Firefighters Occupational Health Hazards - Statistical Data Analysis

by

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RESEARCH STUDENT DECLARATION FORM

Type of Award **MSc by Research**

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ABSTRACT

There have been reports of higher death rates among firefighters in the USA, Canada, and Nordic countries due to various cancers and other diseases, but research on the health of UK firefighters is relatively limited.

The aim of this thesis is to assess whether Scottish male firefighters experience elevated mortality rates from cancers and other diseases as compared to the general population.

The study compared mortality rates from cancer and other diseases among male firefighters in Scotland from 2000 to 2020 with those of the general male population in Scotland. The data was presented as standardized mortality ratios (SMRs) with 95% confidence intervals (CIs).

The study revealed that Scottish male firefighters had a significantly higher risk of mortality from cancer when compared to the general population (SMR 1.61, CI 1.42-1.81). The risk of death due to unspecified malignant neoplasms was almost three times higher for Scottish male firefighters (SMR 2.73, CI 1.71-4.00). Moreover, Scottish male firefighters showed excess mortality for site-specific cancers, including prostate (SMR 3.80, CI 2.56-5.29), myeloid leukaemia (SMR 3.17, CI 1.44-5.58), oesophagus (SMR 2.42, CI 1.69-3.29), and urinary system (kidney and bladder) (SMR 1.94, CI 1.16-2.91). The mortality rate from neoplasms of unknown behaviour was over six times greater in Scottish male firefighters (SMR 6.37, CI 2.29-12.49). Additionally, Scottish male firefighters showed significantly higher mortality rates for acute ischemic heart diseases (SMR 5.27, CI 1.90-10.33), stroke (SMR 2.69, CI 1.46-4.28), interstitial pulmonary diseases (SMR 3.04, CI 1.45-5.22), renal failure (SMR 3.28, CI 1.18-6.44), and musculoskeletal system diseases (SMR 5.64, CI 1.06-13.83).

The findings indicate that Scottish male firefighters experience a significant increase in mortality rates from cancers and other diseases as compared to the general population. It highlights the pressing need for preventative health monitoring and presumptive legislation to safeguard the health of Scottish male firefighters.

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LIST OF TABLES, FIGURES AND EQUATIONS

GLOSSARY OF TERMS, ABBREVIATIONS, LISTS OF SYMBOLS

SIR - Standardised Incidence Rate.

SMR - Standardised Mortality Rate.

IARC - International Agency for Research on Cancer.

WHO - World Health Organisation.

IIAC – Industrial Injuries Advisory Council.

FBU – Fire Brigade Union.

PPE – Personal Protective Equipment.

ICD – International Classification of Diseases.

NRS – National Records of Scotland.

SM – Scottish Male

CI – Confidence intervals

FOI – Freedom of information

AIMS AND OBJECTIVES

The main aim of this work was to evaluate cancers and other diseases mortality rates amongst Scottish male firefighters.

Main objectives included:

- Identification, collection, and summary of data for the Scottish male general population and firefighters population against each year (2000-2020), gender, and age.
- Identification, collection, and summary of cancers and other diseases mortality rates amongst male Scottish general population and firefighters population (for 2000-2020).
- Identification, collection, and summary of number of male retired Scottish firefighters (for 2000-2020).
- Scottish male firefighters statistical evaluation of cancers and other diseases by calculated standardised mortality rates.

Throughout this thesis diseases will be referred to as either cancers or other diseases and will generally be treat as two different groups.

1 INTRODUCTION

In the USA, Canada, and Australia the link between exposure to fire effluent and increased incidence of malignant neoplasms (cancers) amongst firefighters is officially recognised, with presumptive legislation protecting firefighters' right to medical support and/or workplace compensation should they develop cancer because of their careers. Poland was the first European country which introduced presumptive legislation for number of cancers in 2019. Table 1.1 displays the specific cancers for which firefighters have presumptive legislation, split by country [i,ii].

Table 1.1 Countries with presumptive legislation by cancers and other diseases type.

	Presumptive legislation for firefighters			
Cancer type	**Poland**	**Canada**	**USA**	**Australia**
Bladder	+	+	+	+
Brain		+	+	+
Colorectal		+	+	+
Oesophageal		+	+	+
Kidney	+	+	+	+
Leukaemia	+	+	+	+
Lung	+	+	+	
Mesothelioma			+	
Multiple myeloma		+	+	+
Non-Hodgkin's lymphoma	+	+	+	+
Skin cancer (melanoma)	+	+	+	
Thyroid			+	
Ureter	+	+		+
Liver	+			
Female Specific Cancers				
Breast		+		
Ovarian		+		
Cervical		+		
Male Specific Cancers				
Prostate		+	+	+
Testicular		+	+	+
Other diseases				
Chronic obstructive pulmonary disease.	+		+	
A sudden cardiac event or stroke while, or not later than 24 hours after, engaging in the activities			+	

In 2022, the International Agency for Research on Cancer (IARC), World Health Organisation, re-classified occupational exposure to firefighters as "carcinogenic to humans"[i]. The IARC review considers the growing number of studies worldwide which indicate elevated incidences of cancers and other diseases in firefighters[ii,iii,iv,v,vi,vii,viii]. However, little such support is in place for UK firefighters. UK's Industrial Injuries Advisory Council (IIAC) failed to recognise cancer (except mesothelioma) as an occupational risk for UK firefighters[ix] . Lack of sufficient evidence (due to a lack of studies on UK firefighters) was cited as one of the key reasons for this decision.

This research work, independently carried out for the Fire Brigades Union, was to statistically evaluate cancers and other diseases mortality rates among Scottish male firefighters between 2000-2020 when compared to the general Scottish male population.

1.1 Cancers and Other Diseases Amongst the UK Firefighters

In the UK, there is very little published on the firefighters' health. Recently, a few research publications were released evaluating firefighters' experiences and behaviours on a range of topics. These included exposure to fire toxins (duration, frequency etc.), contamination and decontamination practices, personal protective equipment (PPE) (provision, maintenance, cleaning, storage, fit etc.), health (cancer, mental health), attitude/culture, and awareness and training .

It has been reported that carcinogens from fire incidents not only remain on firefighters' personal protective equipment (PPE) but are also tracked back to fire stations. This puts firefighters at an increased risk of developing adverse health outcomes and emphasises the importance of managing those risks by implementing controls which protect against exposures.

Results also revealed that firefighters who have served more than 15 years were 1.7 times more likely to develop cancer when compared to those who have served less time. Firefighters were at least twice as likely to be diagnosed with cancer if they noticed soot in their nose/throat or remained in their PPE for more than four hours after attending a fire incident. In addition, an increased likelihood of developing cancer was identified for: eating while wearing PPE; failing to store clean/dirty PPE separately; working in a station that smells of fire; or/and not having designated (separate) clean and dirty PPE areas [x,xi,xii,xiii] .

1.2 Worldwide Firefighters Cancers and Other Diseases

A database was created which recorded information from existing publications which studied the health outcomes of firefighters compared to various other populations (e.g., general population, other occupations). As well as collecting the health outcomes, the statistical measures employed were also collected. Websites such as www.researchgate.net [xiv] and www.jstor.org [xv] were searched using one of these words: firefighter, fire fighter, health, health outcome, incidence, mortality, prevalence, morbidity, risk, cancer, disease, ratio, population.

A total of 167 publications[xvi] were included in the database for analyses with publication dates between 1945 and 2023. The number of publications per year is summarised and presented in Figure 1.1 and Tables 1.2 and 1.3.

Specific criteria were used to include or exclude any publication appearing in the search.

The inclusion criteria were:

- Must investigate a relationship between firefighters and a health outcome (defined as any biological response - so all biomonitoring studies were excluded as we weren't interested if there was no associated health outcome.)
- Must compare health outcome in firefighters to a comparison group of non-firefighters (e.g., other occupational groups like policemen etc. or to general population etc.)
- Must investigate the prevalence, risk, incidence etc. of a health outcome within firefighters (compared to non-firefighting populations)
- Must be primary research.

The exclusion criteria were:

- Studies that do not investigate a relationship between firefighters and a health outcome.
- Studies that investigate a health outcome within populations of firefighters - but do not compare this with health outcomes in a non-firefighting comparison population.
- Studies that look at the causes/predictors of health outcomes, instead of some measure of prevalence of those health outcomes, within populations of firefighters (and do not draw comparisons to non-firefighting populations)
- No secondary research (e.g., systematic reviews, narrative reviews, meta-analyses, evidence maps etc.)

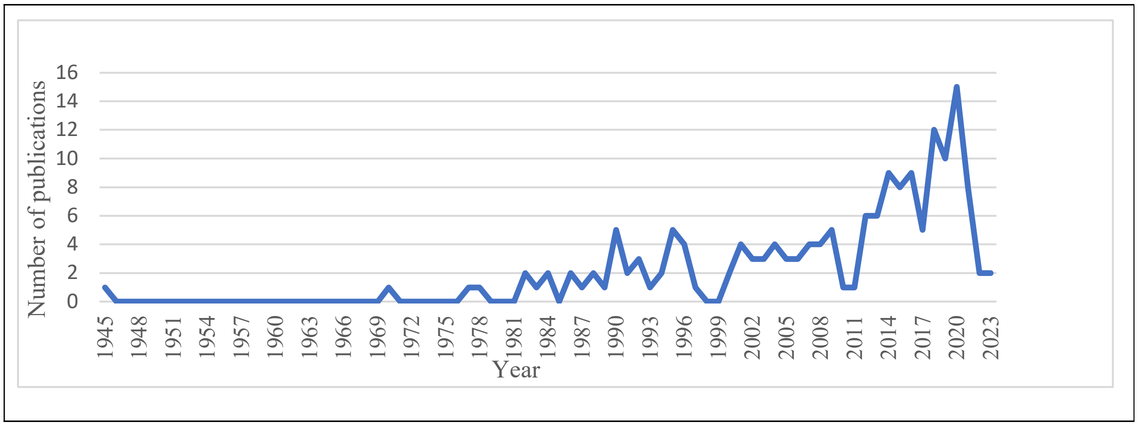

Figure 1.1 Total number of publications per year 1945-2023

The number of publications on firefighters is relatively low, highlighting how understudied this field is. However, it can be clearly seen that from 1980 studies began being published yearly. This coincides with when USA started giving presumptive legislation to individual states (e.g., California in 1982[xvii]). From this point the US then contributed over half of all the publications between 1983-1992. From 1990 onwards several studies were being published per year and from 2010 there was a steep increase peaking at 15 in 2020. This could be partially attributed to a combination of Australia receiving presumptive legislation in 2011[xviii], collapse of the World Trade Centre, debate on the firefighters' health in the EU Parliament 2017[xix] and 2019 Best practice report FBU[xx].

Table 1.2. Total publications included in the database, split by country.

These publications include all types of health outcomes and measures.

Country	Publications	Percentage
The Netherlands	7	4%
UK	6	4%
Denmark	4	2%
Germany	3	2%
Rest of Europe (excluding four countries above)	13	8%
USA	71	43%
Canada	10	6%
Australia	10	6%
South Korea	14	8%
Rest of World (excluding Europe and four countries above)	29	17%
Total	**167**	**100%**

Table 1.3. Shows the number of publications studying SIR (Standardised Incidence Rate) of cancers or other diseases in firefighters or SMR (Standardised Mortality Rate) of cancers or other diseases in firefighters.

Note: a publication may study cancers or other diseases using both SIR and SMR, therefore any publication could count in one or more columns. Table 1.3 is a subset of Table 1.2.

	Number of publications			
Country	**SIR of cancers**	**SIR of other diseases**	**SMR of cancers**	**SMR of other diseases**
The Netherlands	0	0	0	0
UK	1	0	1	0
Denmark	0	2	1	1
Germany	0	0	0	0
Rest of Europe (excluding four countries above)	1	0	4	4
USA	5	2	10	11
Canada	0	0	2	2
Australia	2	0	4	3
South Korea	3	2	1	1
Rest of World (excluding Europe and four countries above)	2	0	2	2
Total	**14**	**6**	**25**	**24**

Table 1.2 shows that of the 167 publications identified, over 40% of all publications were from the USA along with South Korea (8%), Canada (6%), Australia (6%) and the rest of the world (17%). Of the 29 publications from the 'Rest of World (excluding Europe)', the biggest contributors were China, Japan, and New Zealand, all with 3 each. Maybe unsurprisingly, the countries with the most frequently studied firefighting populations are also those where presumptive legislation exists (i.e., USA, Canada, Australia). In comparison, the UK is amongst the least studied in terms of firefighters' occupational health.

Many of these publications studied several health outcomes using several statistical measures. Each publication was inspected and categorised into the broad health outcome studied (e.g., cancer, other diseases, injury, mental illness), specific health outcome (e.g., malignant neoplasm of the prostate, chronic ischaemic heart disease) and measures used (e.g., Standardised Incidence Rate, Standardised Mortality Rate, prevalence, odds ratio, rate ratio).

Publications studying the standardised incidence (SIR) and standardised mortality rates (SMR) of cancers and other diseases were the most common and are shown in Table 1.3. SIR and SMR are usually used when a cohort's incidence and mortality rates are being studied and being compared to the population from which the cohort belongs. The standardised incidence (SIR) or mortality ratio (SMR) quantifies the increase or decrease in incidence or mortality of a study cohort with respect to the general population. Both are often used against year, age, and gender[xxi]. A number more than 1 indicates higher than expected incidence or mortality.

Each publication could be categorised in all four categories and could study one or more type of cancers or other diseases. For example, if a publication studied at least one type of cancer using SIR it will count once in the category 'SIR of cancers'. The same publication could also have studied at least one type of other disease using SMR and will count once in the category 'SMR of other diseases'. Any publication which did not study any of these four categories was categorised as 'other' and will not appear in Table 1.3. Such publications looked at other health outcomes (e.g., injury/accidents, suicide, mental illness) and other measures (e.g., prevalence %, incidence %, mortality %, odds ratio, rate ratio, hazard ratio).

It can be also seen from Table 1.3 that 14 of the 167 publications (8%) used SIR of cancers, 6 of the 167 publications (4%) used SIR of other diseases, 25 of the 167 publications (15%) used SMR of cancers and 24 of the 167 publications (14%) used SMR of other diseases.

It should also be noted that SMR of cancers was used nearly twice as often as SIR of cancers whilst SMR of other diseases was used nearly four times as often as SIR of other diseases.

1.3 International Classification of Diseases

Each health outcome which appears in the studies in Table 1.3 was coded in line with the International Classification of Diseases (ICD 10) [xxii]. This coding system is maintained by the World Health Organisation (WHO) and categorises diseases, symptoms, and other elements of patient's diagnosis.

For example, 'malignant neoplasms of oesophagus' is coded as C15. This belongs to a broader group called 'malignant neoplasms of digestive organs.' and coded as C15-C26 which in turn belongs to a broader group called 'malignant neoplasms' and coded as C00-C97. Figure 1.2 illustrates the ICD 10 hierarchy.

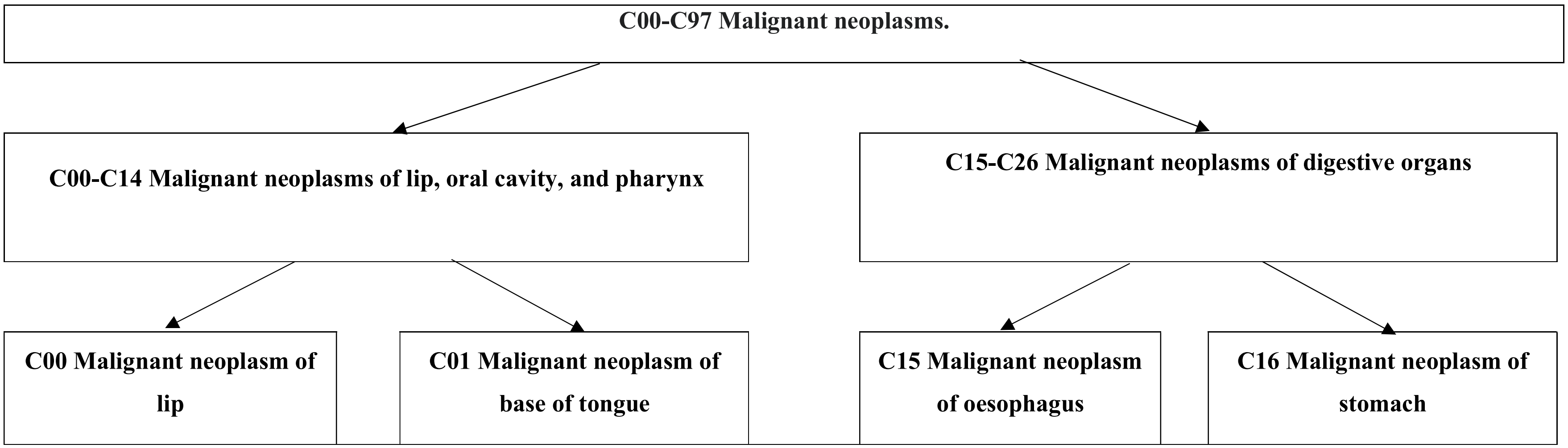

Figure 1.2. Example of the ICD 10 hierarchy

1.4 Standardised Cancer Incidence and Mortality Rates

Figure 1.3 shows the number of publications with cancer standardised incidence and mortality rates (SIR and SMR). The most commonly studied cancers were:

- C34- malignant neoplasm of bronchus and lung, which was studied using SIR in 10 publications and using SMR in 15 publications.
- C20 – malignant neoplasm of rectum (SIR=9, SMR=14)
- C43 - malignant melanoma of skin (SIR=10, SMR=13)
- C16 – malignant neoplasm of stomach (SIR=7, SMR=15),
- C61 - malignant neoplasm of prostate (SIR=9, SMR=12),
- C67 - malignant neoplasm of bladder (SIR=9, SMR=11),
- C71 - malignant neoplasm of brain (SIR=8, SMR=11),
- C21 - malignant neoplasm of anus and anal canal (SIR=7, SMR=11),
- C15 - malignant neoplasm of oesophagus (SIR=7, SMR=10).
- C64 - malignant neoplasm of kidney, except renal pelvis (SIR=10, SMR=8)
- and C73 - malignant neoplasm of thyroid gland (SIR=9, SMR=5).

