THE LONDON SCHOOL OF ECONOMICS AND POLITICAL SCIENCE

Health Risks to Firefighters - Cancers

A Literature Review

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Abbreviations

PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
GRADE	Grading of Recommendations, Assessment, Development and Evaluations
SIR	Standardised Incidence Ratio
SMR	Standardised Mortality Ratio

Executive summary

Since the last century, researchers have conducted numerous meta-analyses and systematic reviews to investigate the association between firefighters and cancer. However, discrepancies persist due to variations in exposure, location, periods, analysis of cancer types, and study designs. Despite attempts to determine cancer risk and the minimal employment duration required for disease development, conclusions vary across studies.

Recent studies have presented conflicting results regarding cancer incidence among firefighters. The complexities of cancer site measurement, exposure, and geography further complicate the assessment of cancer incidence and mortality among firefighters.

Hence, this systematic review aims to contribute to the ongoing debate by investigating the association between firefighting occupation and cancer incidence and mortality. The primary objective is to study cancer incidence and mortality among firefighters worldwide compared to the general population. Additionally, secondary objectives include identifying significant findings, assessing source reliability, studying recent scientific developments, exploring areas of controversy, and identifying gaps in existing findings.

The review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. A comprehensive search strategy was implemented, resulting in the inclusion of six meta-analyses and systematic reviews. The selected studies were published between 2010 and 2024 according to the inclusion criteria. However, these studies included the synthesis of evidence from 96 studies and documents published between 1959 and 2022.

The results are divided into cancer incidence and mortality. While some studies report similar cancer incidence rates between firefighters and the general population, others identify significantly elevated risks for specific cancer types. Similarly, variations in cancer mortality rates are observed among firefighters compared to the general population. Our research shows there is consistent and robust evidence of increased incidence of skin melanoma, prostate, bladder, testicular, and colon cancer. On the other hand, there is evidence of increased mortality from rectal and non-Hodgkin's lymphoma for firefighters when compared to the general population.

Other cancer types assessed show varying degrees of evidence, given methodological approaches and characteristics included in each study. Therefore, further research is needed to understand the incidence and mortality of these types of cancer in firefighters. Specifically, additional research should assess mediating factors for cancer incidence and mortality, such as gender, use of personal protective equipment, and environmental characteristics.

Limitations of the studies include the limited inclusion of female cohorts and, when included, the limited number of female subjects that are part of the cohorts, potentially affecting generalizability to women firefighters and generating discrepancies related to sex as a mediator for cancer risk and mortality. Furthermore, none of the studies included an analysis of incidence or mortality by incorporating demographic information such as race, ethnicity, or age.

This systematic review highlights the agreements and discrepancies in the occupation risk of firefighting for cancer incidence and mortality according to the most recent systematic reviews and meta-analyses. Further research is needed to address methodological challenges and provide more conclusive evidence regarding the association between firefighting occupation and cancer risk.

1. Introduction

Since the last century, researchers have conducted multiple meta-analyses and systematic reviews to establish an association between firefighters and cancer. The results have had numerous discrepancies, as it is challenging to establish causality because of variations in exposure, location, periods, analysis of cancer types, and study designs.[1] For example, researchers have tried to determine the risk of cancer and the associated minimal employment requirement to develop the disease, concluding that incidence varied according to the years worked.[2] In addition, vast amounts of meta-analysis have focused on multiple cancer types, each concluding contradictions respecting mortality and incidence, although stating an elevated risk for specific cancers.[3,4]

According to the International Agency for Research on Cancer (IARC), "occupational exposure as a firefighter was classified as `carcinogenic to humans' based on sufficient evidence for cancer in humans",[5] highlighting the availability of evidence to conclude that there is a risk of developing specific cancers.[5,6] Nevertheless, despite the availability of metanalyses focusing on firefighter mortality and cancer incidence, there is still an ongoing debate on its risk variation according to cancer and the necessary recommendations to protect firefighters. Additionally, the available metanalyses present different methods, while the heterogeneity causes inconsistent findings; thus, establishing a causal relationship remains elusive.[5] Other researchers have posed further complications, including study designs that vary from small sample sizes to changes in safety regulations and types of firefighter exposures.[1]

For example, four meta-analyses conducted since 2006 have found different results on cancer incidence.[3,4,6,7] Researchers presented different risks of cancers such as multiple myeloma, non-Hodgkin lymphoma, prostate, colorectal, testicular, bladder, pancreatic, and kidney, among others.[1] In addition, *Laroche et al.* conducted a review of systematic reviews to elaborate on the previous discrepancies.[8] They concluded a significant increase in the incidence of rectal, prostate, bladder, testicular, mesothelioma, and malignant melanoma compared to the general population.[8] In addition to the complexity of the cancer site, researchers have struggled to measure the impact on cancer incidence and mortality because of variance in exposure and geography.[1]

The variations in the available scientific evidence and the methodology from previous meta-analyses demonstrate the need to study cancer risk in firefighters.

