly, the two groups were made as compatible as possible with respect to other risk factors for chronic diseases such as cancer, ischaemic heart disease, and respiratory disease. In particular, it was hoped that the so-called healthy worker effect could be eliminated by choosing a hand picked comparison group of occupationally active workers in physically demanding jobs. Apart from stratification for age and calendar time, no further control for bias was practicable. The possibility still exists, however, that lifestyle differed between the firefighters and the comparison group. Possible differences in smoking habits would be of particular interest, because smoking is associated with an increased risk of those diseases (lung cancer, ischaemic heart disease, and chronic respiratory disease) that occur in excess among firefighters. Smoking is extremely prevalent among Danish men, however, and possible differences in smoking habit are likely to have caused only a minor degree of confounding.²⁰ Thus it seems unlikely that the comparison of the exposed and the unexposed part of the study cohort has been invalidated by serious bias.

Expectedly, the study design would be able to expose strong associations only. By following up the

mortality of a group of 886 occupationally active workers for only ten years, several adverse effects of the exposure under study may escape detection. It would have been appropriate to extend the follow up period beyond ten years, but this was not practicable. Another aspect which affected the sensitivity of the study was the definition and ascertainment of the compared exposure categories.²¹ In this study, the only criteria for a subject to be included into either category were (1) belonging to a particular occupation and (2) being employed on the day of census. Thus "exposure" means potential exposure at the time of enrolment into the study. The firefighters constitute a rather stable group, however, with a low turnover, in part because of secure employment and an advantageous pension scheme. The job title appearing in the 1970 census papers may, therefore, be anticipated to reflect the work history of most of the firefighters. Similar arguments hold good for the occupational groups selected for comparison with the firefighters. Thus the demonstrated differences in mortality are likely to reflect differences in long term occupational exposure.

A 40 to 80% increase in cardiovascular mortality has previously been reported for firefighters,^{16–18} and studies on proportionate mortality have also indicated an excess number of deaths from cardiovascular disease.^{22–24} Other mortality studies have failed to confirm this.^{25–27} One of these was, however, extremely small.²⁵ Another study indicated no excess mortality from circulatory diseases among Boston firefighters during the period 1915–75.²⁶ The precision and accuracy of diagnoses from death certificates and of age, period, and cause specific death rates are likely to have been rather poor, however, within the first two to three decades included in that study and this may have blurred a possible relation. In another mortality study, 990 firefighters were followed up from 1939 through 1978 and the mortality from almost any cause, including ischaemic heart disease, was found to be lower than that of the total population.²⁷ The authors also found indications of a healthy worker effect relating to the high standard of physical fitness required on entry to the fire service. In this context, it is remarkable that a survey of active firefighters showed an increased prevalence of ischaemic responses on electrocardiography at near maximal stress testing,²⁸ and that several of the firefighters, who had such signs of ischaemia, were found to have no atherosclerotic lesions in the coronary arteries as determined by arteriography.²⁹

In my study, a small increase in mortality from ischaemic heart disease was noted. It is of interest to consider carbon monoxide as an occupational risk factor for ischaemic heart disease among firefighters. Although carbon monoxide does not seem to play a part in the development of atherosclerosis,^{30–31} it is

beyond doubt that the concentration of carboxyhaemoglobin influences the risk of organ ischaemia, and in a person with pre-existent coronary atherosclerosis, exposure to carbon monoxide may precipitate a fatal attack of ischaemic heart disease.

A significantly increased mortality from cancer was seen among the Danish firefighters after the latency of five years from establishing the cohort. This lag time may indicate that persons with a subsequently fatal cancer are unable to remain active firefighters and have to leave their jobs some five years before they die. An excess number of deaths from digestive cancer was seen among relatively young persons, whereas an excess of deaths from lung cancer was seen among persons of older age.

Previously, the cohort study by Mastromatteo had indicated a slightly increased mortality from cancer among firefighters (SMR = 113)¹⁶ and studies on proportionate mortality have shown an increased frequency of buccal cancer, rectal cancer, lung cancer, skin cancer, and leukaemia as cause of death among firefighters.²³⁻²⁴ Furthermore, a recent case-control study has shown a significantly increased incidence of lung cancer among firefighters.¹⁵ An increased risk of respiratory and digestive cancer has also been reported for chimney sweeps and other occupational groups exposed to combustion effluents.³²⁻³⁶

Thus inhalation of soot fumes and gases during firefighting may bring about an increased risk of respiratory and digestive cancer. The chemical exposure comprises a wide range of toxic and genotoxic substances, many of which are likely to be adsorbed to particle surfaces.³⁷ Furthermore, the inhalation of respiratory irritants may impair the respiratory self clearance mechanism and thereby prolong the exposure of the bronchial epithelium to inhaled particles and particle adsorbed carcinogens. Once cleared from the airways, inhaled particles are transferred to the gastrointestinal tract where toxic and carcinogenic substances may exert their effect on the digestive epithelium. This route of exposure may be of importance for the risk of digestive cancer among firefighters and other occupational groups exposed to combustion effluents.

In conclusion, inhalation of carcinogenic and toxic compounds during firefighting may constitute an occupational cancer risk. It is suggested that the risk could be minimised by an extended consistent use of respiratory protective equipment.

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Requests for reprints to: E S Hansen, Institute of Community Health, J B Winsløvsvej 17, DK-5000 Odense C, Denmark.

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