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RESEARCH ARTICLE

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Cancer incidence in a cohort of Danish firefighters: An extended long-term follow-up 1968–2021

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Abstract

Objectives: To update and extend the examination of cancer incidence in a cohort of Danish firefighters, now adding 7 years of follow-up and 2766 additional firefighters. The primary focus was directed toward cancer sites that recently contributed to the hazard evaluation conducted by the International Agency for Research on Cancer (IARC).

Methods: The updated cohort consisted of 11,827 male Danish firefighters who were followed up for cancer from 1968 to 2021. Cohort cancer morbidity was compared with a working population reference group, and standardized incidence ratios (SIR) were used for estimation of relative risks, along with 95% confidence intervals (95% CI).

Results: Among full-time firefighters, SIR of skin melanoma was 1.30 (95% CI: 1.02–1.66), and SIR = 1.37 (95% CI: 1.02–1.85) for over 5 years of employment. Slightly positive associations were also observed for cancer of the urinary bladder (SIR = 1.16; 95% CI: 0.93–1.45), prostate (SIR = 1.11; 95% CI: 0.97–1.28), and testis (SIR = 1.11; 95% CI: 0.75–1.63).

Conclusions: This updated study provides evidence indicating an elevated risk of skin melanoma in firefighters. Consistent with IARC's evaluation, we also identified positive associations for urinary bladder, prostate, and testis cancer. In contrast, our findings did not suggest an increased risk of colon cancer, non-Hodgkin lymphoma, and mesothelioma. The latter may be due to small numbers in our still relatively young cohort. Continuous follow-up for cancer in firefighters is warranted, including assessment of influence from surveillance bias.

KEYWORDS
cancer, cohort, epidemiology, firefighters

1 | INTRODUCTION

Firefighters operate at fire scenes and other emergency events that potentially involve exposure to complex and unique mixtures of carcinogens. Exposures include combustion products from fires, (including polycyclic aromatic hydrocarbons [PAHs], polychlorinated biphenyls [PCBs], particulate matter [PM], volatile organic compounds, and heavy metals), structural building components (asbestos), and diesel exhaust from fire trucks. Firefighters involved in training, ship, and aviation firefighting are also exposed to various chemicals occurring in firefighting foams (such as per-and polyfluoroalkyl substances [PFAS]).[1] Recently, PFAS have attracted heightened attention due to concerns over both

public and occupational health.[2] Other cancer-relevant exposures in firefighting include night shift work, and solar ultraviolet radiation.[1]

For decades, a large body of literature has provided evidence of excess cancer morbidity in firefighters. This includes large meta-analyses and the classification of firefighting as possibly carcinogenic (Group 2B) by the International Agency for Research on Cancer [IARC] in 2007.[3–11] A recent meta-analysis conducted by DeBono et al.,[11] which involved 35 cohort studies, was carried out as part of the reevaluation by IARC in 2022, assessing the carcinogenicity of firefighting. The evaluation resulted in a reclassification of occupational exposure as a firefighter as carcinogenic to humans (Group 1), which was based on sufficient evidence for mesothelioma and bladder cancer. Moreover, limited evidence was found for prostate cancer, testicular cancer, colon cancer, skin melanoma, and non-Hodgkin lymphoma [NHL].[1] Only a limited number of subsequent studies addressing the risk of cancer in firefighters have been carried out.[12,13]

Epidemiological research presenting limited evidence for specific cancers in firefighters may be due to heterogenicity from, for example, study population characteristics, including different time periods, encountered exposures, applied comparison groups, and duration of follow-up, and this area therefore needs further epidemiologic attention. A Danish study reported on cancer incidence from 1968 to 2014 among a large cohort of firefighters using national registries of high quality.[14] In this updated study, we report results from an extended follow-up of this cohort, adding 7 years of follow-up and including 2766 additional firefighters. This is an attentive evaluation aimed at assessing cancer sites considered to have sufficient or limited evidence in the recent meta-analysis conducted by IARC.[1]

2 | METHODS AND MATERIALS

2.1 | Establishing the cohort

The materials and methods in relation to the establishment of the cohort of Danish firefighters have been described in detail earlier.[14] In summary, fire departments, trade unions, and firefighting authorities were contacted to systematically gather individual-level employment data for past and current firefighters until December 31, 2014. This information included the unique Danish 10-digit personal identification number (PIN), which has been assigned to all residents in Denmark since April 2, 1968, through the Danish Civil Registration System (DCRS).[15] Subsequently, the firefighters' PIN was used to obtain individual-level employment history from the Danish Supplementary Pension Fund register (ATP), backdating to April 1, 1964. This register holds information on all residents with registered employment history. This information was used to supplement or verify periods of firefighting employments.[16]