A number of publications broadly reported studying number of different malignant neoplasms rather than the specific cancer. This showed the same trend as above with SMR being studied more than SIR (SIR=8, SMR=18). It is also worth noting that some publications reported SIR and SMR at specific level e.g. C15 (malignant neoplasm of oesophagus) while the others at more broad levels e.g. C00-C14 (malignant neoplasm of lip, oral cavity and pharynx) and C00-C96 (all malignant neoplasms) without a breakdown of the specific ICD codes within. In some publications, 'All MNs' were grouped together and presented as one figure for both SIR and SMR. These broad categories are included in Figure 1.3.

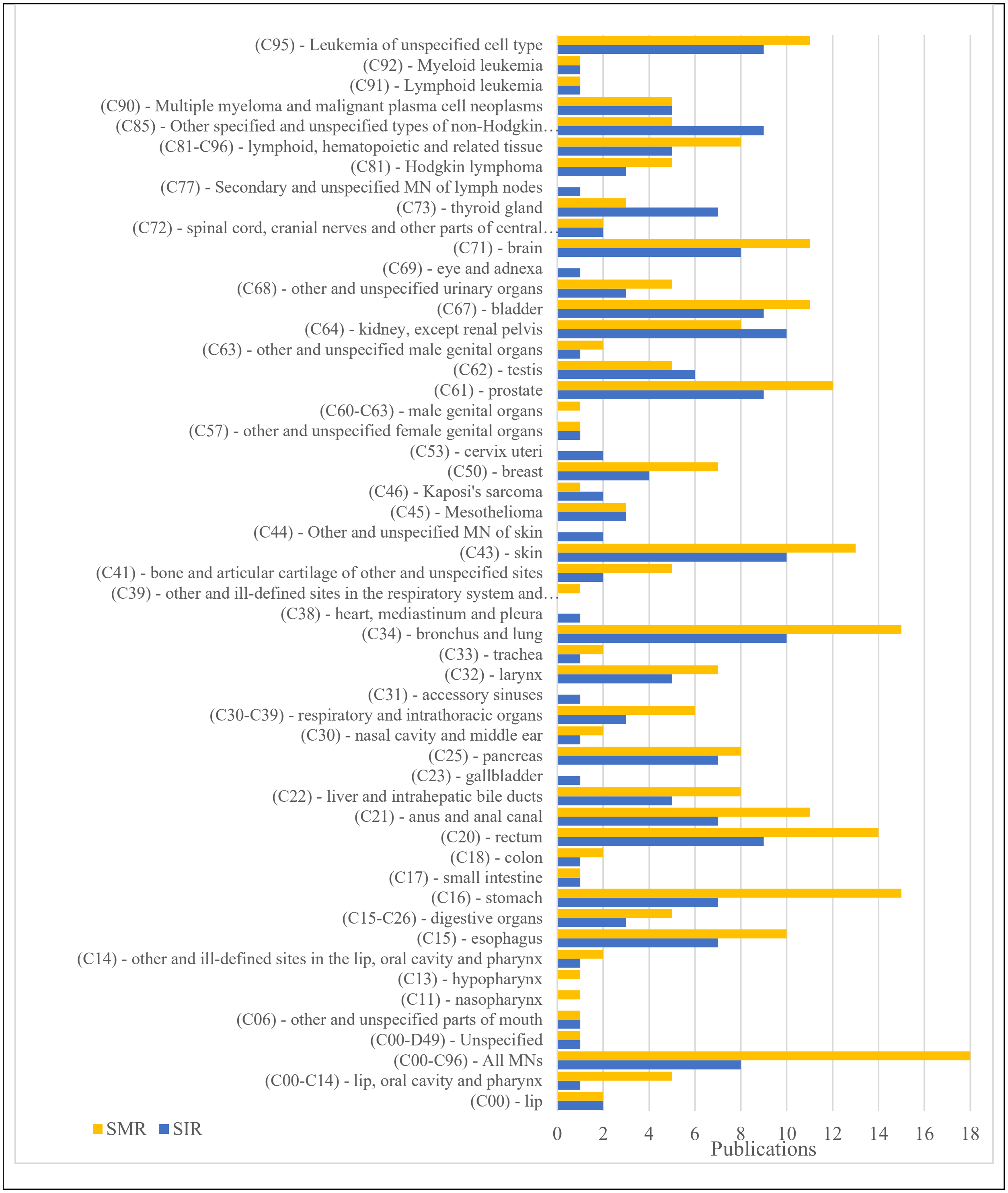

Figure 1.3. Cancer standardised incidence and mortality rates (against ICD codes)

1.5 Standardised Incidence and Mortality Rates for Other Diseases Than Cancers.

Figure 1.4 shows the number of publications that report SIR and SMR for other diseases. It is quite clear that the publications reported more frequently the SMR than SIR. Ischaemic heart diseases (I20 – I25) were the most studied, 5 publications presenting SIR and 16 publications using SMR. They were followed by the chronic lower respiratory diseases (J40 – J47) (SIR in 3 publications, SMR in 13) and cerebrovascular diseases (I60 – I69) with one publication presenting SIR and 11 SMR. Several publications reported diseases of the respiratory system (J00-J99) with one publication presenting results on SIR and 16 on SMR. Similar number of publications was released for the diseases of the circulatory system (1 publication with SIR and 15 on SMR).

It is also worth noting that some publications reported SIR and SMR at a quite specific level e.g. I20-I25 (ischaemic heart diseases) while the others reported SIR and SMR at more broad levels e.g. I00-I99 (circulatory system) without a breakdown of the specific ICD codes within. These broad categories are included in Figure 1.4.

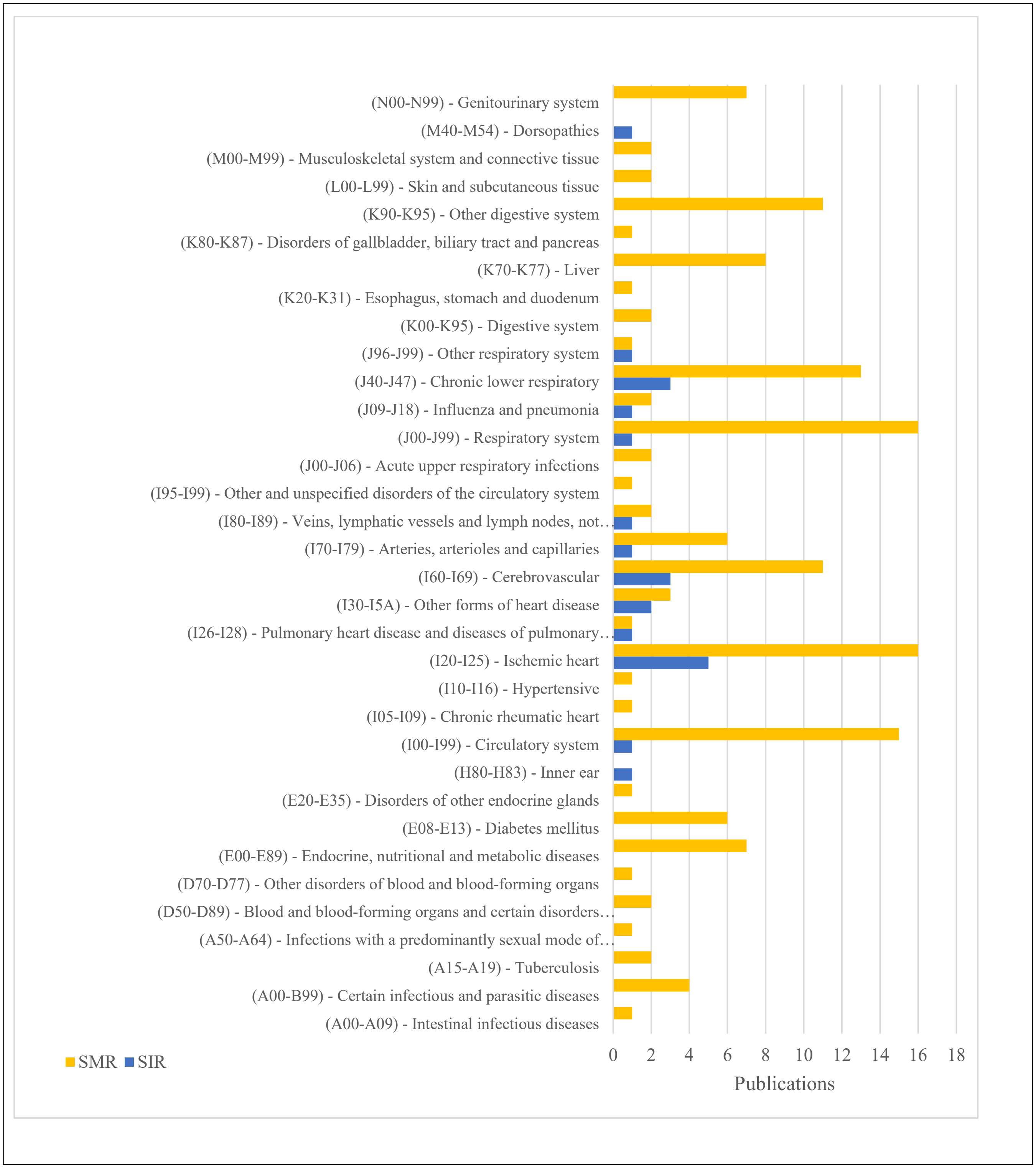

Figure 1.4. Standardised incidence and mortality rates for other diseases.

2 METHODOLOGY

This chapter describes data collection and analysis (cancers and other diseases standardised mortality rates) for the Scottish male firefighters.

2.1 Data Collection

To calculate the SMR of Scottish male firefighters compared to General Scottish male population required the datasets such as Scottish male general population numbers, Scottish male general population mortality numbers, Scottish male firefighter population numbers and Scottish male firefighter population mortality numbers (all by year 2000-2020 and age).

2.2 Scottish Male General Population

Scottish male general population numbers were obtained from 'National Records of Scotland' website[xxiii] for the period 2000-2020. The website presented data split by age, gender, and year. The data was transformed and filtered into the format required by extracting only males and grouping the numbers into age groups by year as presented in Table 2.1.

Table 2.1. Age groups for the Scottish male general population.

Males age group	2000	….all years in between….	2020
30-34			
35-39			
40-44			
45-49			
50-54			
55-59			
60-64			
65-69			
70-74			

2.3 Scottish Male General Population Mortality

Scottish male general population mortality numbers were obtained from 'National Records of Scotland' [xxiv] website. The website presented this raw data split by age group, gender, and ICD code for the cause of death for each year (2000-2020) individually. NRS manages official statistics in accordance with relevant public records legislation and codes of practice on records management, including the Public Records (Scotland) Act 2011 and the Scottish Ministers Code of Practice on Records Management by Scottish Public Authorities under the Freedom of Information (Scotland) Act 2002 (Section 61 Code of Practice) [xxv].

Data was downloaded for each year separately, combined, and transformed and filtered into the format as in Table 2.1 for each ICD code.

2.4 Scottish Male Firefighter Population

Firefighter population figures for the years 2000–2020 were obtained from annual publications released by the Scottish Fire and Rescue Service[xxvi], and from Her Majesty's Inspectorate of Constabulary and Fire and Rescue Services. The website data was split by age, gender, year, and employment type. Employment types included: 'wholetime operational', 'retained duty system', 'retained full-time' and 'volunteer'. 'Control' and 'support' which were excluded. Data was downloaded for each year separately, combined, and transformed and filtered into the format as in Table 2.1 for each ICD code.

Figures for retired firefighters as presented in the format in Table 2.1 were obtained from the Scottish Public Pensions Agency, through a freedom of information request.

2.5 Scottish Male Firefighter Mortality

Scottish male firefighters' mortality numbers split by year (2000-2020), age and gender were obtained from 'National Records of Scotland' through a freedom of information request (FOI). The firefighters' ICD code (for the cause of death) was included in the FOI. Female firefighters were excluded due to their small sample size, and the raw data transformed into the format as presented in Table 2.1. This data included retired Scottish firefighters as their last occupation recorded on the death certificate.

2.6 Data Compilation

The raw data presented in sections 2.2 to 2.5 was combined using a combination of Python, Microsoft Excel, Microsoft Access and structured query language programming software.

Ethical review by the University of Central Lancashire Ethics Committee was not required as all data was publicly accessible and fully anonymised.

3 EXPERIMENTAL

There have been only two studies on the UK firefighters investigating their cancers and other diseases incidence and mortality rates[xxvii,xxviii]. These studies hint at cancer becoming a growing concern for UK firefighters over time, whereby initial investigation of the topic over the 1965-1993 period found reduced cancer incidence/mortality in firefighters [xxvii], and subsequent study over the 1984-2005 period found significantly higher mortality rates for kidney cancer [xxviii].

3.1 Data Extrapolation

The data sets for Scottish male firefighter population were only available for years 2013 – 2020. In addition, in 2013 the age groups provided were wider than the age groups selected. '30-39' was used rather than '30-34' and '35-39'. In addition, the numbers included both male and female.

Therefore, it was necessary to reorganise data into the format as presented in Table 2.1. Table 2.2 and 2.3 presents extrapolation that was used. The '30-39' age band was split into '30-34' and '35-39'. Table 2.2 presents an example of the raw data for 2013 for 'wholetime operational' firefighters for the age band '30-39'.

The data set showed that there were 1254 'wholetime operational' firefighters in 2013 in the age group '30-39'. Using the proportion between ages '30-34'and '35-39' for years 2014-2016 (which was 41% and 59% respectively), 1254 was split by these proportions as in Table 2.2.

Table 2.2. Example of extrapolation method.

Age group	Wholetime operational (2013)		Age group	Wholetime operational (2013)
30-39	1254	->Extrapolated to ->	30-34	509
			35-39	745

Due to firefighter population figures not being available for 2000-2012, again data extrapolation was used. Mean figures were taken from 2014-2016 and used for years 2000-2012. From the data analysis, assumptions were made that years 2014-2016 were more representative than 2014-2020. The mean figures were then attributed to years 2000-2012. An example of how the mean of 2014-2016 was calculated is shown in Table 2.3.

Table 2.3. An example of using the firefighters age bands mean values of known years to extrapolate data to previous years.				
Age group	**2014**	**2015**	**2016**	**Mean 2014-2016**
30-34	337	335	337	336
35-39	350	352	387	363
40-44	510	456	392	453
45-49	627	576	555	586
50-54	398	432	460	430
55-59	202	181	178	187
60-64	71	62	73	69
65-69	2	5	3	3
70-74	0	0	0	0

Once the above numbers were calculated, they needed to exclude the number of females. The percentages of females for each year were obtained from 'Scottish Fire and Rescue Service' website. For example, in 2020 6.1% of the wholetime operational firefighters were female. The number for the 'wholetime operational' firefighters in that year was reduced then by 6.1%.

3.2 Statistical Analysis

A total of 1191 fully anonymised records of Scottish firefighter deaths for males and females were obtained from NRS. 424 of these records pertained to firefighters who were employed in other sectors such as aviation, oil, chemical, retail, railway, coal mining, armed forces etc., and were excluded from analysis as it was not possible to confirm that these roles involved active firefighting.

767 records included those employed by the government or/and Fire and Rescue Services. These included 96 supporting staff (control room operator, receptionist, administrative assistant etc.) which were excluded from the analysis. Due to their small sample size, records concerning female firefighters (n=11) were also excluded. Any deaths attributed to external causes of morbidity and mortality (e.g., such as suicide, drowning etc.) were also not included in this analysis (n=37).

A total of 623 mortality records for both serving and retired Scottish male firefighters were included in the analyses (n=285 for cancer mortality, and n=338 for other diseases).

This study does not follow a standard cohort study design (which typically follows the same group of people over time, collecting baseline data for each individual at the onset of the study). Instead, the analyses in this publication are based on aggregate data.

This work exclusively reports SMR data for firefighters. The standardised incidence (SIR) or mortality ratio (SMR) quantifies the increase or decrease in incidence or mortality of a study cohort with respect to the general population. The expected number of Scottish male firefighter deaths were calculated by multiplying the mortality rate of the general population by the number of fire fighters in each age group/year as in Equation 1. A number more than 1 indicates higher than expected incidence or mortality.

$$E = \frac{\text{SM firefighter population (2000-2020) x Number of SM general population deaths (2000-2020)}}{\text{SM general population (2000-2020)}}$$

Equation 1. Equation for expected number of SM deaths

The equation used to calculate the Standardised Mortality Rate (SMR) for each ICD code or group of ICD codes was the observed (or actual) number of Scottish male firefighter deaths divided by the expected number of Scottish male firefighter deaths.

$$\text{SMR} = \frac{\text{Observed number of deaths (O)}}{\text{Expected number of deaths (E)}}$$

Equation 2. Equation for Standardised Mortality Rate

Standardised mortality ratios (adjusted for age and calendar year) were calculated using the actual number of Scottish male firefighter deaths as obtained above [xxix]. 95% confidence intervals were calculated using methods described in Ulm, 1990[xxx]. The 95% confidence intervals were calculated using the Vandenbroucke method is presented in Equation 3[xxxi].

$$\text{Lower 95\% CI} = \frac{((\sqrt{O}) - 1.96*0.5)^2}{E}$$

$$\text{Upper 95\% CI} = \frac{((\sqrt{O}) + 1.96*0.5)^2}{E}$$

Equation 3. Equation for 95% Confidence Intervals

4 RESULTS

4.1 Scottish Male Firefighters Cancer Standardised Mortality Rates

Table 2.4 presents SMR for cancers for Scottish male firefighters with 95% confidence intervals (worth noting that column "Expected" was rounded to zero decimal places). When looking at overall results for malignant neoplasms the SMR was 1.61. This suggests that Scottish male firefighters are 1.61 times more likely to die of a malignant neoplasm than the Scottish general population.

Individual cancer with higher SMR compared to the general population were observed in cancers of prostate (SMR 3.80, CI 2.56-5.29), myeloid leukaemia (SMR 3.17, CI 1.44-5.58), oesophagus (SMR 2.42, CI 1.69 -3.29), cancers without specification of site (SMR 2.73, CI 1.71-4.00) and neoplasms of unknown behaviour (SMR 6.37, CI 2.29-12.49). Neoplasms of unknown behaviour refers to a category of tumours or growths which behaviour or potential for malignancy is not known. The SMR for malignant neoplasms of the urinary system (such as kidney and bladder) was found to be also higher (SMR 1.94, CI 1.16-2.91).