Hence, we conducted a systematic review on the association between firefighting occupation and cancer incidence and mortality to contribute to the current debate, providing an updated scenario. The objective of the present systematic review is to study the mortality and incidence of cancer in firefighters from 2010 onward from diverse countries compared to the general population from the same country.

In addition to the primary objective, the report identified significant and established findings, evaluated source reliability, explored recent scientific developments, and examined areas of controversy and gaps in existing research.

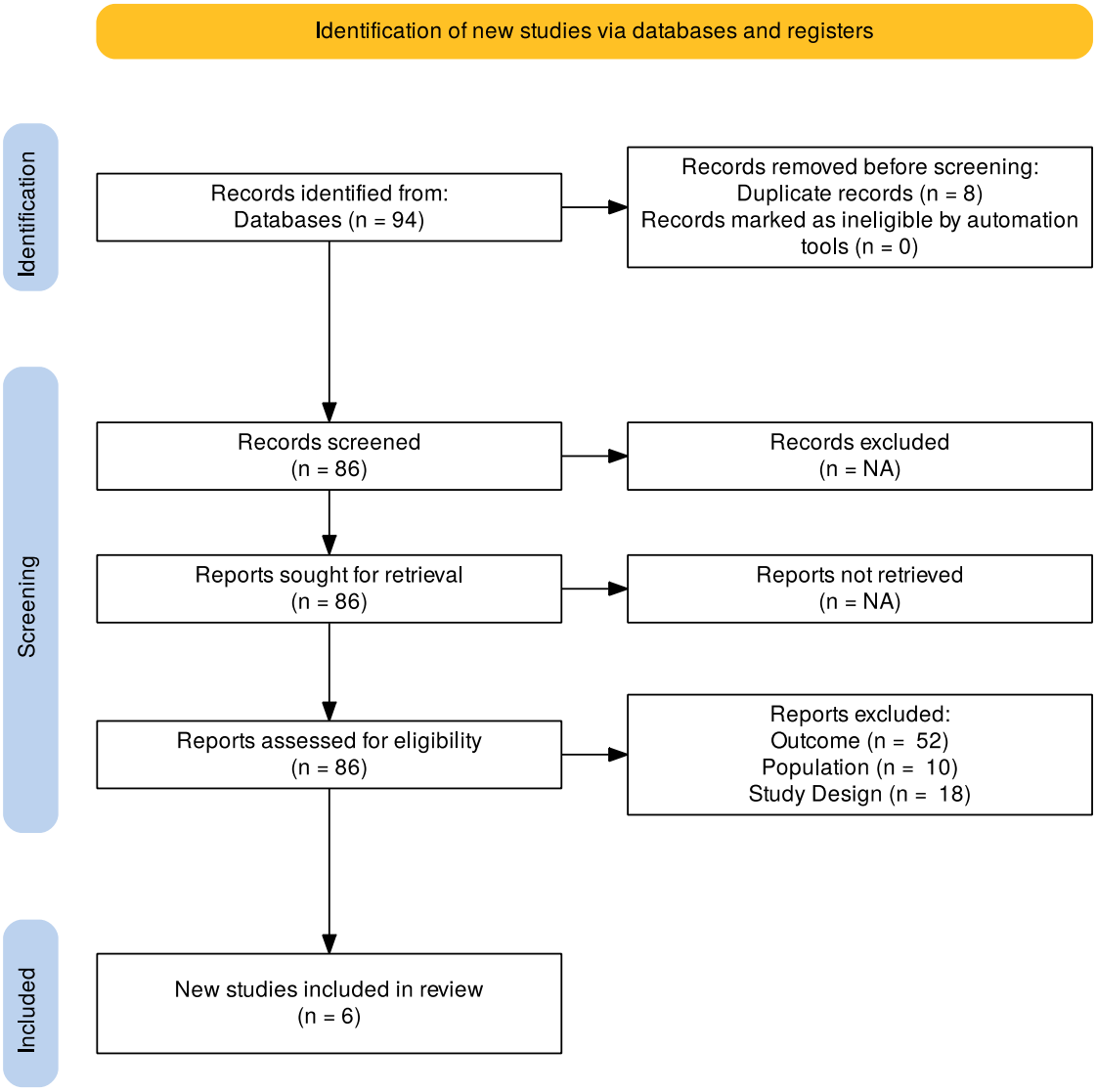
2. Methods

The literature search was conducted using PubMed, Embase and Cochrane Library. For grey literature, we used Google Scholar. This review was performed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement. We systematically searched for systematic reviews and meta-analyses focusing on cancer incidence and mortality in firefighters that gathered cohorts conducted in any geographical place, specific to firefighters, on both sexes, irrespective of the period conducted. We excluded metanalyses outside the specified dates (before 2010), metanalyses focusing only on specific types of cancer (i.e. prostate cancer) when focusing on health outcomes other than cancer, and articles published in languages other than English. We also excluded research studies only published as preprints or reports or when only an abstract was published.

The results showed 94 publications. After removing duplicate records, we screened 86 metanalyses. We excluded 52 for the outcome assessed, 10 due to the population included, and 18 due to the study design. A total of six meta-analyses were included in this study.[1,3,7–10] The selected studies were published between 2010 and 2024 according to the inclusion criteria; these studies systematically summarised 96 studies published between 1959 and 2022. A detailed process of the identification of research studies is shown in Figure 1. PRISMA Flowchart.

For the complete list of articles included, please refer to Table 1. For the list of all source articles per study, please consult Annex I. Source articles for the included studies.

Figure 1. PRISMA Flowchart



2. Results