2.2 | Study population

For firefighters born in 1928 and later with complete PIN numbers, the gathered data was scrutinized using several inclusion criteria (for a detailed account of the updated cohort construction, please refer to Supporting Information: Figure 1). In contrast to the initial study,[14] firefighters whose first employment occurred after December 31, 2004 were now included. This inclusion was made because a minimum lag period of about 10 years from first employment to end of follow-up was now applicable to all firefighters, which was not the case in our initial study. However, female firefighters remained excluded due to an insufficient number for meaningful analyses.

2.3 | Reference group

An external occupational male reference group was applied, which consisted of a randomly selected sample of workers matched on birth year and sex, using data obtained from the ATP. The updated reference group was shaped according to the same overall criteria as the updated cohort of firefighters, resulting in a total of 418,161 male employees.

2.4 | Firefighter employment

As described in detail in the original study,[14] several dimensions of firefighter employment were applied, including employment type (full time vs. volunteer/part-time firefighters), and job function (specialized smoke divers vs. regular firefighters). In the present study where the period of initial employment as a firefighter ranged from 1946 to 2012, we examined time period of initial employment in to groups (≤1985 and >1985) reflecting important changes in the work environment, for example, improvements of protection gear,[17] and duration of employment incorporating 10 years of lag time (≤5 years and >5 years). Additional strata related to duration of employment were not applicable, given that the majority of firefighters had either a limited or an extensive number of firefighter employment years.

2.5 | Vital status and cancer

For the updated cohort of firefighters and reference group, we used DCRS to obtain information on vital status and emigration.[15] Information on cancer diagnosis and date was retrieved from the Danish Cancer Registry, where previously used International Classification of Diseases (ICD-7, ICD-O1, and ICD-O3) have been reclassified to ICD-10.[18] In the present study, follow-up for the cohort of firefighters began on the latest of either date of first employment or April 2, 1968. It ended on date of cancer diagnosis, death, first emigration or December 31, 2021, whichever came first.

2.6 | Statistical analysis

For each firefighter, we calculated person-years at risk during the follow-up period, which were divided into 5-year age and calendar

intervals. Using the incidence rates from the reference group, we estimated the expected number of specific cancers within the same age and time intervals. The observed versus expected number of cancer cases were then calculated as standardized incidence ratios (SIRs) with corresponding 95% confidence intervals (CIs). Analyses were stratified according to employment type. Finally, we conducted sensitivity analyses making an additional effort to minimize the healthy worker hire bias by limiting the reference group to individuals who had been employed for a minimum of 10 years.

To deal with left truncation, we also conducted a sensitivity analysis focusing on firefighters born ≥1946, which pertained to the cohort of men who turned 18 at the initiation of ATP, which should also approximate an inception cohort since 1968.

Due to the multiple analyses, we focused on reporting increased or decreased risk estimates of ≥15%. Only results with four or more observations are shown in the tables due to confidentiality policy from Statistics Denmark. Statistical analyses were conducted using Stata statistical software v 16.1 (StataCorp). The study was entirely registry-based, and no ethical approval or informed consent was, therefore, necessary according to Danish regulations on research ethics.

3 | RESULTS

This updated study, adding 7 years of additional follow-up, contributed 321,392 person-years of observation (Table 1) and a total of 1.732 cancers occurred during follow-up (Table 2), which is 80,847 (34%) more person-years and 611 new cancers (36%) than the original study ending in 2014.[14]

Among full-time firefighters, SIR of all cancers (SIR = 1.09; 95% CI: 1.03–2.16) was marginally increased. Moreover, full time firefighters were indicated to have an increased risk of skin melanoma (SIR = 1.30, 95% CI: 1.02–1.66), and we also noted a modest excess of urinary bladder cancer (SIR = 1.16, 95% CI: 0.93–1.45) and indication of a decreased risk of colon cancer (SIR = 0.83, 95% CI: 0.65–1.07) (Table 2). Focusing on full time firefighters, specialized firefighting was strongly associated with an increased risk of skin melanoma (SIR = 2.41, 95% CI: 1.43–4.08), and elevated risk estimates were also observed for prostate cancer (SIR = 1.17, 95% CI: 0.79–1.73), testis cancer (SIR = 1.81, 95% CI: 0.75–4.36), and NHL (SIR = 1.67, 95% CI: 0.69–4.02). Analyses by initial time period of employment indicated an elevated risk of skin melanoma (SIR = 1.46, 95% CI: 1.11–1.92) and testis cancer (SIR = 1.32, 95% CI: 0.79–2.19) for initial employment before 1985. Employment after 1985 was associated with an increased risk of urinary bladder cancer (SIR = 1.32, 95% CI: 0.69–2.54). When considering duration of employment with 10 years of lag time, employment for ≤5 years showed an excess of prostate, testis, and urinary bladder cancer. Moreover, longer duration of >5 years was indicated to significantly increase the risk of skin melanoma (SIR = 1.37, 95% CI: 1.02–1.85). Contrary, longer duration of employment was associated with a decreased risk of colon and testis cancer (Table 3).

