OEM Online First, published on January 26, 2018 as 10.1136/oemed-2017-104734

ORIGINAL ARTICLE

Incidence of cardiovascular disease in a historical cohort of Danish firefighters

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► Additional material is published online only. To view please visit the journal online (http://dx.doi.org/10.1136/oemed-2017-104734).

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Received 25 August 2017
Revised 13 December 2017
Accepted 31 December 2017

ABSTRACT

Objectives Firefighters are exposed to multiple cardiovascular hazards, but few epidemiological studies have addressed their cardiovascular morbidity. The objective of this study was therefore to examine the incidence of cardiovascular diseases (CVD) in Danish firefighters.

Methods We used individual historical employment records on 11.691 male Danish firefighters supplied by trade unions and fire agencies. The Supplementary Pension Fund Register was used to establish two occupational reference groups (a random sample from the male employed population and military employees). Information on CVD incidence was retrieved from the nationwide Danish National Patient Registry. SIRs and Poisson regression analyses (incidence rate ratio) were used for estimation of risks, including 95% CIs.

Results In comparison with the population sample, the age-adjusted and calendar time-adjusted SIR for all CVDs combined was increased in firefighters (SIR=1.10, 95% CI 1.05 to 1.15). The risk was also elevated for the most frequent outcomes, including angina pectoris (SIR=1.16, 95% CI 1.08 to 1.24), acute myocardial infarction (SIR=1.16, 95% CI 1.06 to 1.26), chronic ischaemic heart disease (SIR=1.15, 95% CI 1.06 to 1.24) and atrial fibrillation/flutter (SIR=1.25, 95% CI 1.14 to 1.36). This analysis showed the most elevated SIRs for CVD in full-time firefighters compared with part-time/volunteer firefighters. Both types of firefighters employed <15 years had an increased risk of CVD. Similar risk patterns appeared in comparisons with the military. Internal analysis supported external findings.

Conclusion The risk of overall CVD, including the most frequent subtypes was modestly increased in Danish firefighters and was most elevated in full-time firefighters compared with other male employees.

Key messages

What is already known about this subject?

► Firefighters are exposed to various occupational cardiovascular hazards, but their incidence of cardiovascular disease (CVD) has not been adequately studied.

What are the new findings?

► This is the first large cohort study exploring the association between firefighting and CVD incidence. Results show that male Danish firefighters have an increased risk of major CVDs compared with other male employees.

How might this impact on policy or clinical practice in the foreseeable future?

► The study results should help inform CVD prevention approaches for firefighters.

INTRODUCTION

Firefighters experience different workplace hazards that may increase their risk for cardiovascular disease (CVD). At the fire scene, firefighters regularly experience mixtures of particles, steam and gases with a complex set of chemicals.[1] Studies have shown that inhaled particles can induce pulmonary inflammation followed by a systematic inflammation response, which is associated with an increased risk of cardiovascular events.[2 3] Cardiovascular effects of carbon monoxide are also documented; regular exposures may advance arteriosclerosis and cause impairment to the heart through restriction of oxygen.[4] Firefighters will often be operating in unbalanced positions while wearing weighty protective equipment in a hot environment, which have a combined effect on the cardiovascular physiology.[5] Firefighters are also exposed to a range of psychological stressors when providing emergency services and also normally perform 24 hours shifts that furthermore contribute to the CVD clustering of hazards in firefighting.[6 7]

It is therefore not surprising that firefighters have an increased risk of cardiac death occurring during and following specific firefighting activities. Recent reviews have, nevertheless, not suggested an elevated CVD mortality in firefighters,[1 8] which might be due to high long-term CVD survival rates[9] and the use of the general population as reference in these earlier studies introducing a potential healthy worker effect.[10] Different types of firefighters may moreover experience this cluster of CVD hazards with varying intensity and have a different lifestyle and occupational history also affecting their risk of CVD in distinctive ways. However, only a limited number of studies have explored their incidence of CVD and explored the risk by type of employment.[11 12] Incidence studies are therefore wanted for a more sufficient evaluation of the CVD risk in different types of firefighters.