Table 2.4. Standardised Scottish male firefighter mortality ratios for certain cancers in Scotland together with their 95% confidence intervals (CI).

Causes of death are coded in accordance with the 10th revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-10). MN = malignant neoplasm.

CAUSE OF DEATH (ICD-10 CODES)	EXPECTED	OBSERVED	SMR (95% CI)
MALIGNANT NEOPLASMS[C02-C92]	**168**	**271**	**1.61 (1.42, 1.81)**
MN Head and neck[C02, C06, C09-10, C14]	5	5	0.98 (0.31, 2.03)
MN Digestive organs[C15-22, C24-26]	**59**	**95**	**1.60 (1.30, 1.94)**
MN oesophagus[C15]	**14**	**35**	**2.42 (1.69, 3.29)**
MN stomach[C16]	7	9	1.30 (0.59 ,2.29)
MN Intestine[C17-C18]	10	15	1.48 (0.82 ,2.32)
MN rectum[C19-21]	9	7	0.74 (0.29, 1.38)
MN liver[C22]	7	11	1.67 (0.83, 2.80)
MN pancreas[C25]	9	14	1.58 (0.86, 2.51)
MN other digestive organs[C26]	2	3	1.25 (0.24, 3.06)
MN respiratory organs[C30, C32-34,C39]	50	60	1.21 (0.92, 1.53)
MN bronchus and lung[C34]	47	56	1.19 (0.90, 1.52)

MN skin[C43-44]	4	5	1.17 (0.37, 2.42)
MN mesothelial and soft tissues[C45, C48-49]	4	8	2.11 (0.90, 3.82)
MN mesothelioma[C45]	2	5	2.14 (0.68, 4.43)
MN prostate[C61]	**8**	**30**	**3.80 (2.56, 5.29)**
MN urinary system (kidney and bladder)[C64, C67]	**10**	**19**	**1.94 (1.16, 2.91)**
MN kidney[C64]	6	11	1.84 (0.91, 3.08)
MN bladder[C67]	4	8	2.09 (0.89, 3.80)
MN brain[C71]	10	11	1.08 (0.54, 1.81)
MN without specification of site[C80]	**8**	**22**	**2.73 (1.71, 4.00)**
MN primary lymphoid, haematopoietic tissue[C81, C83, C85, C90, C92]	10	15	1.49 (0.83, 2.34)
MN myeloid leukaemia[C92]	**3**	**9**	**3.17 (1.44, 5.58)**
Neoplasm of unknown behaviour[D38, D46-47]	**1**	**6**	**6.37 (2.29, 12.49)**
Myelodysplastic syndromes[D46]	**1**	**3**	**5.56 (1.05, 13.63)**

4.2 Scottish Male Firefighter Other Diseases Standardised Mortality Rates

Table 2.5 presents SMR for other diseases for Scottish male firefighters with 95% confidence intervals (worth noting that column "Expected" was rounded to zero decimal places). SMR of acute ischaemic heart diseases (other than myocardial infarction) was found to be 5.27 (CI 1.90-10.33) while interstitial pulmonary diseases were found to be 3.04 (CI 1.45-5.22) greater when compared to general public. Renal failure was also found to be elevated in Scottish male firefighters compared to the Scottish male population (SMR 3.28, CI 1.18-6.44). SMR for stroke, not specified as haemorrhage or infarction was 2.69 (CI 1.46-4.28) and for the diseases of the musculoskeletal system 5.64 (CI 1.06-13.83).

Table 2.5. Standardised Scottish male firefighter mortality ratios for certain diseases in Scotland together with their 95% confidence intervals (CI).

Causes of death are coded in accordance with the 10th revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-10). MN = malignant neoplasm.

CAUSE OF DEATH (ICD-10 CODES)	EXPECTED	OBSERVED	SMR (95% CI)
OTHER DISEASES[G-N]	**280**	**304**	**1.09 (0.97 ,1.21)**
Other sepsis[A41]	3	4	1.38 (0.36, 3.07)
Endocrine and metabolic[E11, E14, E78, E85, E87]	9	10	1.17 (0.56, 2.00)
Mental and behavioural disorders[F01, F03, F10, F19]	24	13	0.53 (0.28, 0.86)
Nervous system[G00, G10, G12, G20, G30, G35, G40, G82, G90]	14	19	1.36 (0.82, 2.04)
Spinal muscular atrophy and related syndromes[G12]	3	6	1.81 (0.65, 3.55)
Parkinson[G20]	1	3	2.65 (0.50, 6.50)
Alzheimer[G30]	1	3	2.79 (0.53, 6.84)
Circulatory sytem[I10-12, I21, I24-27, I33, I35, I42, I48, I51, I60-64, I67, I69, I71, I73, I80]	171	180	1.06 (0.91, 1.22)
Acute myocardial infarction[I21]	58	57	0.99 (0.75, 1.26)
Other acute ischaemic heart diseases[I24]	**1**	**6**	**5.27 (1.90, 10.33)**
Chronic ischaemic heart diseases[I25]	55	56	1.02 (0.77, 1.31)
Pulmonary heart diseases[I26, I27]	3	4	1.41 (0.37, 3.12)
Cerebral infarction[I63]	4	6	1.60 (0.58, 3.14)
Stroke[I64]	**5**	**14**	**2.69 (1.46, 4.28)**
Aortic aneurysm and dissection[I71]	4	8	1.83 (0.78, 3.31)
Respiratory system[J18,J22,JJ44-45, J69, J84]	33	38	1.15 (0.82 ,1.55)
Pneumonia, organism unspecified[J18]	9	7	0.78 (0.31 ,1.46)
Other chronic obstructive pulmonary disease[J44]	17	16	0.97 (0.55 ,1.50)
Other interstitial pulmonary diseases[J84]	**3**	**10**	**3.04 (1.45 ,5.22)**
Diseases of digestive system[K26, K43-44, K51, K55-56, K59,K63, K66, K70, K74, K76, K80, K83, K85-86, K90]	60	57	0.95 (0.72, 1.21)
Hernia (ventral, diaphragmatic)[K43, K44]	**0**	**2**	**12.51 (1.18, 35.86)**
Other diseases of intestines[K55-56, K59, K63]	3	6	1.77 (0.64, 3.48)

Alcoholic liver disease[K70]	42	30	0.71 (0.48, 0.98)
Other diseases of liver[K74, K76]	8	12	1.57 (0.81, 2.59)
Musculoskeletal system[M31, M72]	**1**	**3**	**5.64 (1.06, 13.83)**
Renal failure[N17-N19]	**2**	**6**	**3.28 (1.18, 6.44)**
Acute renal failure[N17]	1	1	1.72 (0.00, 6.73)
Chronic kidney disease[N18]	1	3	3.12 (0.59, 7.64)
Unspecified kidney failure[N20]	0	2	7.09 (0.67, 20.31)

4.3 Scottish Male Firefighter Age Mortality Distribution

Figure 2.1 (A) and (B) presents the total number of cancers and other diseases deaths from 2000-2020, for the Scottish general population and Scottish male firefighters.

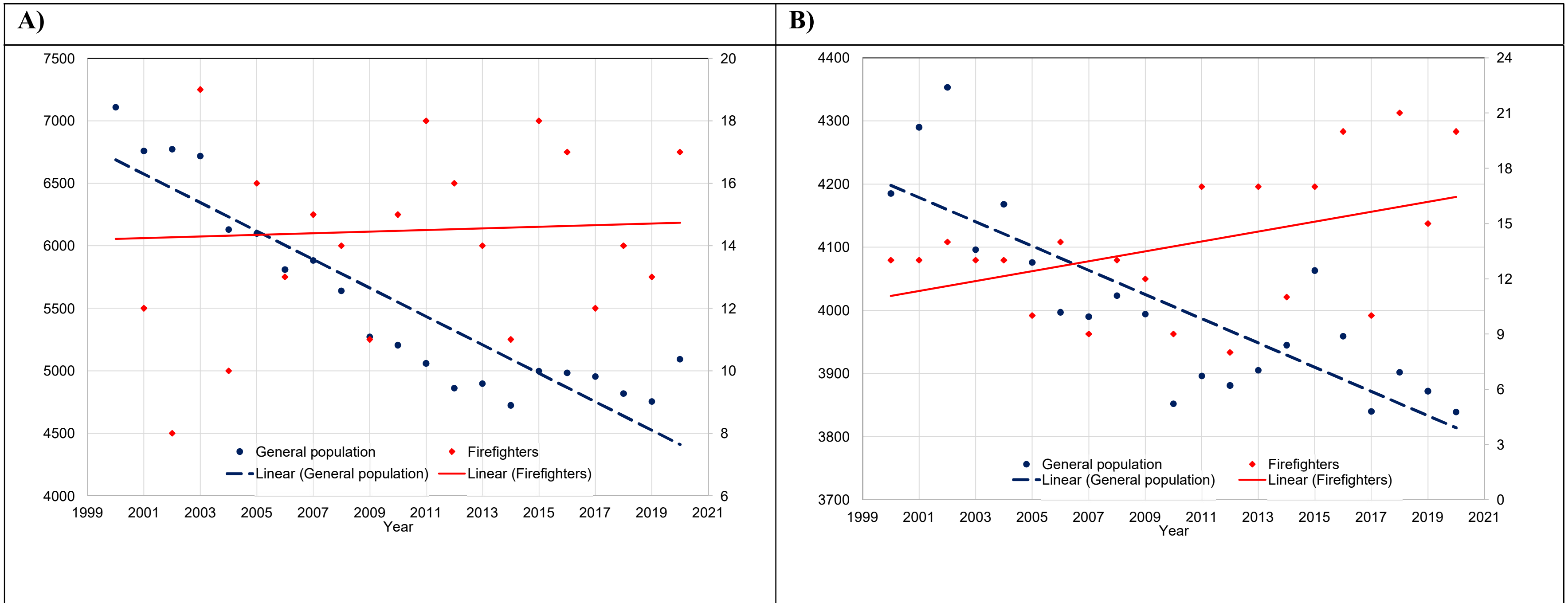

Figure 2.1. Total number of A) disease and B) cancer deaths from 2000-2020, for general Scottish male population and Scottish male firefighters.

An overall downward trend in the number of cancers and other diseases deaths in the general population over time reflects the introduction, and increasing availability of, life-saving measures such as early diagnostics, effective treatment etc., as outlined in the UK NHS's Long-Term Plan for the UK general public[xxxii]. However, this downward trend is not seen in Scottish male firefighters, who instead display a concerning upward trend in number of cancer deaths over time. There may be several plausible explanations for this observation. As demonstrated in Figure 2.2 and explained in the next section, Scottish male firefighters appear to have lower death rates compared to the general population until the 50-54 age bracket (cancer) and 55-59 (other diseases). They then have higher cancer death rates when compared to the general population. These firefighters may be too young to be offered national NHS cancer screening programmes, which are typically targeted at older demographics—preventing early diagnosis and treatment. Additionally, Scottish male firefighters may be more susceptible to specific cancers which are less common in the general population and are thus not targeted by national screening programmes—again delaying diagnosis and treatment. Finally, the increasing domination of synthetic materials (which produce a more toxic fire effluent) in modern times may in part contribute to the apparent increase in Scottish male firefighter cancer deaths over time.

Table 2.6 presents Scottish male firefighters at a significantly increased risk of cancers at any specific age groups, compared to the Scottish general population. It also shows the peak cancer incidence and mortality age groups for both Scottish male firefighters and Scottish male general population. The peak mortality age group for the Scottish male firefighters was obtained from the data collected in section 2.5 which was presented in the format of Table 2.1 split by each ICD code.

A)

B)

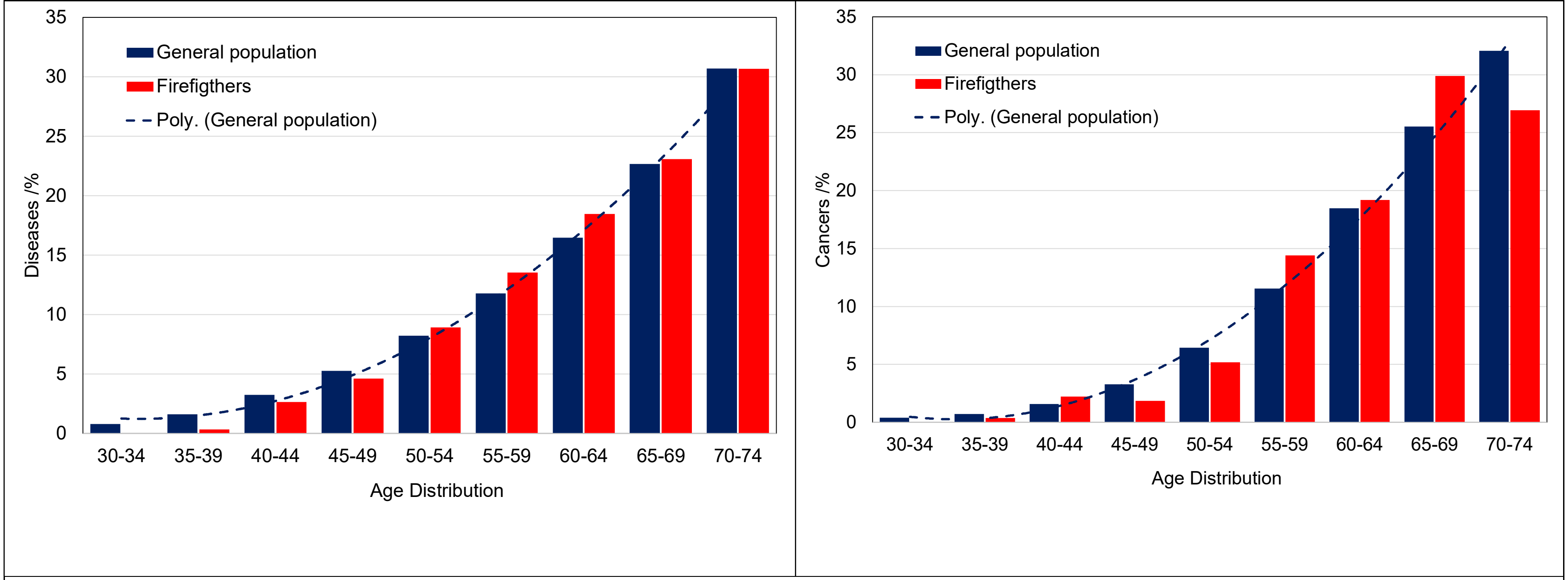

Figure 2.2. Age distribution for A) other diseases and B) cancer deaths from 2000-2020, for Scottish male general population and Scottish male firefighters.

Table 2.6: Scottish male firefighters at a significantly increased risk of cancers at any specific age groups, compared to the Scottish general population. It also shows the peak cancer incidence and mortality age groups for both Scottish male firefighters and Scottish male general population.

ICD Code	Cancer	Was it significant across all ages (30-74)	Age group when first became significant.	Scott male firefighter peak mortality age group	Scott males general population peak incidence age group[xxxiii]	General Scottish male population peak mortality age group. [xxiv]
C15	Oesophageal	Yes	60-64	70-74	70-74	75-79
C16	Stomach	No	NA	75-79	75-79	75-79
C18	Colon/Bowel	No	NA	60-64	75-79	80-84
C17, C18	Intestine	No	NA	60-64	Not available	80-84
C19, C21	Rectum	No	NA	65-69	70-74	75-79
C22	Liver	No	65-69	65-69	70-74	70-74
C25	Pancreas	No	60-64	60-64	70-74	70-74
C15-C22, C24, C26	Digestive organs	Yes	60-64	65-69	70-74	75-79
C34	Lung	No	65-69	65-69	70-74	70-74
C30, C32, C34, C33, C39	Nasal cavity and middle ear, and respiratory system with intrathoracic organs	No	65-69	65-69	70-74	70-74
C45	Mesothelioma	No	NA	60-64	70-74	75-79
C61	Prostate	Yes	65-69	70-74	70-74	80-84
C64	Kidney	No	NA	55-59	65-69	75-79
C67	Bladder	No	NA	70-74	75-79	80-84
C64, C67	Kidney, except renal pelvis and bladder	Yes	55-59	70-74	70-74	80-84

C71	Brain, other CNS and intracranial tumours	No	NA	65-69	65-69	70-74
C80	Cancer of unknown primary	Yes	60-64	65-69	NA	75-79
C85	Non-Hodgkin lymphoma	No	NA	70-74	70-74	80-84
C90	Myeloma	No	NA	65-69	70-74	75-79
C92	Leukaemia	Yes	NA	65-69	75-79	75-79
C81, C83, C85, C90, C92	Primary lymphoid, haematopoietic tissueC81	No	NA	65-69	70-74	75-79

As presented in Table 2.6, some of the cancers did not show to have significant SMR when studying for all ages (30-74), but they were found to be significant at specific age groups. For example, pancreas cancer was non-significant for all ages (30-74) but was found to be significant at age group 60-64.

From Table 2.6, the vast majority of Scottish male firefighters' cancer mortality peak age group was younger than both Scottish male general population peak incidence and mortality age groups. This finding is supported by Wolffe et al (2023)[xiii], who found that serving UK firefighters have higher cancer incidence rates compared to the general population of the same age (323% higher in the age group 35-39, potentially leading to Scottish male firefighters having higher death rates than the general population from around the age of 50 (presented in Figure 2.2). Similarly, in one published study on firefighters, it is shown that there was an increased incidence in five Nordic countries of prostate cancer and skin melanoma in the age group 30-49 [xxxiv].

Most notable results were found for bowel, kidney, leukemia, mesothelioma and pancreas where the general Scottish male population peak incidence age group was at least 10 years older than the Scottish male firefighters peak mortality age group. This would suggest that Scottish male firefighters are diagnosed with (and in fact, are dying from) cancer at a younger age than the Scottish male population.

