Final Report on
Queensland Fire Fighters' Cancer Incidence Study

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1 Summary

This is the final report of a retrospective study of cancer in operational Queensland fire fighters carried out by the Monash Centre for Occupational and Environmental Health (MonCOEH) in the School of Public Health and Preventive Medicine at Monash University.

This study was undertaken because of a previous finding of an excess of brain tumours among fire fighters in the Atherton Fire Station. A Queensland Health report recommended investigating the feasibility of a wider study of cancer rates among fire fighters in Queensland, in particular to identify whether brain tumours, testicular cancer, prostate cancer or non-Hodgkin lymphoma are in excess in this larger group. In addition, we looked at other specific cancers that had been found at increased incidence among fire fighters in previous Australian and international studies.

The main objective of the study was to investigate cancer incidence among Queensland's operational fire fighters that has occurred since 1995 (the first year of state-wide electronic records of fire fighters), and to compare with the expected number of cancers based on incidence in the general Queensland community. The specific aims were to investigate the incidence of benign and malignant brain tumours and other specified cancers that have been shown to be in excess in previous studies of fire fighters in Australia and overseas.

Active fire fighters in employment at or after 1st July 1995 and before 31st December 2006, in any fire station in Queensland were included in the study. Identifying details, such as full name and date of birth, were obtained from personnel records held by Queensland Fire and Rescue Service. These details were compiled into a database which was sent for linkage against the Queensland Cancer Registry database to identify all cancers occurring in this group between 1995 and 2006. Expected numbers of cancers for men and women, standardised for age, were calculated using Queensland population data for the same period. Standardised incidence ratios (SIRs) for brain tumours (benign and malignant) and other cancers were calculated.

Ethics approval was obtained from the Standing Committee on Ethics in Research into Humans (SCERH) at Monash University, and the Queensland Health Department following a review by the Queensland Cancer Registry.

The main findings were:

- Overall cancer incidence in male active fire fighters was not higher than expected.
- The incidence of malignant brain tumours was not higher than expected in male active fire fighters.
- Melanoma incidence was found in a borderline statistically significant excess in male active fire fighters. The incidence of other malignant tumours was not higher than expected in male active fire fighters.
- For benign brain tumours, there was a doubling of the expected number in men, but this was based on only 3 observed cases (versus 1.5 expected) and was not statistically significant. The employment records indicated that none of these cases had ever worked at Atherton.
- Further analyses of the male active fire fighters, limited to those who had worked for more than 12 months and those who had worked in full time employment, resulted in similar patterns of cancer incidence, with no statistical excess in any type of cancer.
- Overall cancer incidence in women who were active fire fighters was not higher than expected. As the numbers of individual cancer types in women were small, no further analysis of cancer subgroups could be performed.

This study indicates that there is no excess in the overall rate of cancer (for men and women) nor is there an excess rate of any type of cancer (in men) among Queensland fire fighters in the period 1995-2006. In addition, similar patterns of cancer incidence were found when restricting the analysis to those male fire fighters with more than 1 year's service or when restricting the analysis to fulltime fire fighters only.

The study has several limitations, including:

- The small size of the group of active fire fighters and the limited statistical power resulting from this, especially for female fire fighters and for uncommon tumours, such as benign brain tumours.
- The fact that cancer rates could not be examined prior to 1995.
- The cohort has had a short period of follow up, with almost half of the fire fighters included in the study having started work after 1995.
- Cancers which were diagnosed outside Queensland could not be identified.
- The results could not be adjusted for differences in factors known to affect cancer rates, such as cigarette smoking and sun exposure.
- The re-analyses based on breakdown by more than 12 months (when training is completed) and by categorising fire fighters as full or part time, did not permit more sophisticated assessment of the impact of different exposures.

While this study provides reassurance that no excesses of cancer have occurred in fire fighters in Queensland since 1995, the above limitations affect the strength of this conclusion to some degree. More definitive results will be obtainable through a national fire fighter cancer and mortality study, which should have greater numbers, greater potential to investigate cancer further back in time and greater potential to investigate specific exposures and/or activities during fire fighter duties.