TABLE 1 Characteristics of the cohort of 11,827 male Danish firefighters: 1968–2021.

Characteristics	Full-time (%)	Part-time/ volunteer (%)
Cohort		
Firefighters eligible for SIR analysis	4650	7177
Person-years of follow-up	155,580	1653,812
Mean years of follow-up (SD)	33 (13.6)	23 (11.4)
Mean attained age[a] (SD)	62 (14.1)	54 (13.6)
Mean birth year	1955	1966
Vital status[†]		
Alive	3358 (72.3)	6416 (89.4)
Dead	1035 (22.4)	539 (7.5)
Emigrated	248 (5.3)	222 (3.1)
Firefighter employment		
Mean age at first hire (SD)	26 (6.4)	31 (8.4)
Average year of first hire	1982	1997
Job function		
Regular	4166 (90.0)	7177 (100)
Specialized	484 (10.0)	0
Time period of initial employment		
≤1985	2468 (53.1)	1061 (14.8)
>1985	2182 (46.9)	6116 (85.2)
Duration of employment		
≤5 years	1566 (33.7)	2665 (37.1)
>5 years	3084 (66.3)	4512 (62.9)

[a]End of follow-up (emigration, death, or December 31, 2021, whichever came first)

[†]31 December 2021.

Part-time/volunteer firefighters employed before 1985 were indicated to have an increased risk of urinary bladder cancer (SIR = 1.42, 95% CI: 1.02–1.97) and NHL (SIR = 1.27, 95% CI: 0.72–2.25). Employment after 1985 was associated with a slight elevation in the risk of skin melanoma (SIR = 1.17, 95% CI: 0.88–1.57), and a decrease in the risk of colon (SIR = 0.83, 95% CI: 0.55–1.23) and urinary bladder cancer (SIR = 0.60, 95% CI: 0.35–1.04). No noteworthy associations were observed for duration of employment (Table 4).

Supporting Information S1: Table 1 shows characteristics of the cohort stratified by employment before and after April 2, 1968, where the follow-up for cancer began. A remarkable higher proportion of part-time/volunteers started in the most recent period compared with full time firefighters. Results from our sensitivity analysis restricting the reference group to individuals employed for a

TABLE 2 Standardized incidence ratio analyses: Cancer incidence among 11,827 male Danish firefighters by type of employment compared to the sample of employees: 1968–2021.

	Entire cohort (*N* = 11,827)			Full time (*N* = 4650)			Part-time/volunteer (*N* = 7177)		
	Obs.	SIR	95% CI	Obs.	SIR	95% CI	Obs.	SIR	95% CI
All cancers (minus nonmelanoma skin cancer)	1732	1.03	0.98–1.08	993	1.09	1.03–1.16	739	0.95	0.88–1.02
Colon	110	0.85	0.70–1.02	61	0.83	0.65–1.07	49	0.86	0.65–1.14
Skin melanoma	127	1.21	1.02–1.44	65	1.30	1.02–1.66	62	1.13	0.88–1.45
Mesothelioma	9	0.93	0.48–1.78	-	-	-	-	-	-
Prostate	348	1.06	0.96–1.18	202	1.11	0.97–1.28	146	1.00	0.85–1.18
Testis	57	1.03	0.79–1.33	26	1.11	0.75–1.63	31	0.97	0.68–1.38
Urinary bladder	128	1.11	0.93–1.32	79	1.16	0.93–1.45	49	1.04	0.79–1.38
Non-Hodgkin lymphoma	49	0.99	0.75–1.31	24	0.95	0.64–1.43	25	1.03	0.69–1.53

Note: ICD: colon (C18–19), skin melanoma (C43), mesothelioma (C23), prostate (C61), testis (C62), urinary bladder (C67, D090, D303, and D414), and non-Hodgkin lymphoma (C82–85 and C883–889).