The results are divided according to cancer incidence and cancer mortality.

2.1 Cancer Incidence

The systematic reviews and meta-analyses revealed various findings regarding cancer incidence among firefighters. Casjens et al. found that the overall cancer risk among firefighters was similar to that of the general population. However, they identified statistically significant elevated standardised incidence ratios (SIRs) for mesothelioma (1.46, 95%CI 1.01-1.90), bladder cancer (1.14, 95%CI 1.04-1.23), and colon cancer (1.11, 95%CI 1.00-1.21). In Europe, an increased incidence of pancreas cancer was noted. They also found lower incidences that were statistically significant for liver (0.81, 95%CI 0.65-0.98) and brain cancer (0.81, 95%CI 0.65-0.98).[9]

Lee et al. reported significantly higher incidence rates for skin melanoma (1.14, 95%CI 1.08-1.21), other skin cancers (1.24, 95%CI 1.16-1.32), and prostate cancer (1.09, 95%CI 1.04-1.14) among firefighters compared to the reference population. Conversely, incidence rates were significantly lower for various cancers, including oesophagus (0.73, 95%CI 0.60-0.88), liver (0.62, 95%CI 0.51-0.75), larynx (0.65, 95%CI 0.52-0.81), lung (0.67, 95%CI 0.63-0.73), colorectal (0.86, 95%CI 0.80-0.93), digestive system (0.81, 95%CI 0.76-0.86), respiratory (0.62, 95%CI 0.58-0.67), kidney and bladder (0.85, 95%CI 0.77-0.83) and lymphatic and hematopoietic tissue cancers (0.82, 95%CI 0.75, 0.89).[1]

DeBono et al. (2023) observed positive associations between firefighter employment and the incidence of several cancers, including mesothelioma (1.58, 95%CI 1.14-2.20), skin melanoma (1.36, 95%CI 1.15-1.62), testicular (1.37, 95%CI 1.03-1.82), thyroid (1.28, 95%CI 1.02-1.61), prostate (1.21, 95%CI 1.12-1.32), colon (1.19, 95%CI 1.07-1.32), and bladder cancers (1.16, 95%CI 1.08-1.26), as well as non-Hodgkin's lymphoma (1.12, 95%CI 1.01-1.25). They also found a lower incidence of lung cancer (0.85, 95%CI 0.75-0.96).[10] Jalilian et al. (2019) reported increased cancer incidence among firefighters for colon (1.14, 95%CI 1.06-1.23), rectal (1.09, 95%CI 1.00,1.20), prostate (1.15, 95%CI 1.05-1.27), testicular (1.34, 95%CI 1.08-1.68), bladder (1.12, 95%CI 1.04-1.21), thyroid (1.22, 95%CI 1.01-1.48), mesothelioma (1.60, 95%CI1.09-2.34), and malignant melanoma (1.21, 95%CI 1.02-1.45).[3]