The main aim of this historical cohort study was to estimate the risks of specific diagnoses of CVD by firefighting employment type (full-time vs part-time/volunteer) by conducting both internal and external comparisons. We used active

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To cite: Pedersen JE, Ugelvig Petersen K, Ebbehøj NE, *et al*. *Occup Environ Med* Epub ahead of print: [please include Day Month Year]. doi:10.1136/oemed-2017-104734

male employees as references and attempted to estimate dose–effect relationships based on different proxies for exposure as firefighter.

METHODS

Data collection

In Denmark, firefighting is usually managed by municipalities, but in several areas, firefighter assignments have been contracted to private enterprises that employ full-time and part-time firefighters. In other specific areas, firefighting service is covered by volunteer firefighters according to tradition and they have similar working conditions as part-time firefighters.

We identified Danish firefighters by retrieving individual historical job information, including personal identification number (PIN), name, date of birth, type of employment, job titles and date of start and end of firefighting employment, from Danish municipalities, countrywide trade unions and one private company covering firefighting assignments in all different parts of Denmark. Furthermore, 1726 individuals with a specified occupation relating to firefighting in the Danish Civil Registration System were retrieved from this register.

Information from the different sources was merged using the PIN, which has been assigned to all residents in Denmark since 2 April 1968 by the Danish Civil Registration System and is primarily used for unique personal identification by all Danish authorities. This register contains current and historical information, including personal identifiers, for example, name, date of birth, date of death, emigration or disappearance.[13] A total number of 17 134 individual firefighter records were identified. However, 1254 PINs were missing, and these were searched for in the Danish Civil Registration System by use of personal information. In total, 980 (78%) of the missing PINs were identified, leaving 16 860 individuals with firefighter records.

The PINs were afterwards linked with individual records from the Supplementary Pension Fund Register to supplement with missing information on employment periods as firefighters. This register, with compulsory membership for all wage earners aged 16–66 years since 1964, contains dates of start and end of each employment and a unique ID of the related company. Information is kept even when a person retires, emigrates or dies.[14]

To minimise selective survival bias, firefighter records were excluded if they only appeared in datasets containing records on firefighters currently being employed and thus without firefighter history (n=441). Records were also excluded if they only contained job titles related to administrative work or ambulance duty (n=2.968). A few firefighters (n=71) were excluded because of their excessively young age (<10 years) or old age (>60 years) at initial employment. Emigration to Greenland (n=7), firefighters with initial employment after end of follow-up (n=99), firefighters with records not containing information on start of employment (n=143) and firefighters with obscure employment dates (n=4) also resulted in exclusions. Furthermore, the years of follow-up and number of observations for CVD in the relatively small group of women in the cohort were considered insufficient for meaningful statistical analysis and they were also excluded (n=316). Firefighters employed less than 1 month (n=117) were excluded because their firefighting exposure would have been minimal. Firefighters born before 1 January 1927 and thereby being older than 50 years at the earliest date of follow-up were also excluded from the study to avoid a potential healthy worker effect (n=918).[10] Last of all, firefighters diagnosed with CVD (main or secondary) before initial employment were excluded (n=74).

To further minimise a potential healthy worker effect, two different occupational cohorts were established as reference groups based on data from the Supplementary Pension Fund Register: (A) a random sample of men from the general employed population (n=396 906) and (B) all past and current employees from the Danish military (n=262 548) assuming that their socioeconomic and lifestyle characteristics are comparable with firefighters. Both references were shaped according to the same criteria as the cohort of firefighters.

Firefighters' and reference groups' PINs were used to retrieve information in the Danish Civil Registration System on residence and dates of emigration, disappearance or death.

We used hospitalisation as a proxy measure for CVD incidence, and information on CVD among the firefighter cohort and the reference groups was obtained by individual linkage to the Danish National Patient Registry by use of the PIN. This registry stores information on all hospitalisations in Denmark since 1 January 1977 and outpatients from 1994. The registry contains detailed information on time of admission and discharge, primary diagnosis and additional diagnoses. In the period 1977–1993, diagnoses were coded according to the International Classification of Diseases, Revision 8 (ICD-8), and afterwards diagnoses were coded according to ICD-10.[15] In Denmark, the healthcare system, including hospitalisation, is free of charge for all residents. A total of 10 outcomes were selected for examination, including angina pectoris (413, I20), acute myocardial infarction (410, 411, I21), chronic ischaemic heart disease (412, I25), heart failure (427.09–11, 427.19, 519.19, I50, J81, J68, R570), cardiac arrest (427.27, I46), atrial fibrillation/flutter (427.93–94, I48), cerebral apoplexy (433.09–434.99, 436.01–436.90), transient ischaemic attack (435.09–435.99, G45), arteriosclerosis (440, I70) and arterial embolism/thrombosis (444, I74). Because diabetes is a known risk factor for CVD[16] and a sufficient number of hospitalisations were available in the data, diabetes (249.00–250.09, DE10, DE149) was included to examine risk differences between the cohort of firefighters and each of the two reference groups.