Abbreviations: CI, confidence interval; ICD, International Classification of Diseases; SIR, standardized incidence ratio.

minimum of 10 years were generally consistent with our main findings (Supporting Information S1: Table 2). When restricting the cohort of firefighters to those born ≥1946 (i.e. approximate an inception cohort since start of follow-up in 1968), risk estimates for some cancers, including skin melanoma and testis cancer, were slightly attenuated (Supporting Information S1: Table 3).

4 | DISCUSSION

In this updated study among an extended large cohort of Danish firefighters with additional 7 years of follow-up, we assessed cancer incidence with specific emphasis on cancer sites recently evaluated to have sufficient or limited evidence for cancer in humans by IARC. Findings in the present study showed strong associations between firefighting and skin melanoma. In some analyses, slightly elevated risk estimates were observed for prostate, testis, and urinary bladder cancer, however, most risk estimates were affected by large statistical uncertainty. We did not observe convincing evidence for elevated risks of colon cancer, mesothelioma, and NHL.

These updated findings indicated a consistent risk pattern for skin melanoma, i.e., an increased risk among full-time firefighters and in those with specialized training, initial employment in earlier time periods and with longer duration of employment. These observations align with the results of the recent meta-analysis by IARC, which indicated a positive association between ever employment as firefighter and incident skin melanoma (mRR = 1.36, 95% CI: 1.15–1.62) with a positive duration-response relationship.[11] While it has been proposed that chemical exposures such as PCBs during firefighting may contribute to the risk,[19] it is important to note that ultraviolet radiation is the primary known risk factor for skin melanoma.[20] Given that firefighters typically wear protective gear and clothing during outdoor tasks, thereby limiting their occupational exposure to sunlight, our observations may at least partly be subject to medical surveillance bias, and partly from potential confounding arising from more leisure time sun exposure due to more spare time during the time of the day where the sun may shine because of nightshift work compared to the Danish general day working population.

In the recent IARC meta-analyses, positive associations were observed for most genitourinary cancers, including prostate (mRR = 1.21, 95% CI: 1.12–1.32), testis (mRR = 1.37, 95% CI: 1.03–1.82) and urinary bladder cancer (mRR = 1.16, 95% CI: 1.08–1.26).[11] Focusing on prostate cancer, we observed some weak positive associations. There has been a significant rise in the occurrence of prostate cancer in Denmark over the past decades, which most likely is related to the increased use of prostate-specific antigen tests.[21] This trend could be particularly pronounced in professions with regular medical screening, such as uniformed service occupations,[11] and medical surveillance bias may thus influence risk estimates for this cancer site in a positive direction.

We also observed some positive associations between firefighting and testis cancer. Compared to other Western countries, Denmark exhibits one of the highest incidence rates of testis cancer,[22] and knowledge of risk factors are limited, including early-life events such as cryptorchidism.[23] Therefore, environmental and occupational factors contributing to this malignancy have yet to be definitively established. However, a recent review presents supportive evidence for a positive association between PFAS and testis cancer. PFAS have been utilized in aqueous film-forming foam employed in firefighting.[24] In Denmark and other countries there are examples of pollution with PFOS, a subgroup of PFAS, from fire schools where PFOS-containing fire extinguishing foam was extensively used.[25] Recently, IARC classified PFOA, another subgroup of PFAS, with limited evidence in epidemiologic studies of testicular cancer.[2] The association between firefighter's exposure to PFAS and cancer risk is, however, unclear and needs future attention. We observed some positive associations for urinary bladder cancer,

TABLE 3 Standardized incidence ratio analyses: cancer incidence among 4650 full time firefighters by dimensions of employment: 1968–2021.