Soteriades et al. (2019) found increased risks for colon (1.26, 95%CI 1.10-1.44), prostate (1.21, 95%CI1.04-1.42), and testicular (1.73, 95%CI1.31-2.27) cancers among firefighters.[7]

Laroche & L'Espérance (2021) concluded that incidence rates of rectal cancer, prostate cancer, bladder cancer, testicular cancer, mesothelioma, and malignant melanoma were consistently reported as higher among firefighters compared to the general population.[8]

From the six reviewed studies, it is possible to note that skin melanoma, prostate, bladder, testicular, and colon cancer have the most significant amount of evidence of increased incidence for firefighters. From these, bladder cancer shows contradictory results, with one of the articles demonstrating a decreased incidence.[1]

2.2 Cancer mortality

Casjens et al. found that the overall cancer mortality of firefighters was similar to that of the general population but decreased over time, with significant differences between firefighters who started their employment before and after 1970, which might be associated with improvements in personal protection equipment.[9] Increased standardised mortality ratios (SMR) were observed for rectal cancer (1.35, 95%CI 1.12-1.59) and bladder cancer (1.72, 95%CI 1.05-2.38), while a reduction was noted for lymphohematopoietic cancers (0.76, 95%CI 0.61-0.91).[9]

Lee et al. reported higher mortality rates for rectum (1.18, 95%CI 1.02-1.36), testis (1.64, 95%CI1.00-2.67), and non-Hodgkin lymphoma (1.20, 95%CI1.02-1.40) among firefighters. Conversely, lower mortality rates were observed for stomach (0.77, 95%CI0.68-0.87), colon (0.78, 95%CI 0.66-0.91), liver (0.60, 95%CI 0.51-0.71), larynx (0.49, 95%CI 0.37-0.65), bone (0.52, 95%CI 0.13-2.10), brain (0.64, 95%CI 0.53-0.78), Hodgkin's disease (0.17, 95%CI 0.08-0.37), lip/oral cavity/pharynx (0.65, 95%CI 0.53-0.78), and lymphatic and hematopoietic tissue cancers (0.82, 95%CI 0.71-0.95)[1]. DeBono et al. observed increased mortality risk for non-Hodgkin's lymphoma (1.20, 95%CI 1.03-1.40) among firefighters.[10] Jalilian et al. found elevated mortality for rectal (1.36, 95%CI 1.18-1.57) and non-Hodgkin's lymphoma (1.42, 95%CI1.05-1.90).[3]

Soteriades et al. reported increased mortality risks for brain and CNS (1.26, 95%CI 1.02-1.55), non-Hodgkin's lymphoma (1.44, 95%CI 1.27-1.63), skin melanoma (1.62, 95%CI 1.26-2.10), colorectal (1.16, 95%CI 1.07-1.25), rectal (1.25, 95%CI 1.09-1.44), bladder (1.28, 95%CI 1.05-1.56), prostate (1.27, 95%CI 1.01-1.61), leukaemia (1.19, 95%CI 1.04-1.36), Hodgkin's lymphoma (1.80, 95%CI 1.27-2.56), lymphosarcoma and reticulosarcoma (1.58, 95%CI 1.09-2.27), multiple myeloma (1.28, 95%CI 1.03-1.58), pancreatic (1.14, 95%CI 1.01-1.28), and kidney (1.29, 95%CI 1.06-1.57) cancers among firefighters.[7] Lastly, Laroche & L'Espérance noted that death rates from rectal cancer and non-Hodgkin's lymphoma were reported as higher among firefighters.[8]

From the reviewed studies, rectal cancer and non-Hodgkin's lymphoma have the greatest amount of evidence for increased mortality, with no research study finding contradictions among them. There were other types of cancer (Hodgkin's lymphoma, colon, and leukaemia) that showed contradictory results, with one study showing increased mortality,[8] while another showing a decrease.[3]

Table 2 summarises the findings according to each meta-analysis, divided by incidence and mortality.