Statistics

A total number of 11 691 Danish firefighters were eligible for analyses. Firefighters' follow-up period started from the date of first employment or 1 January 1977, whichever came latest. When exploring the risk for each cardiovascular outcome, follow-up ended on the first date of hospitalisation, death, disappearance, emigration from Denmark or 31 December 2014, whichever came first. When exploring the overall risk for CVD ('all cardiovascular diseases'), follow-up ended on the first date of hospitalisation for any of the 10 selected cardiovascular outcomes grouped into this category. CVD incidence rates by 5-year age groups and 5-year calendar periods were estimated for each reference group and applied to the person-years under observation for the firefighter cohort members to obtain the number of CVDs expected had the cohort members experienced the same rate of CVD as that observed in the respective reference group. The SIRs were estimated for the firefighters by calculating the ratio between the observed and expected number of each CVD outcome.

SIRs were calculated for the overall cohort of firefighters and separately for part-time/volunteer and full-time firefighters by each exposure group: (A) era of initial employment (<1970, 1970–1994 and >1995), (B) duration of employment (<5 years, 5–9 years, 10–15 years and >15 years) and (C) by age at initial employment (<25 years, 25–34 years and ≥35 years). To explore acute cardiovascular effects from firefighting, SIRs for CVD outcomes restricted to active firefighter employment time were also estimated.

We used Poisson regression modelling to estimate incidence rate ratios in internal analyses. To account for differences in air pollution potentially affecting the risk for CVD,[17] adjustment was made for geography, which was based on the firefighters' last known regional residence in Denmark corresponding to the National Bureau of Statistics regional classification. We did not adjust for diabetes in internal analyses since many of the strata would contain too few or no cases.

Tests for trends were also undertaken using Pearson's correlation coefficient, and Pearson goodness-of-fit test was used to test distributional assumptions. Three sensitivity analyses were undertaken; the first analysis was carried out to evaluate the effect of prevalent cases with former CVD thereby exploring if a significant part of the observations reflected prevalence instead of incidence of CVD. This was conducted by excluding subjects registered with CVD during the first 5 years of disease registration in the Danish National Patient Registry (1977–1982). The second analysis investigated the influence of the introduction of ICD-10 in 1994 on the diagnostic of selected outcomes of CVD given that ICD-10 diagnoses appear more comprehensive compared with ICD-8. Lastly, we conducted a sensitivity analysis looking merely at hospitalisation admission data, as the outpatient data were only available for part of the study period (since 1994).

All analyses were performed with Stata statistical software V.14.1.

Table 1 Characteristics of the 11 691 Danish firefighters, 1977–2014

Characteristics	Entire cohort	Part time/volunteer	Full time
Eligible for follow-up	11 691	7013	4678
Birth year, n (%)			
<1950	2667 (23)	934 (14)	1733 (37)
1950–1970	5211 (45)	3.171 (45)	2040 (44)
>1970	3813 (32)	2.908 (41)	905 (19)
Attained age at the end of follow-up, mean (SD)	52 (14.5)	48 (13.6)	58 (14.0)
Vital status at end of follow-up, n (%)			
Alive	10 399 (89)	6614 (94)	3778 (81)
Deceased	1192 (10)	347 (5)	845 (18)
Emigrated	100 (1)	47 (1)	53 (1)
Disappeared	0	0	0
Year of initial employment, n (%)			
<1970	1448 (13)	181 (3)	1267 (27)
1970–1994	4460 (38)	2306 (33)	2154 (46)
>1994	5783 (49)	4526 (64)	1257 (27)
Duration of employment (years), n (%)			
<1	1921 (16)	737 (11)	1184 (25)
1–9	4215 (36)	3260 (46)	955 (20)
10–15	2513 (21)	1695 (24)	818 (18)
>15	3042 (26)	1321 (19)	1721 (37)
Employment in years, mean (SD)	13 (11.7)	11 (10.0)	15 (13.4)
Age at initial employment (years), n (%)			
<25	4924 (42)	2131 (30)	2793 (60)
25–34	4270 (37)	2831 (41)	1439 (31)
≥35	2497 (21)	2051 (29)	446 (9)