2 Background

2.1 Atherton fire fighters cluster investigation

In December 2007, concerns about cancer amongst fire fighters at the Atherton Fire Station in Queensland were raised by the Queensland Fire and Rescue Service. This possible cancer cluster was investigated by Queensland Health and they reported in April 2008.[1] The report found that there "was an elevated rate of brain cancer (of the astrocytoma group) amongst staff at the Atherton Fire Station".

The report recommended the following:

1. "The feasibility of an epidemiological assessment of brain cancer incidence of Queensland fire fighters including comparison with Atherton Fire Station, should be conducted." and
2. "The feasibility of an epidemiological study or disease registry should be considered to examine the possible risks associated with fire fighting in relation to cancer, particularly brain cancer and those types of cancer identified in the evaluation of the International Agency for Research on Cancer (e.g. testicular cancer, prostate cancer and non-Hodgkin lymphoma)."

Following the release of this report, the Queensland Fire and Rescue Service – Cancer Registry Linkage Working Party was established to progress the recommendations in the report. This group is chaired by Mr Iain MacKenzie and has representatives from the United Firefighters Union, Queensland Health, Queensland Cancer Registry and the Department of Employment and Industrial Relations. This group has overseen this retrospective cohort study of cancer in Queensland fire fighters. A recent Queensland Health document on cluster investigations recommends epidemiological follow up of this type after some cluster investigations. [2]

2.2 Literature review of cancer among fire fighters

There have been several studies of the health of fire fighters carried out over the last 50 years in Europe, North America and Australia. The main studies undertaken in Australia, recent major reviews and further papers published since these reviews are summarised below.

There have been two cohort studies of the health of fire fighters in Australia, both of which were carried out many years ago. The first, reported in 1984, was a retrospective mortality study of a small cohort of 990 fire fighters employed in Western Australia between 1939 and 1978.[3] Cancer mortality was not significantly different from that of the general population, but there was a significantly reduced overall mortality rate among fire fighters compared to the general population. This was attributed in the paper to the *Healthy Worker Effect*, that is, the selection of fit and healthy people to become fire fighters. The *Healthy Worker Effect* may also occur when less healthy individuals leave the workforce, the so called *Healthy Worker Survivor Effect*.[4]

The other study was a retrospective cancer incidence study in Victoria in 1993 of 2,865 fire fighters.[5] In this study the overall incidence of cancer was similar to that of the general population. There were elevated incidences of cancers of the upper aerodigestive tract, of the colorectal tract, of the prostate and of non-Hodgkin lymphoma but none of these Standardised Incidence Ratios (SIRs) were statistically significantly increased, and all the SIRs were based on small numbers of cases for statistical analysis (<9). For fire fighters aged 65 years or over, there were statistically significant excesses for all cancers grouped together, SIR 2.14 (95% confidence interval (CI) 1.32–2.37) and for colorectal cancer, SIR 3.65 (95% CI 1.13–7.94).

Both of these Australian investigations were small studies with limited ability to identify increased risks of mortality or cancer incidence.

A systematic review and meta-analysis of the international literature on cancer and heart disease in fire fighters was prepared by Gordon and Finch from Melbourne University and reported in 2007.[6] This review identified 49 published epidemiological studies. In general, the overall mortality of fire fighters was found to be lower than that of the general population. This was considered to be, at least in part, a result of the *Healthy Worker Effect*. There was evidence, however, that the mortality rate was higher than expected for bladder cancer mortality (estimated mortality rate ratio was 1.5 (95% CI 1.07–2.08). There was a suggestion of a higher than expected mortality from non-Hodgkin lymphoma (NHL) and multiple myeloma (MM) but the confidence intervals were wide and the results were not

statistically significant.[6] For cancer incidence, the Melbourne University meta-analysis found evidence of increased incidence of melanoma [estimated incidence rate ratio (IRR) 1.46 (95% CI 1.30–1.63], cancer of the prostate [estimated IRR 1.21 (95% CI 1.13–1.31)] and testicular cancer [estimated IRR 1.57 (95% CI 1.31–1.89).[6]