2.3 Limitations

The availability and quality of data concerning firefighting-related cancer incidence and mortality may exhibit heterogeneity across studies. Certain geographical regions or specific types of cancers might be inadequately represented in the literature. Additionally, this report may be vulnerable to publication bias. Moreover, the exposure of firefighters has evolved over time, with advancements in Protective Equipment and changes in the composition of combustion chemicals to which firefighters are exposed. The findings of the systematic review may possess limited generalizability to all firefighting populations, given the variability in factors such as geographic location, firefighting practices, and occupational regulations among regions. These variations and limitations, along with the differences in the cohorts included in each of the meta-analyses, may account for the discrepancies shown in some types of cancer.

Moreover, although efforts were made to synthesise and interpret the findings of included studies, causal inference may be challenging. Conducting a meta-meta-analysis to evaluate the results of the recent meta-analyses could provide additional insights, by incorporating all results into a single study to obtain pooled indicators. This way, it would be possible to analyse all cohorts at once and better disentangle the agreements and discrepancies. One notable limitation across the studies was the limited inclusion of female cohorts, potentially impacting the generalizability of findings. Sex was identified by Lee et al. as a mediator for cancer incidence and mortality.

3. Conclusion

This report provides an overview of the current literature on firefighters and cancer incidence and mortality. By synthesising evidence from six systematic reviews and meta-analyses, we aimed to show the current debate between researchers to prove the incidence of cancer among firefighters compared to the general population. Our findings revealed significant variations in cancer incidence and mortality rates across different studies, highlighting the complexity of assessing the association between firefighting occupation and cancer outcomes.

Based on the studies included, it is possible to conclude that there is robust and consistent evidence of increased incidence of skin melanoma, prostate, bladder, testicular, and colon cancer. Moreover, there is an increase in mortality for rectal and non-Hodgkin's cancer among firefighters.

Conversely, the studies included show discrepancies in the cancer incidence and mortality for bladder, Hodgkin's lymphoma, colon, leukaemia, kidney, and brain and nervous system. Advancing methodological approaches will be crucial for improving our understanding of firefighting-related cancer, especially for the types of cancer where current literature disagrees. Because of the large number of studies published on the subject and constant updates of meta-analysis, a meta-meta-analysis could help synthesise the available evidence, pooling the different estimates according to cancer.

Moreover, the incorporation of additional variables such as length of exposure, demographic information, environmental factors, and use of personal protective equipment could help clarify the discrepancies between research studies in regard to some types of cancer. Hence, it is paramount for research efforts to address the

methodological variations and promote evidence-based interventions to mitigate occupational hazards and safeguard the well-being of firefighters.

References

1 Lee DJ, Ahn S, McClure LA, *et al.* Cancer risk and mortality among firefighters: a meta-analytic review. *Front Oncol* 2023; **13**. DOI:10.3389/FONC.2023.1130754.

2 Youakim S. Risk of cancer among firefighters: a quantitative review of selected malignancies. *Arch Environ Occup Health* 2006; **61**: 223–31.

3 Jalilian H, Ziaei M, Weiderpass E, Rueegg CS, Khosravi Y, Kjaerheim K. Cancer incidence and mortality among firefighters. *Int J Cancer* 2019; **145**: 2639–46.

4 LeMasters GK, Genaidy AM, Succop P, *et al.* Cancer risk among firefighters: a review and meta-analysis of 32 studies. *J Occup Environ Med* 2006; **48**: 1189–202.

5 Demers PA, DeMarini DM, Fent KW, *et al.* Carcinogenicity of occupational exposure as a firefighter. *Lancet Oncol* 2022; **23**: 985–6.

6 Cancer IA for R on. Painting, firefighting, and shift work. *IARC Monogr Identif Carcinog Risks Hum* 2010; **98**: 1–804.

7 Soteriades ES, Kim J, Christophi CA, Kales SN. Cancer incidence and mortality in firefighters: A state-of-the-art review and meta-analysis. *Asian Pacific Journal of Cancer Prevention* 2019; **20**: 3221–31.

8 Laroche E, L'espérance S. Cancer incidence and mortality among firefighters: An overview of epidemiologic systematic reviews. *Int J Environ Res Public Health* 2021; **18**: 1–32.

9 Casjens S, Brüning T, Taeger D. Cancer risks of firefighters: a systematic review and meta-analysis of secular trends and region-specific differences. *Int Arch Occup Environ Health* 2020; **93**: 839–52.

10 DeBono NL, Daniels RD, Beane Freeman LE, *et al.* Firefighting and Cancer: A Meta-analysis of Cohort Studies in the Context of Cancer Hazard Identification. *Saf Health Work* 2023; **14**: 141–52.

Table 1. Included articles.