4.4 Scottish Male Firefighters Cancer and Other Diseases Underlying Factors

There is very little in the literature on firefighters underlying factors contributing to their deaths. Analysis was available and carried out for the Scottish male firefighters. Data is presented in Figure 2.3.

271 Scottish male firefighters died from some form of cancer. 24 of these firefighters (9%) had an underlying cause of death of 'pneumonia'. The next most common underlying cause of death for Scottish male firefighters who died from a main cause of cancer was 'all types of diabetes' and 'ischaemic heart disease', both with 8%. Other common underlying causes of main cause of cancer were 'sepsis', 'other chronic pulmonary diseases' and 'hypertension'.

304 Scottish male firefighters died from some form of other disease. 41 of these firefighters (13%) had an underlying cause of death of 'pneumonia' The next most common underlying causes were 'all types of diabetes', 'hypertension', 'ischaemic heart disease' and 'heart failure' all accounting for 10% of the firefighters who died from some form of other disease. Other common underlying causes of main cause of other diseases were 'sepsis' and 'other chronic pulmonary diseases'.

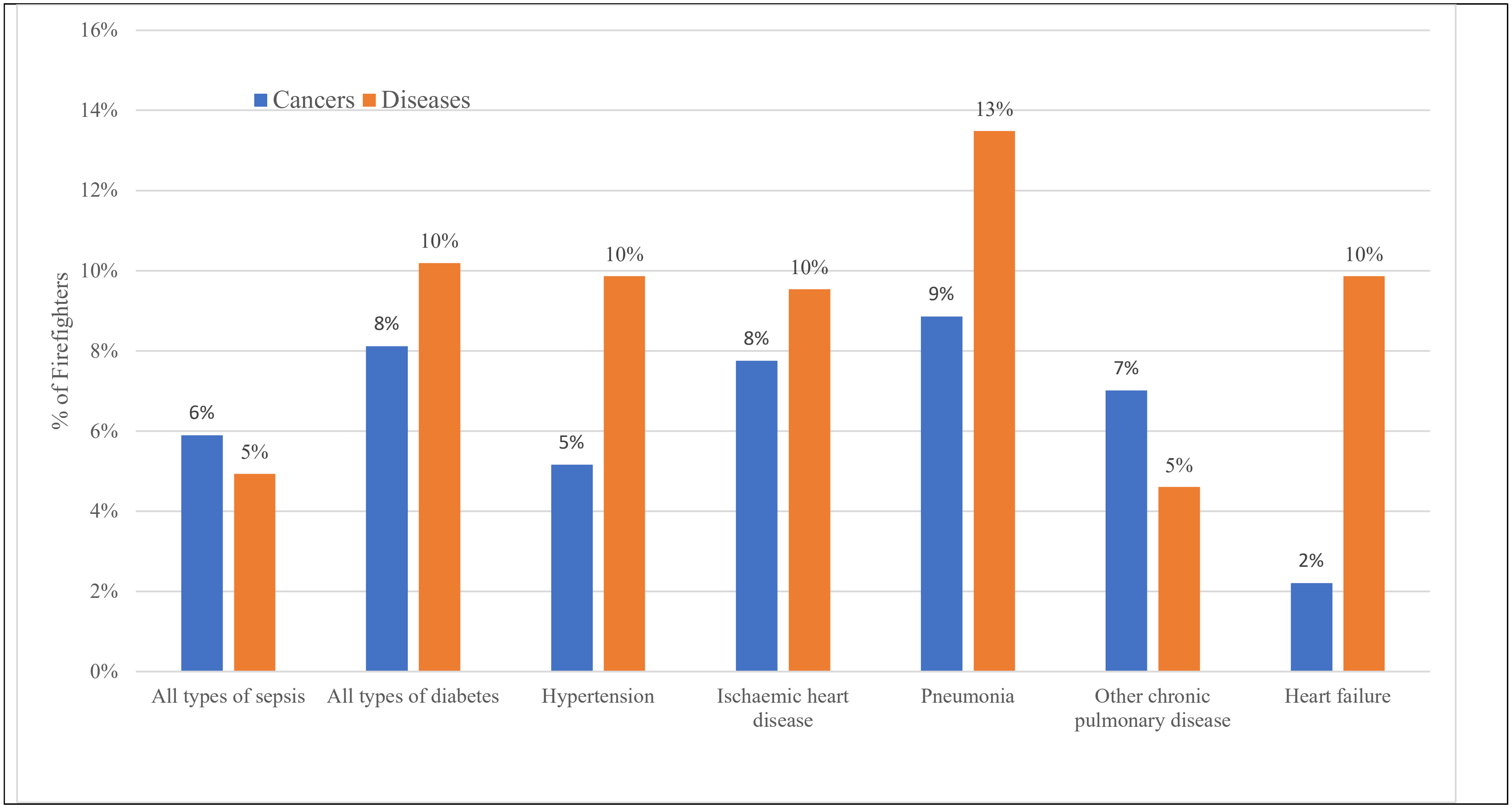

Figure 2.3. The most common Scottish male firefighters' underlying factors leading to their deaths.

(Example: 13% of Scottish male firefighters whose main cause of death was a disease, also had an underlying cause of death of pneumonia. 9% of Scottish male firefighters whose main cause of death was a cancer, also had an underlying cause of death of pneumonia).

5 DISCUSSION

Scottish male firefighters were found to have significant excess mortality for a range of cancers and other diseases when compared to the general male population. This suggests that the firefighting occupation lowers life expectancy. The excess cancer mortality observed in Scottish male firefighters for several site-specific cancers suggests a significant contribution from several exposure pathways and/or fire toxins.

Tables 3.1 and 3.2 present a summary of eight different publications, plus the Scottish male firefighter study, all of which studied the SMR of various cancers and other diseases amongst firefighters. They include data from countries such as USA, Canada, Australia, Germany, France, Denmark, and Spain.

It was found that Scottish male firefighters had an increased risk of developing malignant neoplasms of the digestive system (C15-C22, C24-26). Reassuringly this broad health outcome was one of the most commonly studied worldwide (Figure 1.3). Similarly, SMR for the malignant neoplasms of the prostate (C61) was found to be significant and most commonly studied worldwide. [xxxv]

In the Scottish male firefighter study[xxxv], it was identified that the SMR for all malignant neoplasms (Table 2.4) was significantly higher (SMR 1.61, CI 1.42-1.81). Table 3.1 shows that the USA study (published in 2019 [xlii], studying firefighters' deaths between 1959-2009) yielded similarly significant results (SMR 1.12, CI 1.08-1.16) while other countries did not report similar figures. More recent studies [xliv, xlix] in the Australia and USA reported significant decrease in firefighters' cancer mortality rates (SMR 0.81, CI 0.74-0.89 and SMR 0.16, CI 0.02- 0.57). This may be related to the fact that both countries have presumptive legislation and offering early screening for cancers and other diseases. The USA introduced presumptive legislation in California in 1982[xxxvi]. This was followed by Canada and then Australia, which enacted presumptive legislation in 2011[xxxvii].

The Scottish male firefighters study reported a significant increase in SMR for oesophageal cancer (SMR 2.42, CI 1.69-3.29). Table 3.1 shows that the USA 2019 publication also reported as significant increase (SMR 1.31, CI 1.10-1.55) albeit a smaller increase. The Canadian [xliii], French [xlvi], Danish [xlviii], and Spanish [xlvii] publications reported no significant SMR increase (SMR 0.4, CI 0.05-1.43), (SMR 0.93, CI 0.67-1.27) and (SMR 1.11, CI 0.64-1.92) respectively. The USA study [xlix], recently published, reported a significant decrease (SMR 0.43, CI 0.33-0.56).

Also, the Scottish male firefighters study found that prostate cancer was significantly increased whereas the USA, Canada and Spain reporting no significant increase (SMR 1.08, CI 0.97-1.20; SMR 1.32, CI 0.76-2.15; SMR 1.26, CI 0.67-2.36) respectively. France reported a significant decrease (SMR 0.54, CI 0.31-0.86). However, the USA 2020 publication did not report on prostate cancer but did show an SMR of 0.27 (CI 0.10-0.58) for cancer of male genital organs.

In addition, the Scottish male firefighters study found bladder cancer to be significantly increased (SMR 2.09, CI 0.89-3.80) in contrast to the USA, Canada, France, and Spain who reported no significance (SMR 0.98, CI 0.80-1.18; SMR 1.28, CI 0.51-2.63; SMR 0.73, CI 0.41-1.21; and SMR 0.62, CI 0.32-1.17). Australia, Germany, Denmark nor the USA (2020) presented data for this cancer.

SMR for myeloid leukaemia amongst the Scottish male firefighters was found to be significant (SMR 3.17, CI 1.44-5.58). Canada found no significance for myeloid leukaemia (SMR 1.20, CI 0.33-3.09) and for lymphatic leukaemia (SMR 1.90, CI 0.52-4.88). Spain calculated no significance for leukaemia (SMR 0.90, CI 0.40-2.01). Australia, Germany, Denmark, and France did not study any kind of leukaemia. However, the USA publication (2020) reported cancers of the circulatory system, lymphatic and soft tissue to be at a decreased risk (SMR 0.43, CI 0.28-0.64).

Mesothelioma was found to be not significant (SMR 2.14 CI 0.68-4.43) whereas the USA studies (2019) reported SMR to be 1.86 with CI 1.10-2.94. Similarly, our study found brain cancer SMR to be not significant, while the Canadian publication reported a significant increase (SMR 2.01, CI 1.10-3.37).

Cardiac death is widely thought to be the most common cause of death for firefighters[xxxviii, xxxix,xl] with some studies claiming it accounts for over half of all firefighter deaths [xli]. For the other diseases, acute ischaemic heart diseases (other than myocardial infarction) was found to be the most significant (SMR 5.27, CI 1.90-10.33). The USA, Canada, Denmark, and Sweden publications, all reported no significant increases for the ischemic heart diseases (SMR 0.98, CI 0.95-1.01; SMR 1.04, CI 0.92-1.17; SMR 1.08, 0.89-1.32; and SMR 1.15, 0.74-1.17). Australia reported a significant decrease (SMR 0.68, CI 0.59-0.79) while Germany, France, USA (2020), and Spain did not report any data. The Canadian study found an increased risk of Aortic Aneurysm in contrast to the Scottish study which found no significance. Similarly, the USA (2019) study found an increased risk of cirrhosis and other chronic liver disease whilst the Scottish paper did not.

Table 3.1. Comparison of the worldwide publications studying SMR of cancers amongst firefighters.

* Cancer of the digestive system. ** Cancer of the respiratory system. ***Cancer of the circulatory system, lymphatic and soft tissue. ****Larynx, Trachea and Lung cancers. *****Bone and skin cancers. ^*Cancers of urinary system. ^ World Trade Centre study.

Country	USA	Canada	Australia	Germany	France	Spain	Denmark	USA	Sweden	Scotland
Published	2019[xlii]	1994[xliii]	2015[xliv]	2006[xlv]	2015[xlvi]	2020[xlvii]	2018[xlviii]	2020 (^WTC)[xlix]	1990[l]	2023[xxxv]
Study dates (from -to)	1950-2009	1950-1989	1990-2003	1950-2000	1979-2008	2001-2011	1970-2014	2001-2017	1979-1985	2000-2020
	SMR (95% CI)	SMR (95% CI)	SMR (95% CI)	SMR (95% CI)	SMR (95% CI)	SMR (95% CI)	SMR (95% CI)	SMR (95% CI)	SMR (95% CI)	SMR (95% CI)
CANCERS										
All causes		0.95 (0.88-1.02)		0.79 (0.74-0.84)	0.81 (0.77 - 0.85)	0.99 (0.91-1.07)				
All cancers	1.12 (1.08-1.16)	1.05 (0.91-1.20)	0.81 (0.74-0.89)		0.95 (0.88-1.02)	1.00 (0.89-1.12)	1.12 (1.00-1.26)	0.16 (0.02-0.57)	0.96 (0.50-1.67)	1.61 (1.42-1.81)
Lip, Oral cavity and Pharynx cancers		1.39 (0.38 - 3.57)			1.15 (0.89 - 1.46)	1.34 (0.81-2.21)	1.27 (0.85-1.89)			
Oesophageal cancer	1.31 (1.10-1.55)	0.4 (0.05 - 1.43)			0.93 (0.67 - 1.27)	1.11 (0.64-1.92)		0.43 (0.33-0.56)*		1.60 (1.30-1.94)* Oesophageal 2.42 (1.69-3.29)
Stomach cancer	1.06 (0.88-1.27)	0.51 (0.20 - 1.05)			1.15 (0.77 - 1.65)	1.32 (0.88-1.98)	1.96 (1.22-3.16)			
Colon cancer	1.27 (1.14-1.40)	0.6 (0.3 - 1.08)			0.73 (0.44 - 1.04)	0.62 (0.37-1.02)	1.11 (0.75-1.64)			
Rectal cancer	1.32 (1.07-1.61)	1.71 (0.91-2.93)			1.36 (0.86 - 2.04)	1.08 (0.57-2.04)	1.04 (0.58-1.83)			
Biliary passages and liver cancer		0.84 (0.1 - 3.05)			1.10 (0.80 - 1.46)	1.01 (0.59-1.74)				
Pancreatic cancer		1.40 (0.77-2.35)			1.27 (0.92 - 1.72)	0.43 (0.21-0.88)				
Larynx cancer		0.37 (0.01 - 2.06)			1.10 (0.73 - 1.59)	1.77 (1.01-3.09)	1.13 (0.91-1.42)****	0.21 (0.15-0.30)**		1.21 (0.92-1.53)**
Lung cancer	1.08 (1.02-1.15)	0.95 (0.71-1.24)			0.86 (0.74 - 0.99)	0.94 (0.77-1.15)			1.63 (0.75-3.10)	
Skin cancer	1.05 (0.83-1.31)	0.73 (0.09 - 2.63)			0.65 (0.21 - 1.51)	0.63 (0.19-2.10)	0.75 (0.31-1.80)*****			1.17 (0.37-2.42)
Bone cancer						1.11 (0.16-7.92)				
Prostate cancer	1.08 (0.97-1.20)	1.32 (0.76 - 2.15)			0.54 (0.31 - 0.86)	1.26 (0.67-2.36)	0.66 (0.40-1.07)			3.80 (2.56-5.29)

Cancer of male genital organs	0.39 (0.11-1.00)	2.52 (0.52-7.37)						0.27 (0.10-0.58)		
Bladder cancer	0.98 (0.80-1.18)	1.28 (0.51-2.63)			0.73 (0.41 -1.21)	0.62 (0.32-1.17)				1.94 (1.16-2.91)^*
Kidney cancer	1.22 (1.00-1.47)	0.43 (0.05-1.56)			0.63 (0.30 -1.16)	1.18 (0.57-2.44)				
Brain cancer	0.99 (0.79-1.23)	2.01 (1.10-3.37)								1.08 (0.54-1.81)
Breast cancer	1.24 (0.59-2.27)				0.76 (0.02 -4.23)	3.04 (0.42-21.78)		0.00 (0.00-4.24)		
Non-Hodgkins Lymphoma	1.21 (1.03-1.42)							0.43 (0.28-0.64) ***		
Mesothelioma	1.86 (1.10-2.94)					0.62 (0.09-4.42)				
Lymphatic/haematopoietic cancers		0.98 (0.58-1.56)			0.89 (0.64 -1.20)	1.29 (0.69-2.34)	0.89 (0.56-1.44)			
Lymphosarcoma		2.04 (0.42-5.96)								
Hodgkins disease		0.47 (0.01-2.59)				1.41 (0.34-5.85)				
Multiple Myeloma	0.93 (0.70-1.21)	0.39 (0.01 -2.15)								
Lymphatic leukemia		1.90 (0.52-4.88)				0.90 (0.40-2.01)				
Leukemia	1.11 (0.94-1.31)	1.20 (0.33-3.09)								3.17 (1.44-5.58)
Other cancers		2.38 (1.45 -3.67)				1.02 (0.72-1.53)				
Renal pelvis cancer						7.42 (1.02-53.82)				
Thyroid cancer						2.34 (0.53-10.29)				

Significantly decreased SMR.

Significantly increased SMR.

Table 3.2. Comparison of the worldwide publications studying SMR of other diseases amongst firefighters.

^ World trade centre. *Stroke. **Renal failure. ***Alcoholic liver disease. ****Other diseases of liver.