RESULTS

Of the total cohort, 4678 were employed as full-time firefighters, while 7013 were employed as part-time/volunteer firefighters. Characteristics of the firefighters varied by type of employment; compared with part-time/volunteer firefighters, a larger proportion of full-time firefighters was older at end of follow-up, hired in earlier eras, had a longer duration of employment and had a younger age at initial employment. A total of 1192 firefighters died, 100 emigrated from Denmark and 10 399 were still alive at the end of follow-up (table 1).

In the overall external analyses (table 2), the number of observed cases of CVD in general exceeded the expected number. Results for the total cohort of firefighters showed a significant modestly increased risk for all CVDs combined (SIR=1.10, 95% CI 1.05 to 1.15) and significantly increased risks were observed for the three most frequent CVD outcomes (angina pectoris, acute myocardial infarction and chronic ischaemic heart disease) in comparison with the population sample. A similar risk pattern appeared when the total cohort of firefighters were compared with the military (data not shown). Results from this analysis furthermore showed an elevated risk for all CVDs combined (SIR=1.12, 95% CI 1.05 to 1.19) in full-time firefighters compared with the population sample. An elevated risk was moreover found for 8 of 10 cardiovascular outcomes in full-time firefighters reaching statistical significance for angina pectoris (SIR=1.21, 95% CI 1.11 to 1.32), acute myocardial infarction (SIR=1.18, 95% CI 1.06 to 1.31), chronic ischaemic heart disease (SIR=1.19, 95% CI 1.08 to 1.31), heart failure (SIR=1.18, 95% CI 1.04 to 1.33) and atrial fibrillation/flutter (SIR=1.30, 95% CI 1.16 to 1.45). Compared with the military, both full-time and part-time/volunteer firefighters overall had significantly increased risks for the same stated cardiovascular outcomes, although still leaving a pattern indicating a higher risk for full-time firefighters (data not shown). The risk for heart failure was, however, significantly decreased in part-time/volunteer firefighters compared with both references.

Analyses by duration of employment as firefighter (table 3) showed that the total cohort and both types of firefighters employed <5 years, 5–9 years and 10–15 years in general had an elevated risk for all CVDs combined and for the most frequent CVD outcomes (angina pectoris, acute myocardial infarction and chronic ischaemic heart disease) compared with the employed population sample. However, firefighters employed >15 years were not shown to have an increased risk and the elevated risk thereby decreased by increasing duration of employment.

When exploring the risk for CVD during active firefighting employment (table 4), an overall pattern of a decreased risk was shown reaching statistical significance for four CVD outcomes (heart failure, cardiac arrest, cerebral apoplexy and arteriosclerosis), when the total cohort of firefighters were compared with the employed population sample. However, the risk for atrial fibrillation/flutter was significantly increased. The same risk pattern appeared for both types of firefighters, and no noticeable difference in risk estimates by type of employment were detected. An overall similar risk pattern was observed when comparing the firefighters with the military (data not shown).

When exploring the risk for diabetes in firefighters (see online supplementary table S1), the total cohort had a significantly decreased risk compared with the population sample (SIR=0.87, 95% CI 0.80 to 0.90). When conducting this analyses by type of employment, part-time/volunteer firefighters were shown to have a significantly decreased risk while full-time firefighters had a similar risk.