Included articles	Year	Type of Study	Number of source studies included
Casjens	2020	Systematic review and meta-analysis	25
Jalilian	2019	Systematic review and meta-analysis	50
Lee	2023	Systematic review	38
Laroche	2021	Systematic review	11
DeBono	2023	Meta-analysis	16
Soteriades	2019	Systematic review and meta-analysis	49

Table 2. Findings by type of cancer.

Cancer Type	Increased Incidence	Increased Mortality	Decreased Incidence	Decreased Mortality
Skin Melanoma	2, 3, 4, 6	5		
Other Skin Cancers	2			
Prostate	2, 3, 4, 5, 6	5		
Rectal	4, 6	1, 2, 4, 5, 6		
Bladder	1, 3, 4, 6	1, 5	2	
Testicular	3, 4, 5, 6	2		
Mesothelioma	1, 3, 6			
Non-Hodgkin Lymphoma	3	2, 3, 4, 5, 6		
Hodgkin Lymphoma		5		2
Colon	1, 3, 4, 5	5		2
Thyroid	3, 4			
Leukaemia		5		2
Lymphosarcoma and reticulosarcoma		5		
Multiple myeloma		5		
Pancreatic		5		
Pleura	4			
Kidney		5	2	
Brain and central nervous system		5	1	

Liver			1, 2	2
Lymphohematopoietic			2	1, 2
Esophagus			2	
Colorectal			2	
Larynx			2	2
Digestive system			2	
Respiratory			2	
Lip, oral cavity, pharynx				2
Stomach				2
Lung			2, 3	

Notes: 1- Casjens. 2- Lee. 3- DeBono. 4- Jalilian. 5- Soteriades. 6- Laroche.

Annex I. Source articles of the included studies.

Source articles				Systematic Reviews/ Meta-analysis					
Author	**Year**	**Country**	**Name**	**Casjens**	**DeBono**	**Jaillian**	**Laroche**	**Lee**	**Soteriades**
Ahn and Jeong	2015	Korea	Mortality due to malignant and non-malignant diseases in Korean professional emergency responders.	X	X	X		X	
Ahn YS	2012	Korea	Cancer morbidity of professional emergency responders in Korea	X	X	X		X	
Amadeo B	2015	France	French firefighter mortality: analysis over a 30-year period.	X	X	X		X	
Aronson KJ	1994	Canada	Mortality among fire fighters in metropolitan Toronto.	X	X	X		X	X
Baris D	2001	USA	Cohort mortality study of Philadelphia firefighters.	X	X	X			X
Bates MN	1995	New Zealand	Testicular cancer in the firefighters: a cluster investigation.						X
Bates MN	2000	New Zealand	Retrospective cohort study of mortality and cancer incidence in New Zealand fire fighters.						X
Bates MN	2001	New Zealand	Is testicular cancer an occupational	X	X	X		X	

			disease of fire fighters?						
Bates MN	2007	USA	Registry-based case-control study of cancer in California firefighters.						X
Beaumont JJ	1991	USA	An epidemiologic study of cancer and other causes of mortality in San Francisco firefighters.		X	X		X	X
Berg JW	1975	USA and UK	Occupation and bowel cancer	X		X		X	
Bigert C	2020	Sweden	Cancer incidence among Swedish firefighters: an extended follow-up of the NOCCA study. I		X			X	
Blair A	1985	USA	Mortality patterns among US veterans by occupation.			X		X	
Burnett CA	1994	USA	Mortality among fire fighters: A 27 state survey.			X			X
Burns	1991	USA	The occupational cancer incidence surveillance study (OCISS): risk of lung cancer by usual occupation and industry in the Detroit metropolitan area.						X
Corbin M	2011	New Zealand	Lung cancer and occupation: A New Zealand cancer			X			

			registry-based case–control study						
Crawford JO	2017	UK	Firefighters and Cancer: The Epidemiological Evidence				X		
Daniels RD	2014	USA	Mortality and cancer incidence in a pooled cohort of US firefighters from San Francisco, Chicago and Philadelphia	X	X	X			
Delahunt B	1995	New Zealand	Occupational risk for renal cell carcinoma. A case-control study based on the New Zealand cancer registry.			X			X
Demers PA	1992	USA	Mortality among firefighters from three northwestern United States cities.	X	X	X			X
Demers PA	1994	USA	Cancer incidence among frefghters in Seattle and Tacoma, Washington (United States).	X	X	X		X	X
Deschamps S	1995	France	Mortality amongst Paris firefighters.	X	X	X			X
Dolin OJ	1992	UK	Occupation and bladder cancer: a death-certificate study.					X	X
Donnan SPB	1996	UK	Study of mortality and cancer incidence in firefighters in Britain: a third report, 1965–1993.						X