The Melbourne University findings are very similar to those of another meta-analysis published in 2006.[7] LeMasters *et al*[7] found that fire fighters probably had an increased cancer risk for several cancers, expressed as a summary risk estimate (SRE) greater than 1. The risk was increased for multiple myeloma with an SRE of 1.53 (95% CI 1.21–1.94); for NHL, SRE 1.51 (95% CI 1.31–1.73); for prostate cancer, SRE of 1.28 (95% CI 1.15–1.43), and for testicular cancer, SRE of 2.02 (95% CI 1.30–3.13). Eight additional cancers were identified as having a "possible" association with fire fighting. These were: cancers of the skin, brain, rectum, buccal cavity and pharynx, stomach, colon, as well as malignant melanoma and leukemia.

The Melbourne meta-analysis[6] included a very large Californian registry-based study of fire fighters' cancers[8] which was not included in the earlier LeMasters' *et al* meta analysis. This Californian study by Bates *et al* (2007)[8] identified that there was a significant excess of testicular cancer (odds ratio (OR) 1.54, 95% CI, 1.18–2.02), melanoma (1.50, 1.33–1.70), brain cancer (1.35, 1.06–1.72), oesophageal cancer (1.48, 1.14–1.91), and prostate cancer (1.22, 1.12–1.33).

Since the Melbourne University meta-analysis was released, Kang et al (2008)[9] have reported cancer incidence among male Massachusetts fire fighters employed between 1987 and 2003. Risks were significantly raised for colon cancer (OR 1.36, 95% CI: 1.04–1.79) and brain cancer (1.90, 1.10–3.26). There was some evidence of increased risk for bladder cancer (1.22, 0.89–1.69), kidney cancer (1.34, 0.90–2.01), and Hodgkin lymphoma (1.81, 0.72–4.53), although none reached statistical significance. Golka and Weistenhofer's 2008 review [10] of studies on bladder cancer risk in fire fighters found no increased risk of bladder cancer, although there was some evidence of an excess in career fire fighters highly exposed for decades.

Guidotti [11] also recently reviewed the literature to decide which cancers were most likely to be increased as a result of work as a fire fighter. He concluded that, on a weight of evidence basis, fire fighting was associated with increased risk of the following cancers: bladder, kidney, testicular, brain and lung cancer, the last type of tumour in non-smokers only. He suggested that the following cancers were also possibly associated with fire fighting: NHL, leukaemia and myelomas.

There have been changes in fire fighters' exposure over the years for example as a result of different materials present in building fires, the number of vehicle fires attended and in the use of breathing apparatus. These changes in exposure may have affected cancer risk which makes comparisons between studies difficult to make.

There is international interest in the question of cancer in fire fighters. In October 2007, the International Agency for Research on Cancer (IARC), a research institute of the World Health Organisation, reviewed the evidence about the cancer risks associated with fire fighting. IARC classified fire fighting as "possibly carcinogenic" (Group 2B) on the basis of "limited evidence of carcinogenicity in humans". The IARC Working Group concluded that:

> "Although increases in various cancers in fire-fighters compared with the general population have been noted in several studies, consistent patterns are difficult to discern due to the large variations of exposures." [12]

As part of its review, IARC updated the LeMasters *et al* meta-analysis [7] and concluded that:

> "For three types of cancer the relative risks were consistently increased and the average increase was significant: testicular cancer (all six studies showed increased risks, average relative risk 1·5), prostate cancer (increased risks in 18 of 21 studies, average relative risk 1·3), and non- Hodgkin lymphoma (increased risks in five of six studies, average relative risk 1·2)."[12]

To summarise, the published reviews of the literature indicate that:

- there is good evidence that the following cancers are associated with fire fighting: testicular cancer, prostate cancer, non-Hodgkin lymphoma.
- there is reasonable evidence that the following cancers may be associated with fire fighting: melanoma, multiple myeloma, bladder cancer and brain cancer.
- there is some evidence that the following cancers may be associated with fire fighting: leukemia, kidney cancer, skin cancer, buccal cavity/pharynx, oesophageal, stomach, colon and rectal cancers and lung cancers for non-smokers.