	Job function					
	Specialized (*N* = 484)			Regular (*N* = 4166)		
Cancer site	Obs.	SIR	95% CI	Obs.	SIR	95% CI
Colon	6	0.71	0.32–1.59	55	0.85	0.65–1.11
Skin melanoma	14	2.41	1.43–4.08	51	1.16	0.88–1.52
Prostate	25	1.17	0.79–1.73	177	1.11	0.96–1.28
Testis	5	1.81	0.75–4.36	21	1.01	0.66–1.55
Urinary bladder	7	0.93	0.44–1.96	72	1.19	0.94–1.50
Non-Hodgkin lymphoma	5	1.67	0.69–4.02	19	0.86	0.54–1.35
	Time period of initial employment					
	≤1985 (*N* = 2468)			>1985 (*N* = 2182)		
	Obs.	SIR	95% CI	Obs.	SIR	95% CI
Colon	52	0.82	0.62–1.07	9	0.94	0.48–1.80
Skin melanoma	51	1.46	1.11–1.92	14	0.94	0.56–1.59
Prostate	177	1.10	0.95–1.28	25	1.12	0.81–1.78
Testis	15	1.32	0.79–2.19	11	0.91	0.50–1.64
Urinary bladder	70	1.14	0.90–1.44	9	1.32	0.69–2.54
Non-Hodgkin lymphoma	-	-	-	-	-	-
	Duration of employment with 10 years of lag time					
	≤5 years (*N* = 1566)			>5 years (*N* = 3084)		
	Obs.	SIR	95% CI	Obs.	SIR	95% CI
Colon	27	0.86	0.59–1.26	34	0.81	0.58–1.14
Skin melanoma	16	0.91	0.56–1.49	44	1.37	1.02–1.85
Prostate	87	1.18	0.96–1.46	114	1.06	0.88–1.28
Testis	8	1.22	0.61–2.45	9	0.54	0.28–1.04
Urinary bladder	39	1.27	0.93–1.74	38	1.02	0.74–1.40
Non-Hodgkin lymphoma	8	0.84	0.42–1.69	15	0.96	0.58–1.60

Note: ICD: colon (C18–19), skin melanoma (C43), prostate (C61), testis (C62), urinary bladder (C67, D090, D303, and D414), non-Hodgkin lymphoma (C82–85 and C883–889).

Abbreviations: CI, confidence interval; ICD, International Classification of Diseases; SIR, standardized incidence ratio.

which is consistent with the increased risk reported by IARC,[11] and chemical exposures in firefighting including PAHs, soot, and diesel exhaust, play an important role.[1,26]

Firefighters are routinely exposed to several respiratory system carcinogens, including asbestos, and an increased risk of mesothelioma was observed in the meta-analyses by IARC (mRR = 1.58, 95% CI: 1.14–2.20), where six cohort studies showed a strong association.[11] However, our findings did not indicate any evidence of an increased risk of mesothelioma, which was also the case in a previous Danish registry-based sub-study of the five Nordic countries using the entire population as the reference. [27] Even though we added five more mesothelioma cases to this updated study, it is important to highlight that the overall data set used for the revised analyses remained relatively small in number of cases (*N* = 9). As a result, we faced limitations in conducting in-depth analyses for this cancer site.

Findings from the recent IARC meta-analysis also included positive associations between firefighting and colon cancer and NHL,[11] however, our study did overall not yield results that were in alignment with these findings. Heterogeneity in results across existing studies on firefighting may be attributed, at least in part, to variances in study designs, participant demographics, duration of follow-up, specific timeframes examined, approaches to measuring dimensions of employment, and adjustments made for potential confounding variables. Moreover, noteworthy disparities may exist between countries concerning fire types, such as wildland versus municipal fires, as well as variations in workplace standards, regulations, job responsibilities, and work schedules.

The present study shares a number of limitations with other epidemiological studies addressing firefighting.[1] First, even this is a large cohort, including over 1700 cancer cases, the mean attain age is

TABLE 4 Standardized incidence ratio analyses: cancer incidence among 7177 part-time/volunteer firefighters by dimensions of employment: 1968–2021.

	Time period of initial employment					
	≤1985 (*N* = 1061)			>1985 (*N* = 6116)		
	Obs.	SIR	95% CI	Obs.	SIR	95% CI
Colon	25	0.90	0.61–1.34	24	0.83	0.55–1.23
Skin melanoma	17	1.02	0.63–1.65	45	1.17	0.88–1.57
Prostate	82	1.10	0.88–1.37	64	0.90	0.70–1.15
Testis	4	0.79	0.29–2.12	27	1.00	0.69–1.47
Urinary bladder	36	1.42	1.02–1.97	13	0.60	0.35–1.04
Non-Hodgkin lymphoma	12	1.27	0.72–2.25	13	0.88	0.51–1.51
	Duration of employment with 10 years of lag time					
	≤5 years (*N* = 2665)			>5 years (*N* = 4512)		
	Obs.	SIR	95% CI	Obs.	SIR	95% CI
Colon	-	-	-	-	-	-
Skin melanoma	10	0.92	0.49–1.71	42	0.99	0.73–1.34
Prostate	16	0.91	0.55–1.48	127	0.99	0.84–1.18
Testis	-	-	-	-	-	-
Urinary bladder	-	-	-	-	-	-
Non-Hodgkin lymphoma	-	-	-	-	-	-

Note: ICD: colon (C18–19), skin melanoma (C43), prostate (C61), testis (C62), urinary bladder (C67, D090, D303, and D414), non-Hodgkin lymphoma (C82–85 and C883–889).