Dubrow R	1983	Multiple	Setting Priorities for occupational cancer research and control: synthesis of the results of occupational disease surveillance studies.						X
Elci OC	2003	Turkey	Occupation and the risk of lung cancer by histologic types and morphologic distribution: A case control study in Turkey			X			X
Eliopulos E	1984	Australia	Mortality of fire fighters in Western Australia.	x	X	X		X	X
Feuer E	1986	USA	Mortality in police and firefighters in New Jersey			X			X
Figgs LW	1995	USA	United States non-Hodgkin's lymphoma surveillance by occupation 1984–1989: A twenty-four state death certificate study			X			X
Finkelstein MM	1995	Toronto	Occupational associations with lung cancer in two Ontario cities.			X			
Firth HM	1996	New Zealand	Male cancer incidence by occupation: New Zealand, 1972-1984.			X		X	X
Gaertner RRW	2004	Canada	A case-control study of occupational risk			X			X

			factors for bladder cancer in Canada						
Gallagher RP	1989	Canada	Occupational mortality in British Columbia 1950-1984.						X
Giles G	1993	Australia	Cancer incidence in Melbourne Metropolitan Fire Brigade members, 1980-1989.		X	X		X	X
Glass DC	2016	Australia	Mortality and cancer incidence in a cohort of male paid Australian firefighters.	X	X	X		X	
Glass DC	2016	Australia	Mortality and cancer incidence at a fire training college.					X	
Glass DC	2017	Australia	Mortality and cancer incidence among male volunteer Australian firefighters					X	
Glass DC	2019	Australia	Mortality and cancer incidence among female Australian firefighters.					X	
Goldberg MS	2001	Canada	A case-control study of the relationship between the risk of colon cancer in men and exposures to occupational agents						X
Gomez J	2011	Multiple	Occupational and environmental risk factors of adult primary brain cancers: A				X		

			systematic review.						
Grimes G	1991	Hawaii	Risk of death among Honolulu fire fighters.			X			X
Guidotti TL	1993	Canada	Mortality of urban firefighters in Alberta, 1927–1987.	X	X	X		X	X
Guidotti TL	2014	USA	Health Risks and Occupation as a Firefighter: A Report Prepared for the Department of Veterans' Affairs				X		
Hansen ES	1990	Denmark	A cohort study on the mortality of firefighters.	X	X	X			X
Harris MA	2018	Canada	Surveillance of cancer risks for firefighters, police, and armed forces among men in a Canadian census cohort.		X				
Heyer N	1990	USA	Cohort mortality study of Seattle fire fighters: 1945-1983.		X				
Howe GR	1990	USA, Canada, Australia	Fire fighters and risk of cancer: An assessment and overview of the epidemiologic evidence.				X		
IARC	2010		IARC Monographs on the Evaluation of Carcinogenic Risks to Humans				X		
Ide CW	2014	Scotland	Cancer incidence and mortality in serving whole-time					X	

			Scottish firefighters 1984-2005.						
IRSST	2018	France	Revue de la Littérature Épidémiologique sur le Risque de Cancer chez les Pompiers				X		
Jalilian H	2019	Multiple	Cancer incidence and mortality among firefighters.				X		
Kang D	2008	USA	Cancer incidence among male Massachusetts firefighters,1987-2003.			X			X
Karami S	2012	USA	A case control study of occupation/industry and renal cell carcinoma risk.			X			
Krishnan G	2003	USA	Occupation and adult gliomas in the San Francisco Bay Area			X			X
Krstev S	1998	USA	Occupational risk factors and prostate cancer in US blacks and whites			X			X
Krstev S	1998	USA	Risk for prostate cancer by occupation and industry: A 24-state death certificate study						X
Kullberg C	2018	Sweden	Cancer incidence in Stockholm frefghters 1958–2012: an updated cohort study.	X		X			