3 Study Aims and Objectives

The main objective of the study was to investigate the overall cancer incidence, and the incidence for several types of cancer (see section 7.1 for a list of these cancers), among Queensland's operational fire fighters and to determine whether these were higher than expected, based on rates in the general Queensland community.

Overall cancer incidence among men and women who were active fire fighters was examined and the incidence rates for several specific cancer sites were investigated. The analysis was then repeated, breaking down fire fighters into various categories of employment and duration of employment in an attempt to focus on fire fighters with longer exposure and possible heavier exposure.

4 Study design

4.1 Study type

This was a retrospective cohort study, which means that a group of fire fighters working during a certain time period in the past was studied.

The study is of cancer incidence, i.e. the diagnosis of new cancers. Cancer is a notifiable disease in Queensland (and all other Australian States and Territories). All cancers, except non-melanotic skin cancers, and all deaths are legally notifiable in Australia. Providing that cancer registration is reliable, as it is in Australia, cancer incidence measures are more valid indicators of cancer risk than are cancer mortality measures. This is because many persons who get cancer do not die from their cancer, but from other causes.

We analysed the data for the specific cancer that is of concern *a priori* from the Atherton cluster investigation (malignant brain tumours), as well as cancer sites identified from the literature search (melanoma, prostate, testis, bladder, NHL and MM) where there is good or reasonable evidence of occupational risk. For other cancers, especially where cancer numbers are likely to be small, we investigated only the most common cancers identified by the Queensland Cancer Council in their latest publication [(13)] grouped by organ systems.

Only primary malignant tumours were included in the analysis, with the exception of benign brain tumours. Cancers with a diagnosis date on the QCR prior to the cohort start date in 1995 were not included in the analysis, nor were any cancers diagnosed after 2006. Any cancers diagnosed overseas, interstate or prior to the start date of employment were also not included in the analysis.

4.2 Study population

The fire fighting services in Queensland were amalgamated in 1990 and the employment records centralised and computerised to a common format by 1st July 1995. Prior to this date the records were paper based and spread throughout many stations/locations. It was not feasible to start the cohort prior to this date, as collection of these data would have been a cumbersome and time consuming task, gathering records of unknown quality and completeness. The 1st July 1995 is therefore the date by which the electronic employment records represent a complete set of all employees, and it was decided to commence the start date of the cohort from this date.

The cohort end date was the end of December 2006, as this was the most recent date for which complete Queensland Cancer Registry (QCR) cancer incidence data were available. Therefore, all fire fighters employed by QFRS on 1st July 1995 or at any later time up until 31st December 2006 were included in the cohort for this study.

Fire fighters in employment between 1995 and the end of 2006 were identified from the Queensland Department of Emergency Service electronic records. The following data required for undertaking the cancer registry linkage and/or for checking matches was extracted for all cohort members:

- Employment ID
- Surname including previous name(s) if any
- First Given Name
- Second Given Name (where available)
- Birth Date
- Sex
- Last Contact Date - last date the fire fighter was known to be working

- Postcode (residential)
- Employment Start Date
- Employment End Date
- Occupational status
- Last known full residential address
- Death Date for any fire fighter who has died (if available)
- Employment History (Start/End Date at various locations/position title, job grade and work site) (used in the analysis to categorise fire fighters by occupational status)

The employment records represent a complete set of employees from 1st July 1995 onwards, and the employment history of these employees in terms of start/end dates at various locations/position titles goes back historically to the commencement of their initial employment.