Table 2 SIRs and 95% CIs for CVDs among a cohort of Danish part-time/volunteer and full-time firefighters (n=11 691) in comparison with an employed population sample, 1977–2014

	Total cohort			Part time/volunteer			Full time		
	Obs.*	SIR†	95% CI	Obs.*	SIR†	95% CI	Obs.*	SIR†	95% CI
All CVDs	1839	1.10	1.05 to 1.15	751	1.07	0.99 to 1.15	1088	1.12	1.05 to 1.19
Angina pectoris	815	1.16	1.08 to 1.24	320	1.09	0.98 to 1.21	495	1.21	1.11 to 1.32
Acute myocardial infarction	550	1.16	1.06 to 1.26	206	1.12	0.98 to 1.28	344	1.18	1.06 to 1.31
Chronic ischaemic heart disease	652	1.15	1.06 to 1.24	242	1.07	0.95 to 1.22	410	1.19	1.08 to 1.31
Heart failure	354	1.01	0.91 to 1.12	93	0.71	0.58 to 0.87	261	1.18	1.04 to 1.33
Cardiac arrest	89	0.98	0.80 to 1.21	30	0.79	0.55 to 1.13	59	1.12	0.87 to 1.44
Atrial fibrillation/flutter	504	1.25	1.14 to 1.36	192	1.17	1.02 to 1.35	312	1.30	0.16 to 1.45
Cerebral apoplexy	369	0.95	0.86 to 1.05	139	0.92	0.78 to 1.08	230	0.97	0.85 to 1.11
Transient ischaemic attack	188	1.12	0.97 to 1.30	79	1.17	0.94 to 1.46	109	1.09	0.90 to 1.31
Arteriosclerosis	178	1.02	0.88 to 1.18	50	0.82	0.62 to 1.07	128	1.13	0.95 to 1.35
Arterial embolism/thrombosis	30	0.83	0.58 to 1.19	11	0.78	0.43 to 1.41	19	0.87	0.55 to 1.36

*Observations.
†Adjusted for calendar year and age.
CVDs, cardiovascular diseases.

Internal analysis by type of employment and duration of employment supported external analysis by showing similar risk patterns (see online supplementary table S2,S3); full-time firefighters were shown to have an elevated risk compared with part-time/volunteer firefighters. Both types of firefighters employed >15 years had the lowest CVD risk and no noticeable differences in risk estimates appeared between part-time/volunteer and full-time firefighters. After controlling for geographical residence in internal analyses, the associations generaly weakened, but significant associations did not disappear.

Results from both external and internal analyses by other proxies for exposure, including era of employment and age at initial employment, were regarded as ambiguous as no discerning patterns were recognised.

The sensitivity analysis, exploring the influence of possible prevalent cases with former CVD, did not significantly change risk estimates and overall risk patterns. Analyses of the potential influence of the change from ICD-8 to ICD-10 and outpatient data that had only been available since 1994 revealed that approximately 90% of CVD cases were diagnosed according to ICD-10 and in the period with available outpatient data. The effect of these changes possibly causing differences in trends of CVD morbidity were therefore considered to be insignificant.

DISCUSSION

Overall analyses of the total cohort of 11 691 male Danish firefighters showed a modest significantly increased risk for all CVDs combined and for the three most frequent CVD outcomes (angina pectoris, acute myocardial infarction and chronic ischaemic heart disease) in comparison with the population sample and military employees. Analyses showed the most elevated SIRs for CVD in full-time firefighters and for both types of firefighters employed for less than 15 years. However, analyses showed no increased risk for CVDs during the active period of firefighting. Moreover, the risk for several outcomes (heart failure, cardiac arrest, cerebral apoplexy and arteriosclerosis), not elevated in overall analysis, was significantly decreased during active employment time. Internal analyses supported these findings.

Relatively few papers have addressed the lifetime risk of other diseases than cancer among firefighters; reviews have suggested that specific firefighter duties are associated with acute cardiovascular events, but the increased risk has, however, only been shown for firefighters with higher prevalence of CVD risk factors (ie, overweight and smoking). Firefighters have, nevertheless, not been suggested to have an elevated CVD mortality.[1 8] When exploring the lifetime risk of CVD from firefighting, only few studies have focused on exploring the morbidity.[11 12]

This present study adds to these former examinations by having estimated CVD incidence, which is a more appropriate measure due to the high Danish CVD long-term survival rates.[9] The modestly increased risk for CVD shown for this cohort of male Danish firefighters may be due to the cluster of CVD hazards in firefighting that include repeated exposure to smoke from fire incidences in especially previous eras, which has been significantly reduced today by the required respiratory protection equipment. However, firefighters often do not wear their respiratory protection equipment in the period after fire suppression, when harmful inhalants are still present.[1] Shift work together with psychological stressors in the course of an increasing number of emergencies (ie, fires, natural disasters, traffic accidents and medical services) also contribute to the hazards experienced by firefighters.[6 7]

These exposures in firefighting are assumed to be experienced more frequently by full-time firefighters, which could in part explain why the most elevated risk for CVD was observed for firefighters with this employment type. As the Danish social security system provides a certain level of financial sustainability for Danish citizens, part-time/volunteer firefighters actively seeking this type of work may have a high level of personal resources and a pronounced selection on health contributing to an explanation of the observed significant decreased risk of diabetes in this type of firefighters compared with the population sample and lower risk for CVD compared with full-time firefighters.