Country	USA	Canada	Australia	Germany	France	Spain	Denmark	USA	Sweden	Scotland
Published	**2019**[xlii]	**1994**[xliii]	**2015**[xliv]	**2006**[xlv]	**2015**[xlvi]	**2020**[xlvii]	**2018**[xlviii]	**2020 (^WTC)**[xlix]	**1990**[l]	**2023**[xxxv]
Study dates (from -to)	**1950-2009**	**1950-1989**	**1990-2003**	**1950-2000**	**1979-2008**	**2001-2011**	**1970-2014**	**2001-2017**	**1979-1985**	**2000-2020**
	SMR (95% CI)	SMR (95% CI)	SMR (95% CI)	SMR (95% CI)	SMR (95% CI)	SMR (95% CI)	SMR (95% CI)	SMR (95% CI)	SMR (95% CI)	SMR (95% CI)
DISEASES										
Endocrine, nutritional and metabolic diseases		0.34 (0.11-0.80)			0.67 (0.44 - 0.98)	1.44 (0.81-2.54)		0.09 (0.03-0.20)		1.17 (0.56-2.00)
Diabetes mellitus		0.35 (0.09-0.88)	0.66 (0.42-0.98)				1.00 (0.62-1.64)			
Circulatory system diseases		0.99 (0.89-1.10)	0.62 (0.55-0.70)		0.76 (0.68 - 0.85)					1.06 (0.91-1.22). *2.69 (1.46-4.28)
Chronic rheumatic heart disease		0.15 (0.004 - 0.85)								
Ischemic heart disease	0.98 (0.95-1.01)	1.04 (0.92 - 1.17)	0.68 (0.59-0.79)				1.08 (0.89-1.32)		1.15 (0.74-1.17)	5.27 (1.90-10.33)
Acute myocardial infarction		1.07 (0.93-1.23)								
Cerebrovascular diseases	0.90 (0.83-0.97)	0.76 (0.55-1.03)	0.55 (0.39-0.77)				0.93 (0.66-1.31)			
Atherosclerosis		1.41 (0.91-2.10)								
Aortic aneurysm		2.26 (1.36 - 3.54)								1.83 (0.78 - 3.31)
Diseases of veins		1.68 (0.71-3.31)								
COPD	0.78 (0.71-0.85)		0.54 (0.35-0.80)							
Respiratory diseases		0.98 (0.71-1.31)	0.54 (0.39-0.72)		0.54 (0.39 - 0.73)	1.25 (0.86-1.81)		0.22 (0.14-0.32)		1.15 (0.82-1.55)
Asthma, bronchitis, emphysema		1.30 (0.87-1.89)					1.15 (0.81-1.62)			
Diseases of the digestive system		1.22 (0.89-1.64)	0.50 (0.28 to 0.83		0.79 (0.65 - 0.95)	0.95 (0.68-1.34)		0.15 (0.09-0.24)		0.95 (0.72-1.21)

Cirrhosis and other chronic liver disease	1.16 (1.03-1.29)	1.33 (0.87-1.95)	0.56 (0.39-0.76)							*** 0.71 (0.48-0.98). **** 1.57 (0.81-2.59)
Gallbladder disease		2.96 (0.96-6.90)				0.27 (0.01-1.86)				
Genitourinary system diseases		1.06 (0.53 - 1.90)			0.94 (0.50 - 1.61)			0.04 (0.00-0.20)		**3.28 (1.18-6.44)
Infectious and parasitic diseases		0.14 (0-0.78)			0.30 (0.16 - 0.50)	0.65 (0.20-2.13)				
Diseases of skin and subcutaneous tissue			1.02 (0.44-2.02)		1.80 (0.37 - 5.26)			0.44 (0.01-2.44)		
Blood diseases, immunological disorders					0.63 (0.17 - 1.62)			0.17 (0.10-0.27)		
Diseases of the nervous system						1.02 (0.54-1.96)	0.94 (0.57-1.56)			1.36 (0.82-2.04)
Cardiovascular diseases						0.88 (0.73-1.06)				

Significantly decreased SMR.

Significantly increased SMR.

6 CONCLUSIONS

Prevention requires identifying underlying causes of excess cancers and other diseases and implementing measures which protect firefighters from these causes. Work is already underway to better protect firefighters from exposure to toxic fire effluents e.g., through standardising decontamination procedures. However, there is currently no formal preventative cancers or other diseases monitoring programme in place for UK firefighters. Some papers argue that screening of firefighters is important to detect early symptoms at a younger age [xiii].

Cancer has a long latent period and can appear many years after exposure. Early detection is acknowledged as one of the best indicators of cancer survival. Given the younger ages at which firefighters appear to be developing and dying of cancer, a dedicated health screening programme is urgently required. This need was recently acknowledged during a debate in the Northern Irish Assembly[li] and more recently in the Scottish Parliament[lii].

7 FUTURE WORK

There is a lack of consistency in the cancers and other diseases SMR and SIR recordings. For example, the German publication simply gives one SMR figure for all causes, the Australian publication does not study prostate cancer whilst the USA (2020) publication reports the SMR of broader groups such as cancer of the digestive system. In addition, the three publications from Japan focus only on mental health outcomes. Furthermore, different measures other than SMR are used culminating in a lack of synchronicity and making it difficult to conduct world comparisons. There is a need for a worldwide consensus on predefined ICD 10 categories with a specific set of measures when comparing firefighters to the general population.

The prime recognised limitation in this study is the fact that extracts of entry in a Register to Deaths list just one occupation - the last one held prior to death. Given that, for many years, firefighters can retire between the ages of 55 and 60 (or earlier if they were discharged on the grounds of ill-health), they can then obtain further employment. This may result in an underestimation of firefighter deaths and SMR (particularly for rare cancers).

The association of occupational exposure as a firefighter and deaths due to cancer/disease would also benefit from collecting information on firefighters' length of employment, and any cumulative effect of environmental/occupational exposures. Together with information on historical or/and post-retirement occupation, it would allow more accurate characterisation of risk.

While the comprehensiveness of the studied firefighter population, and its inclusion of retired members, are strengths, a weakness of this work is that data was accessed from Scotland only, not the whole UK. Scotland has its own harmonised and independent recording system of statistics and pensions when compared to the rest of the UK where compilation such data is more difficult and time-consuming.

8 REFERENCES

[i] International Agency for Research on Cancer, Monographs evaluate the carcinogenicity of occupational exposure as a firefighter. [online] Available at: https://www.iarc.who.int/news-events/iarc-monographs-evaluate-the-carcinogenicity-of-occupational-exposure-as-a-firefighter/#:~:text=After%20thoroughly%20reviewing%20the%20available [Accessed 8 May 2023].

[ii] Baris, D., Garrity, T.J., Telles, J.L., Heineman, E.F., Olshan, A. and Zahm, S.H. (2001). Cohort mortality study of Philadelphia firefighters. American Journal of Industrial Medicine, 39(5), pp.463–476. doi:https://doi.org/10.1002/ajim.1040.

[iii] Guidotti, T.L. (1993). Mortality of urban firefighters in alberta, 1927–1987. American Journal of Industrial Medicine, 23(6), pp.921–940. doi:https://doi.org/10.1002/ajim.4700230608.

[iv] Petersen, K.U., Pedersen, J.E., Bonde, J.P., Ebbehøj, N.E. and Hansen, J. (2018). Mortality in a cohort of Danish firefighters; 1970–2014. International Archives of Occupational and Environmental Health, 91(6), pp.759–766. doi:https://doi.org/10.1007/s00420-018-1323-6.

[v] Wagner, N.L., Berger, J., Flesch-Janys, D., Koch, P., Köchel, A., Peschke, M. and Ossenbach, T. (2006). Mortality and life expectancy of professional fire fighters in Hamburg, Germany: a cohort study 1950 – 2000. Environmental Health, 5(1). doi:https://doi.org/10.1186/1476-069x-5-27.

[vi] Deschamps, S., Momas, I. and Festy, B. (1995). Mortality amongst Paris fire-fighters. European Journal of Epidemiology, 11(6), pp.643–646. doi:https://doi.org/10.1007/bf01720297.

[vii] Aronson, K.J., Tomlinson, G. and Smith, L.F. (1994). Mortality among fire fighters in metropolitan Toronto. American Journal of Industrial Medicine, 26(1), pp.89–101. doi:https://doi.org/10.1002/ajim.4700260108.

[viii] Valent, F., McGwin, G., Bovenzi, M. and Barbone, F. (2002). Fatal Work-Related Inhalation of Harmful Substances in the United States. Chest, 121(3), pp.969–975. doi:https://doi.org/10.1378/chest.121.3.969.

[ix] GOV.UK. (n.d.). Firefighters and cancer: position paper 47. [online] Available at: https://www.gov.uk/government/publications/firefighters-and-cancer-iiac-position-paper-47/firefighters-and-cancer-position-paper-47 [Accessed 8 May 2023].

[x] Wolffe, T.A.M., Clinton, A., Robinson, A., Turrell, L. and Stec, A.A. (2023). Contamination of UK firefighters personal protective equipment and workplaces. Scientific Reports, 13(1). doi:https://doi.org/10.1038/s41598-022-25741-x.

[xi] Wolffe, T.A.M., Turrell, L., Robinson, A., Dickens, K., Clinton, A., Maritan-Thomson, D. and Stec, A.A. (2023). Culture and awareness of occupational health risks amongst UK firefighters. Scientific Reports, 13(1). doi:https://doi.org/10.1038/s41598-022-24845-8.

[xii] Wolffe, T.A.M., Robinson, A., Clinton, A., Turrell, L. and Stec, A.A. (2023). Mental health of UK firefighters. Scientific Reports, [online] 13(1), p.62. doi:https://doi.org/10.1038/s41598-022-24834-x.

[xiii] Wolffe, T.A.M., Robinson, A., Dickens, K., Turrell, L., Clinton, A., Maritan-Thomson, D., Joshi, M. and Stec, A.A. (2023). Cancer incidence amongst UK firefighters. Scientific Reports, 12(1). doi:https://doi.org/10.1038/s41598-022-24410-3.

[xiv] ResearchGate. (2019). ResearchGate | Share and discover research. [online] Available at: http://www.researchgate.net. [Accessed 21 Jan. 2021].

[xv] Jstor (1999). JSTOR. Jstor.org. Available at: https://www.jstor.org. [Accessed 21 Jan. 2021].

[xvi] Gaertner, R.R.W., Trpeski, L. and Johnson, K.C. (2004). A case?control study of occupational risk factors for bladder cancer in Canada. Cancer Causes and Control, 15(10), pp.1007–1019. doi:https://doi.org/10.1007/s10552-004-1448-7.

Hansen, E.S. (1990). A cohort study on the mortality of firefighters. Occupational and Environmental Medicine, 47(12), pp.805–809. doi:https://doi.org/10.1136/oem.47.12.805.

Phoon, W.-O., ONG, C.N., Foo, S.C. and Plueksawan, W. (1983). A cross sectional study on the health of fire fighters in Singapore. Sangyo Igaku, 25(6), pp.463–470. doi:https://doi.org/10.1539/joh1959.25.463.

Jeong, H., Park, S., Dager, S.R., Lim, S.M., Lee, S.L., Hong, H., Ma, J., Ha, E., Hong, Y.S., Kang, I., Lee, E.H., Yoon, S., Kim, J.E., Kim, J. and Lyoo, I.K. (2018). Altered functional connectivity in the fear network of firefighters with repeated traumatic stress. The British Journal of Psychiatry, 214(06), pp.347–353. doi:https://doi.org/10.1192/bjp.2018.260.

Beaumont, J.J., Chu, G.S.T., Jones, J.R., Schenker, M.B., Singleton, J.A., Piantanida, L.G. and Reiterman, M. (1991). An epidemiologic study of cancer and other causes of mortality in San Francisco firefighters. American Journal of Industrial Medicine, 19(3), pp.357–372. doi:https://doi.org/10.1002/ajim.4700190309.

Carleton, R.N., Afifi, T.O., Taillieu, T., Turner, S., El-Gabalawy, R., Sareen, J. and Asmundson, G.J.G. (2018). Anxiety-related psychopathology and chronic pain comorbidity among public safety personnel. Journal of Anxiety Disorders, 55, pp.48–55. doi:https://doi.org/10.1016/j.janxdis.2018.03.006.

Mochtar, I. and Hooper, R.W. (2012). Assessment of the 10-year risk of coronary heart disease events for Qatar Petroleum's firefighters and non-firefighter staff in Qatar. Eastern Mediterranean Health Journal, 18(2), pp.127–131. doi:https://doi.org/10.26719/2012.18.2.127.

Kim, M.-G. and Ahn, Y.-S. (2021). Associations between lower back pain and job types in South Korean male firefighters. International journal of occupational safety and ergonomics, 27(2), pp.570–577. doi:https://doi.org/10.1080/10803548.2019.1608061.

Witteveen, A.B., Huizink, A.C., Slottje, P., Bramsen, I., Smid, T. and van der Ploeg, H.M. (2010). Associations of cortisol with posttraumatic stress symptoms and negative life events: A study of police officers and firefighters. Psychoneuroendocrinology, 35(7), pp.1113–1118. doi:https://doi.org/10.1016/j.psyneuen.2009.12.013.

McClure, L.A., Koru-Sengul, T., Hernandez, M.N., Mackinnon, J.A., Schaefer Solle, N., Caban-Martinez, A.J., Lee, D.J. and Kobetz, E. (2019). Availability and accuracy of occupation in cancer registry data among Florida firefighters. PLOS ONE, 14(4), p.e0215867. doi:https://doi.org/10.1371/journal.pone.0215867.

Azabdaftari, N., Amani, R. and Taha Jalali, M. (2009). Biochemical and nutritional indices as cardiovascular risk factors among Iranian firefighters. Annals of Clinical Biochemistry: International Journal of Laboratory Medicine, 46(5), pp.385–389. doi:https://doi.org/10.1258/acb.2009.009026.

Olshan, A.F., Teschke, K. and Baird, P.A. (1990). Birth defects among offspring of firemen. American Journal of Epidemiology, 131(2), pp.312–321. doi:https://doi.org/10.1093/oxfordjournals.aje.a115500.

Zheng, W., McLaughlin, J.K., Gao, Y.-T., Silverman, D.T., Gao, R.-N. and Blot, W.J. (1992). Bladder cancer and occupation in Shanghai, 1980–1984. American Journal of Industrial Medicine, 21(6), pp.877–885. doi:https://doi.org/10.1002/ajim.4700210611.

Demers, P.A., Checkoway, H., Vaughan, T.L., Weiss, N.S., Heyer, N.J. and Rosenstock, L. (1994). Cancer incidence among firefighters in Seattle and Tacoma, Washington (United States). Cancer Causes & Control, 5(2), pp.129–135. doi:https://doi.org/10.1007/bf01830258.

Kang, D., Davis, L., Hunt, P. and Kriebel, D. (2008). Cancer incidence among male Massachusetts firefighters, 1987-2003. American Journal of Industrial Medicine, 51(5), pp.329–35. doi:https://doi.org/10.1002/ajim.20549.

Sama, S.R., Martin, T.R., Davis, L.K. and Kriebel, D. (1990). Cancer incidence among massachusetts firefighters, 1982-1986. American Journal of Industrial Medicine, 18(1), pp.47–54. doi:https://doi.org/10.1002/ajim.4700180106.

Bigert, C., Martinsen, J.I., Gustavsson, P. and Sparén, P. (2019). Cancer incidence among Swedish firefighters: an extended follow-up of the NOCCA study. International Archives of Occupational and Environmental Health, 93(2), pp.197–204. doi:https://doi.org/10.1007/s00420-019-01472-x.

Ide, C.W. (2014). Cancer incidence and mortality in serving whole-time Scottish firefighters 1984-2005. Occupational Medicine, 64(6), pp.421–427. doi:https://doi.org/10.1093/occmed/kqu080.

Ma, F., Fleming, L.E., Lee, D.J., Trapido, E. and Gerace, T.A. (2006). Cancer Incidence in Florida Professional Firefighters, 1981 to 1999. Journal of Occupational and Environmental Medicine, [online] 48(9), p.883. doi:https://doi.org/10.1097/01.jom.0000235862.12518.04.

Ahn, Y.-S., Kyoung Yong Jeong and Kim, K. (2012). Cancer morbidity of professional emergency responders in Korea. American Journal of Industrial Medicine, 55(9), pp.768–778. doi:https://doi.org/10.1002/ajim.22068.

Donovan, R., Nelson, T., Peel, J., Lipsey, T., Voyles, W. and Israel, R.G. (2009). Cardiorespiratory fitness and the metabolic syndrome in firefighters. Occupational medicine. [online] Available at: https://pdfs.semanticscholar.org/14de/abf89eb1c40014334b4668f0165cd58eb5e4.pdf?_ga=2.10161397.176913165.1597855544-793427412.1594986294 [Accessed 24 Apr. 2023].

Gendron, P., Lajoie, C., Laurencelle, L. and Trudeau, F. (2018). Cardiovascular disease risk in female firefighters. Occupational Medicine, 68(6), pp.412–414. doi:https://doi.org/10.1093/occmed/kqy074.

Byczek, L., Walton, S.M., Conrad, K.M., Reichelt, P.A. and Samo, D.G. (2004). Cardiovascular Risks in Firefighters. AAOHN Journal, 52(2), pp.66–76. doi:https://doi.org/10.1177/216507990405200205.

Schermer, T.R., Malbon, W., Adams, R., Morgan, M., Smith, M. and Crockett, A.J. (2013). Change in lung function over time in male metropolitan firefighters and general population controls: a 3-year follow-up study. Journal of Occupational Health, [online] 55(4), pp.267–275. doi:https://doi.org/10.1539/joh.12-0189-oa.

Baris, D., Garrity, T.J., Telles, J.L., Heineman, E.F., Olshan, A. and Zahm, S.H. (2001). Cohort mortality study of Philadelphia firefighters. American Journal of Industrial Medicine, 39(5), pp.463–476. doi:https://doi.org/10.1002/ajim.1040.

Heyer, N.J., Weiss, N.S., Demers, P.A. and Rosenstock, L. (1990). Cohort mortality study of seattle fire fighters: 1945-1983. American Journal of Industrial Medicine, 17(4), pp.493–504. doi:https://doi.org/10.1002/ajim.4700170407.

Pillutla, P., Li, D., Ahmadi, N. and Budoff, M.J. (2012). Comparison of Coronary Calcium in Firefighters With Abnormal Stress Test Findings and in Asymptomatic Nonfirefighters With Abnormal Stress Test Findings. The American Journal of Cardiology, 109(4), pp.511–514. doi:https://doi.org/10.1016/j.amjcard.2011.09.044.

Aronson, K.J., Dodds, L., Marrett, L.D. and Wall, C. (1996). Congenital anomalies among the offspring of fire fighters. American Journal of Industrial Medicine, 30(1), pp.83–86. doi:https://doi.org/10.1002/(sici)1097-0274(199607)30:1%3C83::aid-ajim14%3E3.0.co;2-4.

Wolkow, A., Netto, K., Langridge, P., Green, J., Nichols, D.E., Sergeant, M. and Aisbett, B. (2014). Coronary Heart Disease Risk in Volunteer Firefighters in Victoria, Australia. Archives of Environmental & Occupational Health, 69(2), pp.112–120. doi:https://doi.org/10.1080/19338244.2012.750588.

Martin, C.E., Tran, J.K. and Buser, S.J. (2017). Correlates of suicidality in firefighter/EMS personnel. Journal of Affective Disorders, 208, pp.177–183. doi:https://doi.org/10.1016/j.jad.2016.08.078.

Min, J., Kim, Y., Kim, H.S., Han, J., Kim, I., Song, J., Koh, S.-B. and Jang, T.-W. (2020). Descriptive analysis of prevalence and medical expenses of cancer, cardio-cerebrovascular disease, psychiatric disease, and musculoskeletal disease in Korean firefighters. Annals of Occupational and Environmental Medicine, 32(1). doi:https://doi.org/10.35371/aoem.2020.32.e7.