The start date for the calculation of person-years was 1st July 1995 and the end date was 31st December 2006 for those still employed at that date. In the situation where fire fighters had left fire authority employment, they continued to contribute person-years to the cohort until the end of 2006, although their time of employment was truncated at the time of leaving QFRS. For those fire fighters in the cohort known to have died prior to the end of 2006, their contribution of person-years was truncated at the date of death.

For each of the analyses by employment category, person-years and cancers were only counted from the time of first employment in that employment category. For example, for the Ever Active Fire Fighter analysis person-years and cancers are only counted from the date of first employment as an active fire fighter.

4.3 Active fire fighter and full time employment categorisation

A list of all unique job titles was extracted from the employee job histories. This list of job titles was then categorised as to whether they were or could possibly have been an active fire fighting job or not, with input from QFRS. The definition of an active fire fighting job was 'routinely attends fires as part of employment in that job title'.

Auxiliary and full time employment were defined using the employment category provided in the employee job history. Auxiliary fire fighters were those who ever held an employment category of auxiliary. A person was defined as having a full time job if they ever held a job in any other category, except for volunteer, board or exchange fire fighter. Some fire fighters had held at least one job categorised as full time and another categorised as auxiliary.

More details about the categorisation by occupational status are included in Appendix 1.

4.4 Inclusion and exclusion criteria

Both male and female fire fighters, including station officers, were included in the cohort. However, administrative staff at fire stations who had only ever worked in an administrative role were not included in the cohort, as the study was of active fire fighters.

We excluded QFRS fire fighters whose employment was completed before July 1995 and those who did not commence employment until after 31st December 2006, as these dates were outside the defined cohort dates.

Individuals whose records indicated that they were not QFRS employees were excluded, i.e. those fire fighters with only volunteer designation jobs, or those who were on exchange. Exchange fire fighters are excluded as these are normally overseas or interstate exchange fire fighters who are unlikely to remain in Queensland after their period of employment has ended, and thus would not appear on QCR records if they developed a cancer later in life.

There was no minimum qualifying employment period for entry to the cohort, but it is important to note that basic training is usually completed in the first 12 months of employment. Therefore some analyses were restricted to those fire fighters who served for more than 12 months. This avoids the inclusion of short term workers who are likely to have had little fire fighting experience (and so little potential exposure) during their training. In addition, such short term workers have also been shown to have poorer health records independent of any occupational exposures.[14]

5 Consent and ethics committee approvals

Ethics committee approval was obtained from the Monash University Standing Committee on Ethics in Research involving Humans (SCERH) project number CF08/2670 – 2008001356 on 10/11/2008. On 19/12/2008 ethics committee approval (number RD001172) was obtained from the Queensland Health Department following a review by the Queensland Cancer Registry.

It was not feasible to obtain written consent from all members of the cohort (estimated prior to the study to be several thousand fire fighters). If individual consent had been required, it is likely that contact rates and participation would have been low and this could potentially have introduced a serious bias as well as greatly reducing the power of the study. We were approved to carry out this research without individual fire fighters' consent under the Queensland Public Health Act which allows health data to be released to researchers where it is not feasible to obtain individual consent, but the research is deemed to be in the public interest.

5.1 Storage of data and confidentiality

Data was only accessed by members of the study team at Monash. Electronic data was held on computers with password access. The computers are in offices which are kept locked out of hours and in a section of the building that is only accessible by a card key. The data will be preserved at Monash University for at least seven years after the study is completed, as is required under the Health Records Act 2001. When the data are no longer needed they will be destroyed under the supervision of the principal investigators.

Only grouped results are presented in this report, so that no individual's information can be identified. No information about an individual can be released to Queensland Fire and Rescue Services, its medical services or any other organisation or person, without the signed consent of the individual.