The detected decrease in risk by long-term firefighting might be due to a healthy worker effect; firefighters with a poor initial health would have to leave this work due to the physical workload. A continuing selection process would then result in firefighters remaining employed tending to be healthier compared with firefighters leaving the service.

The fact that the cluster of CVD hazards in firefighting did not result in increased morbidity during active employment time may also reflect a healthy worker effect; Danish fire departments require a stringent selection process on health for employmentr, perform medical examinations and require maintenance

Table 3 SIRs and 95% CIs for CVDs among a cohort of Danish part-time/volunteer and full-time firefighters (n=11 691) in comparison with an employed population sample by duration of employment, 1977–2014

	Total cohort			Part time/volunteer			Full time		
Duration of employment	Obs.*	SIR†	95% CI	Obs.*	SIR†	95% CI	Obs.*	SIR†	95% CI
All CVDs (years)									
<5	621	1.21	1.12 to 1.31	120	1.31	1.09 to 1.56	501	1.19	1.09 to 1.29
5 – 9	172	1.38	1.18 to 1.60	110	1.31	1.09 to 1.58	62	1.50	1.17 to 1.93
10–15	185	1.35	1.17 to 1.56	132	1.37	1.15 to 1.62	53	1.30	0.99 to 1.70
>15	861	0.96	0.89 to 1.02	389	0.90	0.82 to 0.99	472	1.01	0.91 to 1.10
Angina pectoris (years)									
<5	294	1.38	1.22 to 1.53	59	1.58	1.22 to 2.04	235	1.32	1.16 to 1.50
5–9	69	1.34	1.06 to 1.69	46	1.34	1.00 to 1.79	23	1.33	0.88 to 2.00
10–15	78	1.36	1.09 to 1.70	54	1.33	1.01 to 1.73	24	1.44	0.96 to 2.14
>15	374	0.99	0.89 to 1.09	161	0.89	0.76 to 1.03	213	1.08	0.94 to 1.23
Acute myocardial infarction (years)									
<5	188	1.20	1.04 to 1.39	24	1.11	0.74 to 1.65	164	1.22	1.04 to 1.41
5–9	52	1.69	1.29 to 2.22	30	1.51	1.06 to 2.16	22	2.02	1.33 to 3.07
10–15	52	1.46	1.11 to 1.91	35	1.41	1.01 to 1.96	17	1.57	0.97 to 2.52
>15	258	1.02	0.90 to 1.15	117	0.99	0.83 to 1.19	141	1.04	0.88 to 1.23
Chronic ischaemic heart disease (years)									
<5	235	1.28	1.12 to 1.45	30	1.14	0.80 to 1.63	205	1.30	1.13 to 1.49
5–9	43	1.16	0.86 to 1.57	25	1.03	0.70 to 1.52	18	1.40	0.88 to 2.22
10–15	60	1.41	1.09 to 1.81	40	1.31	0.96 to 1.79	20	1.62	1.05 to 2.52
>15	314	1.03	0.92 to 1.15	147	1.02	0.87 to 1.20	167	1.03	0.89 to 1.20
Heart failure (years)									
<5	155	1.26	1.08 to 1.48	14	0.95	0.56 to 1.60	141	1.31	1.12 to 1.54