Abbreviations: CI, confidence interval; ICD, International Classification of Diseases; SIR, standardized incidence ratio.

relatively young, compared to the age where most cancers rises most rapidly. In particular, part-time/volunteer firefighters, were considerably younger and first employed more recently. This fact may have decreased the power of this study to detect increases in risks of especially cancer of the bladder, colon, prostate and, most of all, mesothelioma. Presumably, there is a selection of individuals who are fit and healthy to become firefighter. Therefore, a healthy worker hire effect may have occurred, masking true increased risk estimates. In our sensitive study where we included a sub reference population with at least 10 years of employment with the assumption that this may reduce the healthy worker hire effect, as it is usually an effect related to premature mortality, we did not observe notable changes in SIR's, suggesting no major effect of this bias in our study. Also, we did not observe positive duration–response relationships for any of the investigated cancer sites, except for skin melanoma. Similarly, findings from the meta-analysis by IARC did not indicate duration-response relationships for any cancer sites other than skin melanoma. However, analyses focusing on duration of employment and cancer sites such as urinary bladder cancer in firefighters may especially be influenced by a healthy worker survivor bias, i.e., firefighters who have been employed for longer periods have lower exposure to fire hazards as they gain seniority. Moreover, workers who are less healthy may leave the occupation due to a decline in health over time.[11] This is supported by a pooled US study involving municipal firefighters, where internal analyses strongly suggested confounding by employment duration in the association between exposed days and bladder cancer mortality.[28] We attempted to mitigate this potential bias by comparing firefighters to a sample of employees and by restricting this reference group to those having a minimum of 10 years of recorded employment history, however, this only affected the results marginally. On the other hand, firefighters' risk of being diagnosed with cancer may also be affected by increased diagnostic intensity through occupational health checkups, which may account for some of the excess of observed cancers among firefighters.

Many cancers are typically caused by multiple factors, and our study was therefore also limited by a lack of information on lifestyle factors such as smoking, alcohol consumption, leisure time physical activity, sun exposure, and occupational exposures encountered in non-firefighting jobs.

The strengths of the study lie in the large cohort of firefighters and the long follow-up period, spanning more than 50 years. However, the mean attained ages were 62 years old for full-time firefighters and 54 for part-time/volunteers, respectively. This means that this cohort must still face the steepest increase in cancer incidence over the next 10–15 years. Moreover, the employment information on firefighters was validated using different sources, and detailed job information allowed for the examination of various aspects of employment as a firefighter. Finally, the national registries used to assess cancer and vital status are of high quality and completeness.

5 | CONCLUSION

Findings from this updated large Danish cohort study confirm previous international observations of excess morbidity from skin melanoma and provide some support to the positive association between firefighting and urinary bladder, prostate, and testis cancer. No convincing evidence of an elevated risk was provided for colon cancer, mesothelioma, and NHL. Continuous follow-up of this and other firefighter cohorts is crucial for contributing valuable evidence in the field. This is essential not only for future prevention measures but also for the consideration of compensation for occupational diseases.

AUTHOR CONTRIBUTIONS

Julie Elbaek Pedersen performed programming of data, analyses, and participated in interpretation of results, and wrote the manuscript. Kajsa Ugelvig Petersen collected the data, designed the study, participated in interpretation of results, and revised the manuscript critically. Maria-Helena Guerra Andersen, Anne Thoustrup Saber, Ulla Vogel, Tina Kold Jensen, and Regitze Sølling Wils supervised the interpretation of results and revised the manuscript critically. Jens Peter Bonde and Niels E Ebbehøj designed the study, supervised the interpretation of results, and revised the manuscript critically. Johnni Hansen was a major contributor in designing the study and supervised all data collection, programming, and analyses, participated in interpretation of results, and supervised writing of the manuscript. All authors read and approved the final manuscript.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DISCLOSURE BY AJIM EDITOR OF RECORD

Leena Nylander-French declares that she has no conflict of interest in the review and publication decision regarding this article.

DATA AVAILABILITY STATEMENT

Research data are not shared.

ETHICS APPROVAL AND INFORMED CONSENT

No ethics approval for purely registry-based research is required in Denmark.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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