Wright, H.E., Larose, J., McLellan, T.M., Miller, S., Boulay, P. and Kenny, G.P. (2013). Do Older Firefighters Show Long-Term Adaptations to Work in the Heat? Journal of Occupational and Environmental Hygiene, 10(12), pp.705–715. doi:https://doi.org/10.1080/15459624.2013.821574.

Han, M., Park, S., Park, J.H., Hwang, S. and Kim, I. (2018). Do police officers and firefighters have a higher risk of disease than other public officers? A 13-year nationwide cohort study in South Korea. BMJ Open, 8(1), p.e019987. doi:https://doi.org/10.1136/bmjopen-2017-019987.

Hong, O., Chin, D.L., Phelps, S. and Joo, Y. (2016). Double Jeopardy. Workplace Health & Safety, 64(6), pp.235–242. doi:https://doi.org/10.1177/2165079916629975.

Zeig-Owens, R., Webber, M.P., Hall, C.B., Schwartz, T., Jaber, N., Weakley, J., Rohan, T.E., Cohen, H.W., Derman, O., Aldrich, T.K., Kelly, K. and Prezant, D.J. (2011). Early assessment of cancer outcomes in New York City firefighters after the 9/11 attacks: an observational cohort study. The Lancet, 378(9794), pp.898–905. doi:https://doi.org/10.1016/s0140-6736(11)60989-6.

Al-Malki, A.L., Rezq, A.M. and Al-Saedy, M.H. (2008). Effect of fire smoke on some biochemical parameters in firefighters of Saudi Arabia. Journal of Occupational Medicine and Toxicology, 3(1), pp.33–33. doi:https://doi.org/10.1186/1745-6673-3-33.

Muegge, C.M., Zollinger, T.W., Song, Y., Wessel, J., Monahan, P.O. and Moffatt, S. (2018). Excess mortality among Indiana firefighters, 1985-2013. American Journal of Industrial Medicine, 61(12), pp.961–967. doi:https://doi.org/10.1002/ajim.22918.

Haddock, C.K., Poston, W.S.C., Jitnarin, N. and Jahnke, S.A. (2013). Excessive Daytime Sleepiness in Firefighters in the Central United States. Journal of Occupational and Environmental Medicine, 55(4), pp.416–423. doi:https://doi.org/10.1097/jom.0b013e31827cbb0b.

Fatal Injuries Among Volunteer Workers — United States, 1993–2002. (2005). Morbidity and Mortality Weekly Report, [online] 54(30), pp.744–747. Available at: https://www.jstor.org/stable/24830582?read-now=1&seq=2#metadata_info_tab_contents [Accessed 24 Apr. 2023].

Valent, F., McGwin, G., Bovenzi, M. and Barbone, F. (2002). Fatal Work-Related Inhalation of Harmful Substances in the United States. Chest, 121(3), pp.969–975. doi:https://doi.org/10.1378/chest.121.3.969.

Dibbs, E., Thomas HE JrU, Weiss, S.T. and Sparrow, D. (1982). Fire fighting and coronary heart disease. Circulation, 65(5), pp.943–946. doi:https://doi.org/10.1161/01.cir.65.5.943.

Moore, K.J., Caban-Martinez, A.J., Kirsner, R.S., Schaefer-Solle, N., Lee, D.J., Koru-Sengul, T. and Kobetz, E.N. (2018). Firefighter Skin Cancer and Sun Protection Practices. JAMA Dermatology, 154(2), p.219. doi:https://doi.org/10.1001/jamadermatol.2017.4254.

Brady, J.M., Brown, H.C., Nguyen, J.T., Smith, H., Mannor, D.A., Kelly, A.M. and Hannafin, J.A. (2017). Firefighters Have a Higher Incidence of Trochlear Chondral Lesions than the Normal Population. HSS Journal ®, [online] 14(2), pp.153–158. doi:https://doi.org/10.1007/s11420-017-9599-8.

Amadeo, B., Marchand, J.-L., Moisan, F., Stéphane Donnadieu, Gaëlle Coureau, Mathoulin-Pélissier, S., C. Lembeye, Imbernon, E. and Brochard, P. (2015). French firefighter mortality: Analysis over a 30-year period. American Journal of Industrial Medicine, 58(4), pp.437–443. doi:https://doi.org/10.1002/ajim.22434.

Centres for Disease Control and Prevention, Health Hazard Evaluation of Police Officers and Firefighters After Hurricane Katrina - New Orleans, Louisiana, October 17--28 and November 30--December 5, 2005. [online] Available at: https://www.cdc.gov/mmwr/preview/mmwrhtml/mm5516a4.htm#tab1 [Accessed 24 Apr. 2023].

Kang, T.S., Hong, O.S., Kim, K.S. and Yoon, C.S. (2014). Hearing among male firefighters: A comparison with hearing data from screened and unscreened male population. Journal of Exposure Science & Environmental Epidemiology, 25(1), pp.106–112. doi:https://doi.org/10.1038/jes.2014.72.

Crosse, B.A. (1989). Subcutaneous and mediastinal emphysema complication of measles. Journal of Infection, 19(2), pp.190-IN5. doi:https://doi.org/10.1016/s0163-4453(89)92164-6.

Ouyang, B., Baxter, C.S., Lam, H.-M., Yeramaneni, S., Levin, L., Haynes, E. and Ho, S. (2012). Hypomethylation of dual specificity phosphatase 22 promoter correlates with duration of service in firefighters and is inducible by low-dose benzo[a]pyrene. Journal of Occupational and Environmental Medicine, [online] 54(7), pp.774–780. doi:https://doi.org/10.1097/JOM.0b013e31825296bc.

Chernyak, Y.I. and Grassman, J.A. (2020). Impact of AhRR (565C > G) polymorphism on dioxin dependent CYP1A2 induction. Toxicology Letters, [online] 320, pp.58–63. doi:https://doi.org/10.1016/j.toxlet.2019.12.002.

Chernyak, Y.I., Merinova, A.P., Shelepchikov, A.A., Kolesnikov, S.I. and Grassman, J.A. (2016). Impact of dioxins on antipyrine metabolism in firefighters. Toxicology Letters, [online] 250-251, pp.35–41. doi:https://doi.org/10.1016/j.toxlet.2016.04.006.

Webber, M.P., Liu, Y., Cohen, H.W., Schwartz, T., Weiden, M.D., Kelly, K.E., Ortiz, V., Zeig-Owens, R., Jaber, N., Colbeth, H.L. and Prezant, D.J. (2018). Incidence and prevalence of antibody to hepatitis

C virus in FDNY first responders before and after work at the World Trade Center disaster site. American Journal of Industrial Medicine, 61(9), pp.733–740. doi:https://doi.org/10.1002/ajim.22871.

www.proquest.com. (n.d.). Incidence of cardiovascular disease in a - ProQuest. [online] Available at: https://search.proquest.com/docview/1992018714?rfr_id=info%3Axri%2Fsid%3Aprimo [Accessed 24 Apr. 2023].

Morioka, H.M. and Brown, M.L. (1970). Incidence of Obesity and Overweight among Honolulu Police and Firemen. Public Health Reports (1896-1970), 85(5), p.433. doi:https://doi.org/10.2307/4593869.

Song, J.Y., Kim, M.-G. and Ahn, Y.-S. (2018). Injury-related hospital admission of female firefighters in South Korea. International Journal of Occupational Safety and Ergonomics, 25(4), pp.575–582. doi:https://doi.org/10.1080/10803548.2017.1411666.

Choi, S.J., Song, P., Suh, S., Joo, E.Y. and Lee, S.I. (2020). Insomnia Symptoms and Mood Disturbances in Shift Workers with Different Chronotypes and Working Schedules. Journal of Clinical Neurology, 16(1), p.108. doi:https://doi.org/10.3988/jcn.2020.16.1.108.

Bates, M.N., Fawcett, J., Garrett, N., Arnold, R., Pearce, N. and Woodward, A. (2001). Is testicular cancer an occupational disease of fire fighters?*. American Journal of Industrial Medicine, 40(3), pp.263–270. doi:https://doi.org/10.1002/ajim.1097.

Sardinas, A., Miller, J.W. and Hansen, H. (1986). Ischemic heart disease mortality of firemen and policemen. American Journal of Public Health, 76(9), pp.1140–1141. doi:https://doi.org/10.2105/ajph.76.9.1140.

Saijo, Y., Ueno, T. and Hashimoto, Y. (2007). Job stress and depressive symptoms among Japanese fire fighters. American Journal of Industrial Medicine, 50(6), pp.470–480. doi:https://doi.org/10.1002/ajim.20460.

Morton, W.R. and Marjanovic, D.Z. (1984). Leukemia incidence by occupation in the portland-vancouver metropolitan area. American Journal of Industrial Medicine, 6(3), pp.185–205. doi:https://doi.org/10.1002/ajim.4700060304.

Turner, P.J.F., Siddall, A.G., Stevenson, R.D.M., Standage, M. and Bilzon, J.L.J. (2018). Lifestyle behaviours and perceived well-being in different fire service roles. Occupational Medicine. doi:https://doi.org/10.1093/occmed/kqy110.

Aldrich, T.K., Ye, F., Hall, C.B., Webber, M.P., Cohen, H.W., Dinkels, M., Cosenza, K., Weiden, M.D., Nolan, A., Christodoulou, V., Kelly, K.J. and Prezant, D.J. (2013). Longitudinal Pulmonary Function in Newly Hired, Non-World Trade Center-Exposed Fire Department City of New York Firefighters. Chest, 143(3), pp.791–797. doi:https://doi.org/10.1378/chest.12-0675.

Bigert, C., Gustavsson, P., Straif, K., Taeger, D., Pesch, B., Kendzia, B., Schüz, J., Stücker, I., Guida, F., Brüske, I., Wichmann, H.-E., Pesatori, A.C., Landi, M.T., Caporaso, N., Tse, L.A., Yu, I.T., Siemiatycki, J., Lavoué, J., Richiardi, L. and Mirabelli, D. (2016). Lung Cancer Among Firefighters. Journal of Occupational & Environmental Medicine, 58(11), pp.1137–1143. doi:https://doi.org/10.1097/jom.0000000000000878.

Firth, H.M., Cooke, K.R. and Herbison, G.P. (1996). Male Cancer Incidence by Occupation: New Zealand, 1972–1984. International Journal of Epidemiology, 25(1), pp.14–21. doi:https://doi.org/10.1093/ije/25.1.14.

Kyron, M.J., Rikkers, W., Bartlett, J., Renehan, E., Hafekost, K., Baigent, M., Cunneen, R. and Lawrence, D. (2021). Mental health and wellbeing of Australian police and emergency services employees. Archives of Environmental & Occupational Health, 77(4), pp.1–11. doi:https://doi.org/10.1080/19338244.2021.1893631.

Colbeth, H.L., Zeig-Owens, R., Hall, C.B., Webber, M.P., Schwartz, T.M. and Prezant, D.J. (2020). Mortality among Fire Department of the City of New York Rescue and Recovery Workers Exposed to the World Trade Center Disaster, 2001–2017. International Journal of Environmental Research and Public Health, 17(17), p.6266. doi:https://doi.org/10.3390/ijerph17176266.

Aronson, K.J., Tomlinson, G. and Smith, L.F. (1994). Mortality among fire fighters in metropolitan Toronto. American Journal of Industrial Medicine, 26(1), pp.89–101. doi:https://doi.org/10.1002/ajim.4700260108.

Demers, P.A., Heyer, N.J. and Rosenstock, L. (1992). Mortality among firefighters from three northwestern United States cities. Occupational and Environmental Medicine, 49(9), pp.664–670. doi:https://doi.org/10.1136/oem.49.9.664.

Deschamps, S., Momas, I. and Festy, B. (1995). Mortality amongst Paris fire-fighters. European Journal of Epidemiology, 11(6), pp.643–646. doi:https://doi.org/10.1007/bf01720297.

Glass, D.C., Del Monaco, A., Pircher, S., Vander Hoorn, S. and Sim, M.R. (2019). Mortality and cancer incidence among female Australian firefighters. Occupational and Environmental Medicine, 76(4), pp.215–221. doi:https://doi.org/10.1136/oemed-2018-105336.

Glass, D.C., Del Monaco, A., Pircher, S., Vander Hoorn, S. and Sim, M.R. (2016). Mortality and cancer incidence at a fire training college. Occupational Medicine, 66(7), pp.536–542. doi:https://doi.org/10.1093/occmed/kqw079.

Glass, D.C., Pircher, S., Del Monaco, A., Hoorn, S.V. and Sim, M.R. (2016). Mortality and cancer incidence in a cohort of male paid Australian firefighters. Occupational and Environmental Medicine, p.oemed-2015-103467. doi:https://doi.org/10.1136/oemed-2015-103467.

Daniels, R.D., Kubale, T.L., Yiin, J.H., Dahm, M.M., Hales, T.R., Baris, D., Zahm, S.H., Beaumont, J.J., Waters, K.M. and Pinkerton, L.E. (2013). Mortality and cancer incidence in a pooled cohort of US firefighters from San Francisco, Chicago and Philadelphia (1950–2009). Occupational and Environmental Medicine, [online] 71(6), pp.388–397. doi:https://doi.org/10.1136/oemed-2013-101662.

Wagner, N.L., Berger, J., Flesch-Janys, D., Koch, P., Köchel, A., Peschke, M. and Ossenbach, T. (2006). Mortality and life expectancy of professional fire fighters in Hamburg, Germany: a cohort study 1950 – 2000. Environmental Health, 5(1). doi:https://doi.org/10.1186/1476-069x-5-27.

Ahn, Y.-S. and Jeong, K.S. (2015). Mortality Due to Malignant and Non-Malignant Diseases in Korean Professional Emergency Responders. PLOS ONE, 10(3), p.e0120305. doi:https://doi.org/10.1371/journal.pone.0120305.

Petersen, K.U., Pedersen, J.E., Bonde, J.P., Ebbehøj, N.E. and Hansen, J. (2018). Mortality in a cohort of Danish firefighters; 1970–2014. International Archives of Occupational and Environmental Health, 91(6), pp.759–766. doi:https://doi.org/10.1007/s00420-018-1323-6.

Pinkerton, L., Bertke, S.J., Yiin, J., Dahm, M., Kubale, T., Hales, T., Purdue, M., Beaumont, J.J. and Daniels, R. (2020). Mortality in a cohort of US firefighters from San Francisco, Chicago and

Philadelphia: an update. Occupational and Environmental Medicine, 77(2), pp.84–93. doi:https://doi.org/10.1136/oemed-2019-105962.

Ma, F., Fleming, L.E., Lee, D.J., Trapido, E., Gerace, T.A., Lai, H. and Lai, S. (2005). Mortality in Florida professional firefighters, 1972 to 1999. American Journal of Industrial Medicine, 47(6), pp.509–517. doi:https://doi.org/10.1002/ajim.20160.

Feuer, E. and Rosenman, K.D. (1986). Mortality in police and firefighters in New Jersey. American Journal of Industrial Medicine, 9(6), pp.517–527. doi:https://doi.org/10.1002/ajim.4700090603.

Vena, J.E. and Fiedler, R.C. (1987). Mortality of a municipal-worker cohort: IV. Fire fighters. American Journal of Industrial Medicine, 11(6), pp.671–684. doi:https://doi.org/10.1002/ajim.4700110608.

Eliopulos, E., Armstrong, B.K., Spickett, J.T. and Heyworth, F. (1984). Mortality of fire fighters in Western Australia. Occupational and Environmental Medicine, 41(2), pp.183–187. doi:https://doi.org/10.1136/oem.41.2.183.

Guidotti, T.L. (1993). Mortality of urban firefighters in alberta, 1927–1987. American Journal of Industrial Medicine, 23(6), pp.921–940. doi:https://doi.org/10.1002/ajim.4700230608.

Plat, M.J., Frings-Dresen, M.H. and Sluiter, J.K. (2012). Impact of Chronic Diseases on Work Ability in Ageing Firefighters. Journal of Occupational Health, 54(2), pp.158–163. doi:https://doi.org/10.1539/joh.11-0105-oa.

Kim, M.G., Seo, J., Kim, K. and Ahn, Y.-S. (2016). Nationwide firefighter survey: the prevalence of lower back pain and its related psychological factors among Korean firefighters. International Journal of Occupational Safety and Ergonomics, 23(4), pp.447–456. doi:https://doi.org/10.1080/10803548.2016.1219149.

Webber, M.P., Moir, W., Zeig-Owens, R., Glaser, M.S., Jaber, N., Hall, C., Berman, J., Qayyum, B., Loupasakis, K., Kelly, K. and Prezant, D.J. (2015). Nested Case-Control Study of Selected Systemic Autoimmune Diseases in World Trade Center Rescue/Recovery Workers. Arthritis & Rheumatology, 67(5), pp.1369–1376. doi:https://doi.org/10.1002/art.39059.

Schulte, P.A., Burnett, C.A., Boeniger, M.F. and Johnson, J. (1996). Neurodegenerative diseases: occupational occurrence and potential risk factors, 1982 through 1991. American Journal of Public Health, 86(9), pp.1281–1288. doi:https://doi.org/10.2105/ajph.86.9.1281.

Guttmann, E. and Baker, A.A. (1945). Neuroses in Firemen. Journal of Mental Science, [online] 91(385), pp.454–457. doi:https://doi.org/10.1192/bjp.91.385.454.

Carozza, S.E. (2000). Occupation and Adult Gliomas. American Journal of Epidemiology, 152(9), pp.838–846. doi:https://doi.org/10.1093/aje/152.9.838.

Krishnan, G., Felini, M., Carozza, S.E., Miike, R., Chew, T. and Wrensch, M. (2003). Occupation and adult gliomas in the San Francisco Bay Area. Journal of Occupational and Environmental Medicine, [online] 45(6), pp.639–647. doi:https://doi.org/10.1097/01.jom.0000069245.06498.48.

Paget-Bailly, S., Guida, F., Carton, M., Menvielle, G., Radoï, L., Cyr, D., Schmaus, A., Cénée, S., Papadopoulos, A., Févotte, J., Pilorget, C., Velten, M., Guizard, A.-V., Stücker, I. and Luce, D. (2013). Occupation and Head and Neck Cancer Risk in Men. Journal of Occupational & Environmental Medicine, 55(9), pp.1065–1073. doi:https://doi.org/10.1097/jom.0b013e318298fae4.