5–9	17	0.83	0.52 to 1.33	8	0.59	0.30 to 1.20	9	1.23	0.64 to 2.37
10–15	20	0.82	0.53 to 1.27	11	0.64	0.36 to 1.16	9	1.23	0.64 to 2.38
>15	162	0.88	0.75 to 1.02	60	0.70	0.54 to 0.90	102	1.03	0.85 to 1.25
Cardiac arrest (years)									
<5	39	1.36	0.99 to 1.86	5	0.91	0.38 to 3.18	34	1.46	1.05 to 2.05
5–9	3	0.42	0.14 to 1.31	2	0.41	0.10 to 1.64	1	2.30	0.06 to 3.08
10–15	7	0.92	0.44 to 1.93	2	0.37	0.09 to 1.47	5	2.29	0.95 to 5.51
>15	40	0.84	0.62 to 1.15	21	0.93	0.61 to 1.43	19	0.76	0.48 to 1.18
Atrial fibrillation/flutter (years)									
<5	170	1.26	1.08 to 1.46	30	1.33	0.93 to 1.91	140	1.24	1.24 to 1.47
5–9	39	1.37	1.00 to 1.87	25	1.26	0.85 to 1.87	14	1.55	1.55 to 2.63
10–15	41	1.31	0.96 to 1.78	30	1.35	0.94 to 1.93	11	1.19	1.19 to 2.16
>15	254	1.21	1.07 to 1.37	107	1.07	0.88 to 1.29	147	1.34	1.34 to 1.58
Cerebral apoplexy (years)									
<5	136	1.06	0.90 to 1.25	19	1.03	0.66 to 1.62	117	1.06	1.06 to 1.27
5–9	30	1.19	0.83 to 1.71	22	1.34	0.88 to 2.03	8	0.90	0.90 to 1.80
10–15	30	1.04	0.72 to 1.48	19	0.93	0.59 to 1.45	11	1.28	1.28 to 2.32
>15	173	0.84	0.72 to 0.97	79	0.81	0.65 to 1.01	94	0.80	0.80 to 1.05
Transient ischaemic attack (years)									
<5	65	1.21	0.95 to 1.54	12	1.38	0.78 to 2.43	53	1.17	1.17 to 1.53
5–9	13	1.10	0.64 to 1.90	10	1.28	0.69 to 2.37	3	0.99	0.99 to 2.65
10–15	26	1.98	1.35 to 2.91	21	2.26	1.48 to 3.47	5	1.29	1.29 to 3.09
>15	84	0.94	0.76 to 1.17	37	0.88	0.64 to 1.22	47	1.00	1.00 to 1.33
Arteriosclerosis (years)									
<5	84	1.36	1.10 to 1.68	8	1.38	0.69 to 2.75	76	1.35	1.35 to 1.69
5–9	10	1.14	0.61 to 2.12	3	0.55	0.18 to 1.72	7	2.00	2.06 to 4.32
10–15	9	0.84	0.42 to 1.56	7	0.92	0.44 to 1.92	2	0.58	0.58 to 2.30
>15	75	0.81	0.65 to 1.01	32	0.75	0.53 to 1.06	43	0.86	0.86 to 1.16
Arterial embolism/thrombosis (years)									
<5	12	1.00	0.57 to 1.76	3	1.59	0.51 to 4.93	9	0.88	0.88 to 1.70
5–9	3	1.20	0.39 to 3.72	1	0.60	0.08 to 4.29	2	2.31	2.31 to 9.22
10–15	2	0.72	0.18 to 2.88	2	1.02	0.26 to 4.09	0	–	–
>15	13	0.69	0.40 to 1.19	5	0.57	0.24 to 1.38	8	0.79	0.79 to 1.59

*Observations.
†Adjusted for calendar year and age.
CVDs, cardiovascular diseases.

Table 4 SIRs and 95% CIs for CVDs among a cohort of Danish part-time/volunteer and full-time firefighters (n=10 765) in comparison with an employed population sample during active firefighter employment time, 1977–2014