LeMasters GK	2006	Multiple	Cancer risk among firefighters: A review and meta-analysis of 32 studies				X		
Lenahan P	2018	USA	A 30-year study of cancer incidence in firefighters and police officers in New Jersey's four largest municipalities.					X	
Lewis SS	1982	USA	Cancer mortality among Los Angeles City firefighters.						X
Ma F	1998	USA	Race-specific cancer mortality in US firefighters: 1984-1993.			X			X
Ma F	2005	USA	Mortality in Florida professional firefighters, 1972 to 1999.	X	X	X		X	X
Ma F	2006	USA	Cancer incidence in Florida professional firefighters, 1981 to 1999	X	X	X			X
Ma F	na	USA	National occupational mortality surveillance (NOMS).						X
Marjerrison N	2022	Norway	Cancer incidence in sites potentially related to occupational exposures: 58 years of follow-up of firefighters in the Norwegian		X			X	

			Fire Departments Cohort.						
Marjerrison N	2022	Norway	Comparison of cancer incidence and mortality in the Norwegian Fire Departments Cohort, 1960-2018.		X				
Mastromatteo E	1959	Not specified	Mortality in city firemen, II. A study of mortality in firemen of a city fire department.	X	X	X		X	X
McDowall ME	1986	UK	Testicular cancer mortality in England and Wales 1971-80: variations by occupation.					X	
Milham	na	USA	Occupational mortality in Washington State. 1950- 1999.						X
Morton W	1984	Canada and USA	Leukemia incidence by occupation in the Portland-Vancouver metropolitan area.	X		X		X	X
Muscat JE	1995	USA	Diesel exhaust, diesel fumes, and laryngeal cancer.						X
Musk AW	1978	USA	Mortality among Boston firefighters, 1915–1975.	X	X	X		X	X
Paget-Bailly S	2013	France	Occupation and head and neck cancer risk in men: results from the ICARE study, a French population-based casecontrol study.			X			

Petersen KKU	2018	Denmark	Long-term follow-up for cancer incidence in a cohort of Danish firefighters.	X	X	X		X	
Petersen KKU	2018	Denmark	Mortality in a cohort of Danish firefighters; 1970-2014.		X			X	
Peterson GR	1980	USA	Occupational Mortality in the State of California, 1959-1961.						X
Pinkerton L	2020	USA	Mortality in a cohort of US firefighters from San Francisco, Chicago and Philadelphia: an update.		X			X	
Pion IA	1995	USA	Occupation and the risk of malignant melanoma.					X	
Pukkala E	2014	Norway	Cancer incidence among firefighters: 45 years of follow-up in five Nordic countries	X	X	X		X	
Rosentock L	1990	USA	Respiratory mortality among firefighters.					X	
Sama SR	1990	USA	Cancer incidence among Massachusetts firefighters, 1982-1986.			X			X
Samet JM	2005	USA	An Occupational Health Investigation of Cancer Among Fire Fighters in Anne Arundel County, Mary-land.				X		

Sritharan J	2017	Canada	Occupation and risk of prostate cancer in Canadian men: A case-control study across eight Canadian provinces.			X	X		
Sritharan J	2022	Canada	Cancer risk among firefighters and police in the Ontario workforce.		X				
Stang A	2003	Germany	Firefighting and risk of testicular cancer: results from a German population-based case-control study			X			X
Steenland K	1987	USA	A case-control study of bladder cancer using city directories as a source of occupational data.						X
Teschke K	1997	Canada	Surveillance of nasal and bladder cancer to locate sources of exposure to occupational carcinogens.						X
Tornling G	1994	Sweden	Mortality and cancer incidence in Stockholm fire fghters.	X	X	X			X
Tsai RJ	2015	USA	Risk of cancer among firefighters in California, 1988-2007.			X			
Vena JE	1987	USA	Mortality of a municipal-worker cohort: IV. Fire fighters.	X	X	X			X

Webber MP	2021	USA	Cancer incidence in World Trade Center-exposed and non-exposed male firefighters, as compared with the US adult male population: 2001-2016.		X			X	
Wende KE	1996	USA	A study of mortality among city of Buffalo firefighters.					X	
Youakim S	2006	Canada, USA, New Zealand, Sweden	Risk of Cancer Among Firefighters: A Quantitative Review of Selected Malignancies.				X		
Zeegers MP	2004	The Netherlands	A prospective study of occupation and prostate cancer risk.			X		X	X
Zeig-Owens R	2011	USA	Early assessment of cancer outcomes in New York City firefighters after the 9/11 attacks: an observational cohort study.		X	X		X	
Zhao G	2020	Spain	Mortality among firefighters in Spain: 10 years of follow-up		X			X	