Strauß, M., Foshag, P., Przybylek, B., Horlitz, M., Lucia, A., Sanchis-Gomar, F. and Leischik, R. (2016). Occupation and metabolic syndrome: is there correlation? A cross sectional study in different work activity occupations of German firefighters and office workers. Diabetology & Metabolic Syndrome, 8(1). doi:https://doi.org/10.1186/s13098-016-0174-0.

Elci, O.C., Akpinar-Elci, M., Alavanja, M. and Dosemeci, M. (2003). Occupation and the risk of lung cancer by histologic types and morphologic distribution: a case control study in Turkey. Monaldi Archives for Chest Disease = Archivio Monaldi Per Le Malattie Del Torace, [online] 59(3), pp.183–188. Available at: https://pubmed.ncbi.nlm.nih.gov/15065312/ [Accessed 24 Apr. 2023].

Averhoff, F.M., Moyer, L.A., Woodruff, B.A., Deladisma, A.M., Nunnery, J., Alter, M.J. and Margolis, H.S. (2002). Occupational Exposures and Risk of Hepatitis B Virus Infection Among Public Safety Workers. Journal of Occupational and Environmental Medicine, [online] 44(6), p.591. Available at: https://journals.www.com/joem/Abstract/2002/06000/Occupational_Exposures_and_Risk_of_Hepatitis_B.24.aspx [Accessed 24 Apr. 2023].

Datta, S.D., Armstrong, G.L., Roome, A.J. and Alter, M.J. (2003). Blood exposures and hepatitis C virus infections among emergency responders. Archives of Internal Medicine, [online] 163(21), pp.2605–2610. doi:https://doi.org/10.1001/archinte.163.21.2605.

Original articles 356 IMAJ • VOL. (2013). Available at: https://www.ima.org.il/FilesUploadPublic/IMAJ/0/65/32805.pdf [Accessed 24 Apr. 2023].

Delahunt, B., Bethwaite, P.B. and Nacey, J.N. (1995). Occupational risk lor renal cell carcinoma. A case-control study based on the New Zealand Cancer Registry. British Journal of Urology, 75(5), pp.578–582. doi:https://doi.org/10.1111/j.1464-410x.1995.tb07410.x.

Erratum. (1997). Health Manpower Management, 23(4), pp.140–147. doi:https://doi.org/10.1108/09552069710184418.

Desrosiers, T.A., Herring, A.H., Shapira, S.K., Hooiveld, M., Luben, T.J., Herdt-Losavio, M.L., Lin, S. and Olshan, A.F. (2012). Paternal occupation and birth defects: findings from the National Birth Defects Prevention Study. Occupational and Environmental Medicine, 69(8), pp.534–542. doi:https://doi.org/10.1136/oemed-2011-100372.

Snow, C.R. and Gregory, D.E. (2016). Perceived Risk of Low-Back Injury Among Four Occupations. Human Factors: The Journal of the Human Factors and Ergonomics Society, 58(4), pp.586–594. doi:https://doi.org/10.1177/0018720816640142.

Leary, D.B., Takazawa, M., Kannan, K. and Khalil, N. (2020). Perfluoroalkyl Substances and Metabolic Syndrome in Firefighters. Journal of Occupational & Environmental Medicine, 62(1), pp.52–57. doi:https://doi.org/10.1097/jom.0000000000001756.

Leischik, R., Foshag, P., Strauss, M., Garg, P., Dworrak, B., Littwitz, H., Lazic, J. and Horlitz, M. (n.d.). Available at: https://www.europeanreview.org/wp/wp-content/uploads/3157-3168.pdf [Accessed 24 Apr. 2023].

Davis, S.C., Jankovitz, K.Z. and Rein, S. (2002). Physical Fitness and Cardiac Risk Factors of Professional Firefighters across the Career Span. Research Quarterly for Exercise and Sport, 73(3), pp.363–370. doi:https://doi.org/10.1080/02701367.2002.10609033.

Reinisch, F., Harrison, R.W., Cussler, S., Athanasoulis, M., Balmes, J.R., Blanc, P.D. and Cone, J.E. (2001). Physician reports of work-related asthma in California, 1993-1996. American Journal of

Industrial Medicine, 39(1), pp.72–83. doi:https://doi.org/10.1002/1097-0274(200101)39:1%3C72::aid-ajim7%3E3.0.co;2-0.

Webber, M.P., Glaser, M.S., Weakley, J., Soo, J., Ye, F., Zeig-Owens, R., Weiden, M.D., Nolan, A., Aldrich, T.K., Kelly, K. and Prezant, D.J. (2011). Physician-diagnosed respiratory conditions and mental health symptoms 7-9 years following the World Trade Center disaster. American Journal of Industrial Medicine, 54(9), pp.661–671. doi:https://doi.org/10.1002/ajim.20993.

Ray, M.R., Basu, C., Roychoudhury, S., Banik, S. and Lahiri, T. (2006). Plasma Catecholamine Levels and Neurobehavioral Problems in Indian Firefighters. Journal of Occupational Health, 48(3), pp.210–215. doi:https://doi.org/10.1539/joh.48.210.

Slottje, P., Witteveen, A.B., Twisk, J.W.R., Smidt, N., Huizink, A.C., Mechelen, W. and Smid, T. (2008). Post-disaster physical symptoms of firefighters and police officers: Role of types of exposure and post-traumatic stress symptoms. British Journal of Health Psychology, 13(2), pp.327–342. doi:https://doi.org/10.1348/135910707x198793.

Sakuma, A., Takahashi, Y., Ueda, I., Sato, H., Katsura, M., Abe, M., Nagao, A., Suzuki, Y., Kakizaki, M., Tsuji, I., Matsuoka, H. and Matsumoto, K. (2015). Post-traumatic stress disorder and depression prevalence and associated risk factors among local disaster relief and reconstruction workers fourteen months after the Great East Japan Earthquake: a cross-sectional study. BMC Psychiatry, [online] 15(1). doi:https://doi.org/10.1186/s12888-015-0440-y.

Park, J., Ahn, Y.-S. and Kim, M.-G. (2019). Pregnancy, childbirth, and puerperium outcomes in female firefighters in Korea. Annals of Occupational and Environmental Medicine, [online] pp.e8–e8. Available at: https://pesquisa.bvsalud.org/portal/resource/pt/wpr-889140 [Accessed 24 Apr. 2023].

Kyron, M.J., Rikkers, W., Page, A.C., O'Brien, P., Bartlett, J., LaMontagne, A. and Lawrence, D. (2020). Prevalence and predictors of suicidal thoughts and behaviours among Australian police and emergency services employees. Australian & New Zealand Journal of Psychiatry, 55(2), p.000486742093777. doi:https://doi.org/10.1177/0004867420937774.

Marcos Aguiar Ribeiro, Santos, P., Marco Antonio Bussacos and Terra-Filho, M. (2009). Prevalence and risk of asthma symptoms among firefighters in São Paulo, Brazil: A population-based study. American Journal of Industrial Medicine, 52(3), pp.261–269. doi:https://doi.org/10.1002/ajim.20669.

Gianniou, N., Katsaounou, P., Dima, E., Giannakopoulou, C.-E., Kardara, M., Saltagianni, V., Trigidou, R., Kokkini, A., Bakakos, P., Markozannes, E., Litsiou, E., Tsakatikas, A., Papadopoulos, C., Roussos, C., Koulouris, N. and Rovina, N. (2016). Prolonged occupational exposure leads to allergic airway sensitization and chronic airway and systemic inflammation in professional firefighters. Respiratory Medicine, 118, pp.7–14. doi:https://doi.org/10.1016/j.rmed.2016.07.006.

Glueck, C.J., Kelley, W., Gupta, A., Fontaine, R.N., Wang, P. and Gartside, P.S. (1997). Prospective 10-year evaluation of hypobetalipoproteinemia in a cohort of 772 firefighters and cross-sectional evaluation of hypocholesterolemia in 1,479 men in the National Health and Nutrition Examination Survey I. Metabolism, 46(6), pp.625–633. doi:https://doi.org/10.1016/s0026-0495(97)90004-4.

Witteveen, A.B., Bramsen, I., Twisk, J.W.R., Huizink, A.C., Slottje, P., Smid, T. and Van Der Ploeg, H.M. (2007). Psychological Distress of Rescue Workers Eight and One-Half Years After Professional Involvement in the Amsterdam Air Disaster. The Journal of Nervous and Mental Disease, 195(1), pp.31–40. doi:https://doi.org/10.1097/01.nmd.0000252010.19753.19.

Choi, J.-H., Shin, J.-H., Lee, M.-Y. and Chung, I.-S. (2014). Pulmonary function decline in firefighters and non-firefighters in South Korea. Annals of Occupational and Environmental Medicine, 26(1). doi:https://doi.org/10.1186/2052-4374-26-9.

Serra, A., Mocci, F. and Randaccio, F.S. (1996). Pulmonary function in Sardinian fire fighters. American Journal of Industrial Medicine, 30(1), pp.78–82. doi:https://doi.org/10.1002/(sici)1097-0274(199607)30:1%3C78::aid-ajim13%3E3.0.co;2-5.

Bates, M.N. (2007). Registry-based case–control study of cancer in California firefighters. American Journal of Industrial Medicine, 50(5), pp.339–344. doi:https://doi.org/10.1002/ajim.20446.

Soravia, L.M., Schwab, S., Walther, S. and Müller, T. (2021). Rescuers at Risk: Posttraumatic Stress Symptoms Among Police Officers, Fire Fighters, Ambulance Personnel, and Emergency and Psychiatric Nurses. Frontiers in Psychiatry, 11. doi:https://doi.org/10.3389/fpsyt.2020.602064.

Rosenstock, L., Demers, P., Heyer, N.J. and Barnhart, S. (1990). Respiratory mortality among firefighters. Occupational and Environmental Medicine, 47(7), pp.462–465. doi:https://doi.org/10.1136/oem.47.7.462.

Tashkin, D.P., Genovesi, M.G., Chopra, S., Coulson, A. and Simmons, M. (1977). Respiratory Status of Los Angeles Firemen: One-Month Follow-Up after Inhalation of Dense Smoke. Chest, [online] 71(4), pp.445–449. doi:https://doi.org/10.1378/chest.71.4.445.

Horsfield, K., Cooper, F.M., Buckman, M.P., Guyatt, A.R. and Cumming, G. (1988). Respiratory symptoms in West Sussex firemen. Occupational and Environmental Medicine, [online] 45(4), pp.251–255. doi:https://doi.org/10.1136/oem.45.4.251.

Huizink, A.C. (2006). Long term health complaints following the Amsterdam Air Disaster in police officers and fire-fighters. Occupational and Environmental Medicine, 63(10), pp.657–662. doi:https://doi.org/10.1136/oem.2005.024687.

Miedinger, D., Chhajed, P.N., Stolz, D., Gysin, C., Wanzenried, A-B., Schindler, C., Surber, C., Bucher, H.C., Tamm, M. and Leuppi, J.D. (2007). Respiratory symptoms, atopy and bronchial hyperreactivity in professional firefighters. European Respiratory Journal, 30(3), pp.538–544. doi:https://doi.org/10.1183/09031936.00015307.

Glueck, C.J., Kelley, W., Wang, P., Gartside, P.S., Black, D. and Tracy, T. (1996). Risk factors for coronary heart disease among firefighters in Cincinnati. American Journal of Industrial Medicine, 30(3), pp.331–340. doi:https://doi.org/10.1002/ajim.4700300313.

Grimes, G., Hirsch, D. and Borgeson, D. (n.d.). Risk of Death Among Honolulu Fire Fighters. [online] Available at: https://evols.library.manoa.hawaii.edu/bitstream/10524/62664/1/1991-03p82-85.pdf [Accessed 24 Apr. 2023].

Bos, J., Mol, E., Visser, B. and Frings-Dresen, M. (2004). Risk of health complaints and disabilities among Dutch firefighters. International Archives of Occupational and Environmental Health, 77(6). doi:https://doi.org/10.1007/s00420-004-0537-y.

Lee, D.J., Fleming, L.E., Gomez-Marín, O. and LeBlanc, W. (2004). Risk of Hospitalization Among Firefighters: The National Health Interview Survey, 1986–1994. American Journal of Public Health, 94(11), pp.1938–1939. doi:https://doi.org/10.2105/ajph.94.11.1938.

Susoliakova, O., Smejkalova, J., Bicikova, M., Potuznikova, D., Hodacova, L., Grimby-Ekman, A. and Fiala, Z. (2014). Salivary cortisol in two professions: daily cortisol profiles in school teachers and firefighters. Neuro Endocrinology Letters, [online] 35(4), pp.314–321. Available at: https://pubmed.ncbi.nlm.nih.gov/25038601/ [Accessed 24 Apr. 2023].

Lui, B., Cuddy, J.S., Hailes, W.S. and Ruby, B.C. (2014). Seasonal heat acclimatization in wildland firefighters. Journal of Thermal Biology, 45, pp.134–140. doi:https://doi.org/10.1016/j.jtherbio.2014.08.009.

Ford, J., Smith, S., Luo, J.-C., Friedman-Jimenez, G., Brandt-Rauf, P., Markowitz, S., Garibaldi, K. and Niman, H. (1992). Serum growth factors and oncoproteins in firefighters. Occupational Medicine, 42(1), pp.39–42. doi:https://doi.org/10.1093/occmed/42.1.39.

Hengstler, J., Fuchs, J., Bolm-Audorff, U., Meyer, S. and Oesch, F. (1995). Single-strand breaks in deoxyribonucleic acid in fire fighters accidentally exposed to o-nitroanisole and other chemicals. Scandinavian Journal of Work, Environment & Health, 21(1), pp.36–42. doi:https://doi.org/10.5271/sjweh.6.

Dutton, L.M., Smolensky, M.H., Leach, C.S., Lorimor, R. and Hsi, B.P. (1978). Stress Levels of Ambulance Paramedics and Fire Fighters. Journal of Occupational and Environmental Medicine, 20(2), pp.111–115. doi:https://doi.org/10.1097/00043764-197802000-00011.

Milner, A., Witt, K., Maheen, H. and LaMontagne, A.D. (2017). Suicide among emergency and protective service workers: A retrospective mortality study in Australia, 2001 to 2012. Work, 57(2), pp.281–287. doi:https://doi.org/10.3233/wor-172554.

Stanley, I.H., Hom, M.A. and Joiner, T.E. (2016). Suicide mortality among firefighters: Results from a large, urban fire department. American Journal of Industrial Medicine, 59(11), pp.942–947. doi:https://doi.org/10.1002/ajim.22587.

Harris, M.A., Kirkham, T.L., MacLeod, J.S., Tjepkema, M., Peters, P.A. and Demers, P.A. (2018). Surveillance of cancer risks for firefighters, police, and armed forces among men in a Canadian census cohort. American Journal of Industrial Medicine, 61(10), pp.815–823. doi:https://doi.org/10.1002/ajim.22891.

Oniszczenko, W. (2014). Temperamental correlates of trauma symptoms in firemen, policemen and soldiers. International Journal of Occupational Medicine and Environmental Health, 27(4). doi:https://doi.org/10.2478/s13382-014-0287-3.

Sparrow, D., Bossé, R., Rosner, B. and Weiss, S.T. (1982). The effect of occupational exposure on pulmonary function: a longitudinal evaluation of fire fighters and nonfire fighters. The American review of respiratory disease, 125(3), pp.319–22. doi:https://doi.org/10.1164/arrd.1982.125.3.319.

Lin, P.-Y., Wang, J.-Y., Shih, D.-P., Kuo, H.-W. and Liang, W.-M. (2019). The Interaction Effects of Burnout and Job Support on Peptic Ulcer Disease (PUD) among Firefighters and Policemen. International Journal of Environmental Research and Public Health, [online] 16(13), p.2369. doi:https://doi.org/10.3390/ijerph16132369.

Jang, T.-W., Jeong, K.S., Ahn, Y.-S. and Choi, K.-S. (2019). The relationship between the pattern of shift work and sleep disturbances in Korean firefighters. International Archives of Occupational and Environmental Health, 93(3), pp.391–398. doi:https://doi.org/10.1007/s00420-019-01496-3.

Saijo, Y., Ueno, T. and Hashimoto, Y. (2008). Twenty-four-hour shift work, depressive symptoms, and job dissatisfaction among Japanese firefighters. American Journal of Industrial Medicine, 51(5), pp.380–391. doi:https://doi.org/10.1002/ajim.20571.

Nuzzo, J.L., Haun, D.W. and Mayer, J.M. (2014). Ultrasound measurements of lumbar multifidus and abdominal muscle size in firefighters. Journal of Back and Musculoskeletal Rehabilitation, 27(4), pp.427–433. doi:https://doi.org/10.3233/bmr-140463.

Figgs, L.W., Dosemeci, M. and Blair, A. (1995). United states non-Hodgkin's lymphoma surveillance by occupation 1984-1989: A twenty-four state death certificate study. American Journal of Industrial Medicine, 27(6), pp.817–835. doi:https://doi.org/10.1002/ajim.4700270606.

Abreu, A., Costa, C., Pinho e Silva, S., Morais, S., do Carmo Pereira, M., Fernandes, A., Moraes de Andrade, V., Teixeira, J.P. and Costa, S. (2017). Wood smoke exposure of Portuguese wildland firefighters: DNA and oxidative damage evaluation. Journal of Toxicology and Environmental Health, Part A, 80(13-15), pp.596–604. doi:https://doi.org/10.1080/15287394.2017.1286896.

Petersen, K.U., Hansen, J., Ebbehoej, N.E. and Bonde, J.P. (2018). Infertility in a Cohort of Male Danish Firefighters: A Register-Based Study. American Journal of Epidemiology, 188(2), pp.339–346. doi:https://doi.org/10.1093/aje/kwy235.

Berríos-Torres, S.I., Greenko, J.A., Phillips, M., Miller, J.R., Treadwell, T. and Ikeda, R.M. (2003). World Trade Center rescue worker injury and illness surveillance, New York, 2001. American Journal of Preventive Medicine, 25(2), pp.79–87. doi:https://doi.org/10.1016/s0749-3797(03)00110-7.