6 Study Methods

6.1 Assembling the cohort

The data provided by the Queensland Department of Emergency Services from their personnel files were checked for completeness by the research team before being collated and passed to QCR for matching. Around 10% of all employees were found to be employed more than once, with different employee identification numbers. The duplicates were removed through a series of queries and manual checks, and the data for each individual person combined into a unique record for the cohort.

There were 9,415 unique individuals provided to the research team by QFRS. Figure 1 is a representation of the assembly of the cohort for inclusion in the study by applying the study inclusion and exclusion criteria.

We included all employees who worked between 1st July 1995 and 31st December 2006, including both full time and auxiliary (paid part time) fire fighters. We excluded 35 individuals who were never in paid employment in Queensland during the study period according to their occupational status in the data base. These were 4 people who only had volunteer designations, 14 who only had volunteer board designations, and 17 who only had exchange designations. An additional 4 individuals were excluded as they did not have a valid date of birth recorded in the data base.

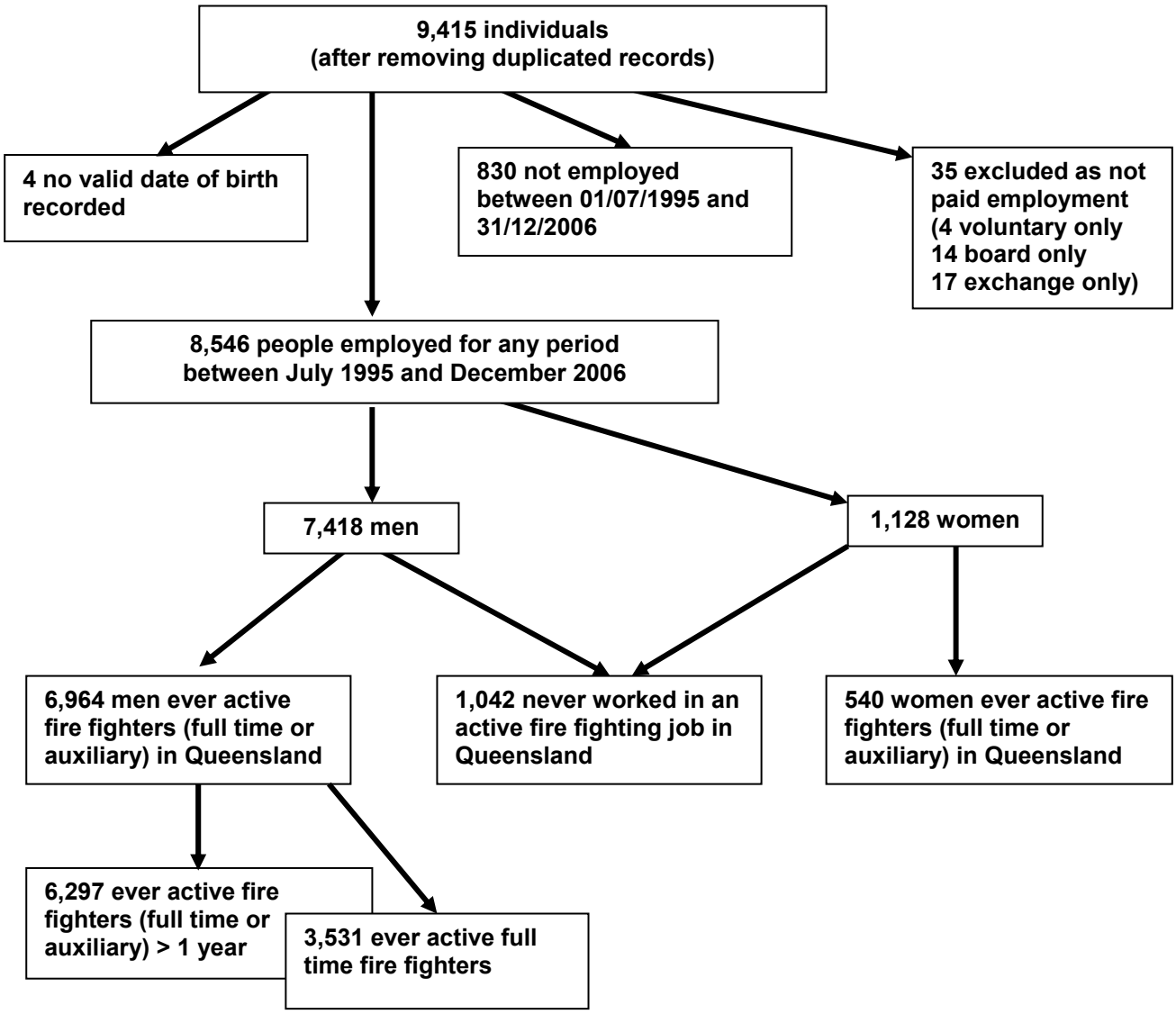

Figure 1: Cohort structure

6.2 Cohort match to Queensland Cancer Registry

A data file containing the details of cohort members was sent to the QCR for linkage to the Queensland Cancer Registry data. After the cohort was matched against the registry, QCR carried out a clerical review of probable or possible matches. The results for confirmed matches were then returned to Monash in a password protected file.

Although no linkage was done to the death registry, 42 employees were recorded as deceased in the employee job histories before 31st December 2006. The end date for each job record was assumed to be the date of death and recorded in the database.

The following data items were obtained from the QCR for each incident case:

- Surname
- Given Name
- Date of Birth
- Occupation
- Sex
- Date of Death
- Cause of Death
- Site Code in ICD-03
- Morphology in ICD-03
- Differentiation
- Behaviour Code
- Date of Diagnosis
- Basis of Diagnosis
- Laterality

6.3 Comparison data