	Total cohort			Part time/volunteer			Full time		
	Obs.*	SIR†	95% CI	Obs.*	SIR†	95% CI	Obs.*	SIR†	95% CI
All CVDs	636	0.93	0.86 to 1.01	355	0.92	0.83 to 1.02	281	0.94	0.84 to 1.06
Angina pectoris	265	0.94	0.83 to 1.06	104	0.88	0.74 to 1.03	125	1.02	0.86 to 1.21
Acute myocardial infarction	197	1.02	0.89 to 1.17	109	1.03	0.86 to 1.25	88	0.99	0.80 to 1.21
Chronic ischaemic heart disease	173	0.88	0.76 to 1.02	99	0.89	0.73 to 1.08	74	0.86	0.68 to 1.07
Heart failure	65	0.66	0.52 to 0.84	36	0.63	0.46 to 0.88	29	0.69	0.48 to 0.99
Cardiac arrest	16	0.53	0.32 to 0.86	9	0.52	0.27 to 0.99	7	0.53	0.25 to 1.11
Atrial fibrillation/flutter	128	1.54	1.30 to 1.83	67	1.35	1.06 to 1.71	61	1.78	1.39 to 2.29
Cerebral apoplexy	87	0.69	0.56 to 0.85	54	0.74	0.57 to 0.96	33	0.60	0.43 to 0.85
Transient ischaemic attack	52	0.90	0.69 to 1.18	31	0.94	0.66 to 1.33	21	0.84	0.55 to 1.28
Arteriosclerosis	30	0.56	0.39 to 0.80	17	0.56	0.35 to 0.90	13	0.55	0.32 to 0.95
Arterial embolism/thrombosis	10	0.68	0.37 to 1.26	4	0.50	0.19 to 1.33	6	0.89	0.39 to 1.97

*Observations.
†Adjusted for calendar year and age.
CVDs, cardiovascular diseases.

of physical fitness during hire, which could negate deleterious effects from firefighting during employment.[10]

Information on lifestyle risk factors (ie, smoking, alcohol consumption and physical inactivity) are generally not obtained in Danish nationwide registries and are therefore often not available for epidemiological research. Cardiovascular risk conditions are normally treated at the general practitioner, and in Denmark, data from primary care are generally unavailable for epidemiological research purposes. In this study, data were therefore restricted to hospitalization data only. Analyses of the risk for other cardiovascular risk conditions than diabetes was not possible to conduct, since we had too few or no hospitalised cases in the available data.

We were, moreover, not able to account for other potential confounders than age, calendar time and geography, which limit this study as other similar studies on firefighters. In particular, the lack of information on tobacco smoking may be an issue. A recent parallel study on the Danish firefighters have, however, not shown evidence of an excess lung cancer risk indicating that smoking is not much more prevalent among Danish firefighters than in the comparison populations. Even though Danish firefighters are selected on health for employment and may be more physically active in their job than other occupational groups, they may not necessarily maintain their physical fitness after end of employment, which could bias risk estimates in the opposite direction together with other possible lifestyle factors.

It was, nevertheless, a strength of this study that sources of bias and confounding may have been reduced by analysing data by both external comparisons using groups of active male employees as references and internal comparisons. It was furthermore a strength of this study that historical individual firefighter records were collected to examine the risk for CVD in different types of firefighters and establish several proxies for exposure.

Furthermore, this study benefits from using data from objective and reliable nationwide registries[13 14] and hospitalisation with free access for all residents. All subtypes of CVD diagnoses requiring hospital treatment could furthermore be retrieved from the Danish National Patient Registry to estimate CVD incidence. The Danish National Patient Registry is considered a valuable tool for epidemiological research,[15] and the registration of acute admission among medical patients has high validity.[18] The statistical power of this study to detect differences in CVD incidence was, moreover, high due to the relatively large number of cases for each subtype of CVD in each exposure group and due to a long period of follow-up for a relatively large cohort of young firefighters.

CONCLUSION

This is the first large cohort study exploring the association between different types of firefighters and CVD incidence. Results show that Danish firefighters have a modestly increased risk for CVD and that this risk is most pronounced in full-time firefighters. For a further evaluation of the CVD risk in different types of firefighters, more incidence studies with information on potential confounders are warranted.

Acknowledgements The authors would like to thank the involved fire departments and trade unions for providing the necessary data used in the study.

Contributors JEP performed programming of data, analyses, participated in interpretation of results and wrote the manuscript. KUP was responsible for collecting the data, performed programming of data, participated in the interpretation of results and revised the manuscript critically. NEE and JPB engaged in the design of the study, participated in the interpretation of results and revised the manuscript critically. JH was a key contributor in the design process of the study and supervised the data collection, programming and analyses, participated in the interpretation of results and supervised the writing of the manuscript. The overall content of the manuscript was guaranteed by JH. All authors have read and approved the final manuscript.

Funding Funding was provided by The Danish Working Environment Research Fund.

Competing interests None declared.

Provenance and peer review Not commissioned; externally peer reviewed.

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Occup Environ Med published online January 26, 2018