Zhao, G., Erazo, B., Ronda, E., Brocal, F. and Regidor, E. (2020). Mortality Among Firefighters in Spain: 10 Years of Follow-up. Annals of Work Exposures and Health, 64(6), pp.614–621. doi:https://doi.org/10.1093/annweh/wxaa036.

Heinzerling, A., Laws, R.L., Frederick, M., Jackson, R., Windham, G., Materna, B. and Harrison, R. (2020). Risk factors for occupational heat-related illness among California workers, 2000–2017. American Journal of Industrial Medicine, 63(12), pp.1145–1154. doi:https://doi.org/10.1002/ajim.23191.

Lesniak, A.Y., Bergstrom, H.C., Clasey, J.L., Stromberg, A.J. and Abel, M.G. (2019). The Effect of Personal Protective Equipment on Firefighter Occupational Performance. Journal of Strength and Conditioning Research, 34(8), pp.2165–2172. doi:https://doi.org/10.1519/jsc.0000000000003384.

Clarity, C., Trowbridge, J., Gerona, R., Ona, K., McMaster, M., Bessonneau, V., Rudel, R., Buren, H. and Morello-Frosch, R. (2020). Associations between polyfluoroalkyl substance and organophosphate flame retardant exposures and telomere length in a cohort of women firefighters and office workers in San Francisco. medRxiv: The Preprint Server for Health Sciences, [online] p.2020.11.05.20226183. doi:https://doi.org/10.1101/2020.11.05.20226183.

Wright-Beatty, H.E., McLellan, T.M., Larose, J., Sigal, R.J., Boulay, P. and Kenny, G.P. (2014). Inflammatory responses of older Firefighters to intermittent exercise in the heat. European Journal of Applied Physiology, 114(6), pp.1163–1174. doi:https://doi.org/10.1007/s00421-014-2843-8.

Vigil, N.H., Beger, S., Gochenour, K.S., Frazier, W.H., Vadeboncoeur, T.F. and Bobrow, B.J. (2021). Suicide Among the EMS Occupation in the United States. Western Journal of Emergency Medicine: Integrating Emergency Care with Population Health, [online] 22(2). doi:https://doi.org/10.5811/westjem.2020.10.48742.

Khaja, S.U., Mathias, K.C., Bode, E.D., Stewart, D.F., Jack, K., Moffatt, S.M. and Smith, D.L. (2021). Hypertension in the United States Fire Service. International Journal of Environmental Research and Public Health, [online] 18(10), p.5432. doi:https://doi.org/10.3390/ijerph18105432.

Hsu, W.-C., Wang, C.-H., Chang, K.-M. and Chou, L.-W. (2021). Shifted Firefighter Health Investigation by Personal Health Insurance Record in Taiwan. Risk Management and Healthcare Policy, Volume 14, pp.665–673. doi:https://doi.org/10.2147/rmhp.s285729.

Farioli, A., Christophi, C.A., Quarta, C.C. and Kales, S.N. (2015). Incidence of Sudden Cardiac Death in a Young Active Population. Journal of the American Heart Association, 4(6). doi:https://doi.org/10.1161/jaha.115.001818.

Schermer, T., Malbon, T., Morgan, M., Briggs, N., Holton, C., Appleton, S., Adams, R., Smith, M. and Crockett, A. (2010). Lung function and health status in metropolitan fire-fighters compared to general population controls. International Archives of Occupational and Environmental Health, [online] 83(7), pp.715–723. doi:https://doi.org/10.1007/s00420-010-0528-0.

Zeegers, M.P.A., Friesema, I.H.M., Goldbohm, R.A. and van den Brandt, P.A. (2004). A Prospective Study of Occupation and Prostate Cancer Risk. Journal of Occupational and Environmental Medicine, 46(3), pp.271–279. doi:https://doi.org/10.1097/01.jom.0000116961.48464.6b.

Lawrence, D. (2020). SafetyLit: Injury Research and Prevention Literature Update - Abstract Details. [online] Safetylit.org. Available at: https://www.safetylit.org/citations/index.php?fuseaction=citations.viewdetails&citationIds. [Accessed 25 Apr. 2023].

Halil, N., Ducatman, A.M., Sinari, S., Billheimer, D., Hu, C., Littau, S. and Burgess, J.L. (2020). Per- and Polyfluoroalkyl Substance and Cardio Metabolic Markers in Firefighters. Journal of Occupational and Environmental Medicine, [online] 62(12), pp.1076–1081. doi:https://doi.org/10.1097/JOM.0000000000002062.

Leary, D.B., Takazawa, M., Kannan, K. and Khalil, N. (2020). Perfluoroalkyl Substances and Metabolic Syndrome in Firefighters. Journal of Occupational & Environmental Medicine, 62(1), pp.52–57. doi:https://doi.org/10.1097/jom.0000000000001756.

Lee, D.J., Koru-Sengul, T., Hernandez, M.N., Caban-Martinez, A.J., McClure, L.A., Mackinnon, J.A. and Kobetz, E.N. (2020). Cancer risk among career male and female Florida firefighters: Evidence from the Florida Firefighter Cancer Registry (1981-2014). American Journal of Industrial Medicine, 63(4), pp.285–299. doi:https://doi.org/10.1002/ajim.23086.

Muegge, C.M. (2020). Health of Indiana Firefighters. scholarworks.iupui.edu. [online] doi:https://doi.org/10.7912/C2/2850.

Mannarino, R.V., Monteiro GTR. Standardized Mortality Analysis of Military Firefighters from 2000-2016 in Rio de Janeiro, Brazil. Research Square; 2021. doi: 10.21203/rs.3.rs-192008/v1.

Webber, M.P., Singh, A., Zeig-Owens, R., Salako, J., Skerker, M., Hall, C.B., Goldfarb, D.G., Jaber, N., Daniels, R.D. and Prezant, D.J. (2021). Cancer incidence in World Trade Center-exposed and non-exposed male firefighters, as compared with the US adult male population: 2001–2016. Occupational and Environmental Medicine, [online] 78(10), pp.707–714. doi:https://doi.org/10.1136/oemed-2021-107570.

Ogunsina, K., Koru-Sengul, T., Rodriguez, V., Caban-Martinez, A.J., Schaefer-Solle, N., Ahn, S., Kobetz, E.N., Hernandez, M.N. and Lee, D.J. (2022). A comparative analysis of histologic types of thyroid cancer between career firefighters and other occupational groups in Florida. BMC Endocrine Disorders, 22(1). doi:https://doi.org/10.1186/s12902-022-01104-5.

Pinkerton, L.E., Bertke, S., Dahm, M.M., Kubale, T.L., Siegel, M.R., Hales, T.R., Yiin, J.H., Purdue, M.P., Beaumont, J.J. and Daniels, R.D. (2022). End-stage renal disease incidence in a cohort of US firefighters from San Francisco, Chicago, and Philadelphia. American Journal of Industrial Medicine, 65(12), pp.975–984. doi:https://doi.org/10.1002/ajim.23435.

Ogunsina, K., Koru-Sengul, T., Rodriguez, V., Caban-Martinez, A.J., Schaefer-Solle, N., Ahn, S., Kobetz, E.N., Hernandez, M.N. and Lee, D.J. (2022). A comparative analysis of histologic types of thyroid cancer between career firefighters and other occupational groups in Florida. BMC Endocrine Disorders, 22(1). doi:https://doi.org/10.1186/s12902-022-01104-5.

Lee, W.-R., Lee, H., Nam, E.W., Noh, J.-W., Yoon, J.-H. and Yoo, K.-B. (2023). Comparison of the risks of occupational diseases, avoidable hospitalization, and all-cause deaths between firefighters and non-firefighters: A cohort study using national health insurance claims data. Frontiers in Public Health, 10. doi:https://doi.org/10.3389/fpubh.2022.1070023.

[xvii] California Professional Firefighters. (n.d.). Firefighter Presumptions. [online] Available at: https://www.cpf.org/health-and-safety/firefighter-presumptions [Accessed 25 Apr. 2023].

[xviii] Parliament of Australia. [online] Available at: https://www.aph.gov.au/Parliamentary_Business/Committees/Senate/Education_Employment_and_Workplace_Relations/Completed_inquiries/2010-13/firefighters/report/c01 [Accessed 25 Apr. 2023].

[xix] European Parliament, Bossuyt, A.V. Parliamentary question. Prevention of cancer among fire fighters, E-006860/2017. [online] www.europarl.europa.eu. Available at: https://www.europarl.europa.eu/doceo/document/E-8-2017-006860_EN.html [Accessed 25 Apr. 2023].

[xx] www.fbu.org.uk. (n.d.). Minimising firefighters' exposure to toxic fire effluents | Fire Brigades Union. [online] Available at: https://www.fbu.org.uk/publications/minimising-firefighters-exposure-toxic-fire-effluents [Accessed 22 May 2023].

[xxi] Science Direct. (2010). Standardized Mortality Ratio - an overview | ScienceDirect Topics. [online] Available at: https://www.sciencedirect.com/topics/medicine-and-dentistry/standardized-mortality-ratio. [Accessed 22 Apr 2023].

[xxii] World Health Organisation (2022). *ICD-11*. [online] International Classification of Diseases 11th Revision. Available at: https://icd.who.int/en [Accessed 22 Apr 2023].

[xxiii] Team, N.R. of S.W. (2013). National Records of Scotland. [online] National Records of Scotland. Available at: https://www.nrscotland.gov.uk/statistics-and-data/statistics/statistics-by-theme/population/population-estimates/mid-year-population-estimates/mid-2021. [Accessed 25 Apr. 2023].

[xxiv] National Records of Scotland Web Team (2013). Vital Events - Deaths. Available at: https://www.nrscotland.gov.uk/statistics-and-data/statistics/statistics-by-theme/vital-events/deaths. [Accessed 25 Apr. 2023].

[xxv] Compliance with the Code of Practice for Official Statistics and Principals : Supporting Principal 5 on Confidentiality Sections. (n.d.). Available at: https://www.nrscotland.gov.uk/files//statistics/about/data-access-and-confidentiality.pdf [Accessed 13 May 2021].

[xxvi] Scottish Fire and Rescue Service Website. (2016). [online] Available at: https://www.firescotland.gov.uk/about-us/who-we-are/statistics/. [Accessed 25 Apr. 2023].

[xxvii] Donnan, S.P.B. (1996). Study of Mortality and Cancer Incidence in Fire-fighters in Britain–A Third Report 1965–1993. London: Home office scientific research and development branch.

[xxviii] Ide, C.W. (2014). Cancer incidence and mortality in serving whole-time Scottish firefighters 1984-2005. Occupational Medicine, 64(6), pp.421–427. doi:https://doi.org/10.1093/occmed/kqu080.

[xxix] Ressing, M., Blettner, M. and Klug, S.J. (2010). Data Analysis of Epidemiological Studies. Deutsches Aerzteblatt Online. [online] doi:https://doi.org/10.3238/arztebl.2010.0187.

[xxx] Ressing, M., Blettner, M. and Klug, S.J. (2010). Data Analysis of Epidemiological Studies. Deutsches Aerzteblatt Online. [online] doi:https://doi.org/10.3238/arztebl.2010.0187.

[xxxi] Vandenbroucke, J.P. (1982). A shortcut method for the calculation of the 95 per cent confidence interval of the Standarized Mortality Ratio. American Journal of Epidemiology, 115(2), pp.303–304. doi:https://doi.org/10.1093/oxfordjournals.aje.a113306.

[xxxii] Plan, N.L.T. (2019). Cancer. [online] NHS Long Term Plan. Available at: https://www.longtermplan.nhs.uk/areas-of-work/cancer/. [Accessed 25 Apr. 2023].

[xxxiii] Public Health Scotland. Cancer incidence in Scotland - Cancer incidence and prevalence in Scotland to December 2019. [online] Available at: https://www.publichealthscotland.scot/publications/cancer-incidence-in-scotland/cancer-incidence-in-scotland-cancer-incidence-and-prevalence-in-scotland-to-december-2019/. [Accessed 25 Apr. 2023].

[xxxiv] Pukkala, E., Martinsen, J.I., Weiderpass, E., Kjaerheim, K., Lynge, E., Tryggvadottir, L., Sparén, P. and Demers, P.A. (2014). Cancer incidence among firefighters: 45 years of follow-up in five Nordic countries. Occupational and Environmental Medicine, 71(6), pp.398–404. doi:https://doi.org/10.1136/oemed-2013-101803.

[xxxv] Stec, A.A., Robinson, A., Wolffe, T.A.M. and Bagkeris, E. (2023). Scottish Firefighters Occupational Cancer and Disease Mortality Rates: 2000-2020. Occupational Medicine. doi:https://doi.org/10.1093/occmed/kqac138.

[xxxvi] California Professional Firefighters. (n.d.). Firefighter Presumptions. [online] Available at: https://www.cpf.org/health-and-safety/firefighter-presumptions [Accessed 25 Apr. 2023].

[xxxvii] Parliament of Australia. [online] Available at: https://www.aph.gov.au/Parliamentary_Business/Committees/Senate/Education_Employment_and_Workplace_Relations/Completed_inquiries/2010-13/firefighters/report/c01 [Accessed 25 Apr. 2023].

[xxxviii] American Heart Association. (n.d.). Firefighters' risk of irregular heartbeat linked to number of on-the-job fire exposures. [online] Available at: https://newsroom.heart.org/news/firefighters-risk-of-irregular-heartbeat-linked-to-number-of-on-the-job-fire-exposures#:~:text=After%20adjusting%20for%20multiple%20risk [Accessed 25 Apr. 2023].

[xxxix] Ashen, M.D., Carson, K.A. and Ratchford, E.V. (2022). Coronary Calcium Scanning and Cardiovascular Risk Assessment Among Firefighters. American Journal of Preventive Medicine, 62(1), pp.18–25. doi:https://doi.org/10.1016/j.amepre.2021.06.005.

[xl] Noh, J., Lee, C.J., Hyun, D.-S., Kim, W., Kim, M.-J., Park, K.-S., Koh, S., Chang, S.-J., Kim, C. and Park, S. (2020). Blood pressure and the risk of major adverse cardiovascular events among firefighters. Journal of Hypertension, [online] 38(5), p.850. doi:https://doi.org/10.1097/HJH.0000000000002336.

[xli] Feairheller, D.L., Smith, M., Carty, M. and Reeve, E.H. (2023). Blood pressure surge with alarm is reduced after exercise and diet intervention in firefighters. *Blood Pressure Monitoring*, 28(3), pp.134–143. doi:https://doi.org/10.1097/mbp.0000000000000649.

[xlii] Daniels, R.D., Kubale, T.L., Yiin, J.H., Dahm, M.M., Hales, T.R., Baris, D., Zahm, S.H., Beaumont, J.J., Waters, K.M. and Pinkerton, L.E. (2013). Mortality and cancer incidence in a pooled cohort of US firefighters from San Francisco, Chicago and Philadelphia (1950–2009). Occupational and Environmental Medicine, [online] 71(6), pp.388–397. doi:https://doi.org/10.1136/oemed-2013-101662.

[xliii] Aronson, K.J., Tomlinson, G. and Smith, L.F. (1994). Mortality among fire fighters in metropolitan Toronto. American Journal of Industrial Medicine, 26(1), pp.89–101. doi:https://doi.org/10.1002/ajim.4700260108.

[xliv] Glass, D.C., Pircher, S., Del Monaco, A., Hoorn, S.V. and Sim, M.R. (2016). Mortality and cancer incidence in a cohort of male paid Australian firefighters. Occupational and Environmental Medicine, p.oemed-2015-103467. doi:https://doi.org/10.1136/oemed-2015-103467.

[xlv] Wagner, N.L., Berger, J., Flesch-Janys, D., Koch, P., Köchel, A., Peschke, M. and Ossenbach, T. (2006). Mortality and life expectancy of professional fire fighters in Hamburg, Germany: a cohort study 1950 – 2000. Environmental Health, 5(1). doi:https://doi.org/10.1186/1476-069x-5-27.

[xlvi] Amadeo, B., Marchand, J.-L., Moisan, F., Stéphane Donnadieu, Gaëlle Coureau, Mathoulin-Pélissier, S., C. Lembeye, Imbernon, E. and Brochard, P. (2015). French firefighter mortality: Analysis over a 30-year period. American Journal of Industrial Medicine, 58(4), pp.437–443. doi:https://doi.org/10.1002/ajim.22434.

[xlvii] Zhao, G., Erazo, B., Ronda, E., Brocal, F. and Regidor, E. (2020). Mortality Among Firefighters in Spain: 10 Years of Follow-up. Annals of Work Exposures and Health, 64(6), pp.614–621. doi:https://doi.org/10.1093/annweh/wxaa036.

[xlviii] Petersen, K.U., Pedersen, J.E., Bonde, J.P., Ebbehøj, N.E. and Hansen, J. (2018). Mortality in a cohort of Danish firefighters; 1970–2014. International Archives of Occupational and Environmental Health, 91(6), pp.759–766. doi:https://doi.org/10.1007/s00420-018-1323-6.

[xlix] Colbeth, H.L., Zeig-Owens, R., Hall, C.B., Webber, M.P., Schwartz, T.M. and Prezant, D.J. (2020). Mortality among Fire Department of the City of New York Rescue and Recovery Workers Exposed to the World Trade Center Disaster, 2001–2017. International Journal of Environmental Research and Public Health, 17(17), p.6266. doi:https://doi.org/10.3390/ijerph17176266.

[l] Hansen, E.S. (1990). A cohort study on the mortality of firefighters. Occupational and Environmental Medicine, 47(12), pp.805–809. doi:https://doi.org/10.1136/oem.47.12.805.

[li] Fire Brigades Union. (n.d.). FBU contaminants project debated in the Northern Ireland Assembly. [online] Available at: https://www.fbu.org.uk/news/2021/10/29/fbu-contaminants-project-debated-northern-ireland-assembly [Accessed 25 Apr. 2023].

[lii] Scottish Parliament TV. Members' Business — S6M-06671 Maggie Chapman: Fire Brigades Union DECON Campaign. [online] Available at: https://scottishparliament.tv/meeting/members-business-

s6m-06671-maggie-chapman-fire-brigades-union-decon-campaign-january-19-2023 [Accessed 25 Apr. 2023].