Comparison population cancer incidence data for primary malignant tumours and benign brain tumours were obtained from the QCR for the period 1995-2006. The QCR codes cancers using the International Classification of Diseases for Oncology, 3rd edition (ICD-O3). These data comprised one record per cancer incidence case consisting of diagnosis date, age, sex, cancer site (3 digit ICD-03 code), morphology and behaviour. These were then summed into the cancer groupings required for analysis, comprising cancer incidence rates per year per 5 year age band per sex for each cancer type and category being investigated.

The behaviour field was obtained so that an incidence rate could be calculated for benign brain tumours (behaviour = /0 = benign). QCR has confirmed that the population cancer incidence data is considered complete from 1995 onwards for benign brain tumours. For all other tumours, only incidence counts of primary malignant or invasive tumours (behaviour = /3 = invasive) were obtained.

Queensland population figures were obtained from the Australian Bureau of Statistics website. These data were used to calculate age and gender specific rates for each type of cancer or cancer grouping being investigated. The QCR data was a count per cancer code and allowed flexibility in our cancer group definition.

Where people had more than one cancer diagnosed, then each primary cancer was included in the population data unless it was a recurrence of the same primary cancer.

6.4 Statistical analyses

We calculated the overall cancer SIR, the SIRs for several grouped and single cancers identified to be of interest from the literature and the SIR for benign brain tumours. In order to allow for multiple cancer diagnoses in an individual, in the calculation of the “all malignancies SIR”, all cancers were counted and the person remained at risk until the end of the period of follow up. In all other analyses the follow up ended with the diagnosis of the first cancer of that category.

We analysed the data for men and women separately because they have different rates for the cancers investigated in this study. Where very small numbers of cases were identified for specific cancers of interest, these were not separately reported to protect the privacy of the individuals concerned. As there were only 9 cancers among the female active fire fighters in the cohort, analysis of subsets and analysis by cancer type are not reported.

A further analysis was carried out restricted to those active fire fighters with at least 12 months of employment in a fire fighting job between 1st July 1995 and 31st December 2006. We also undertook an analysis just involving men who had ever been a full time fire fighter. The reason for doing these two subgroup analyses, is that these further analyses focused on those active fire fighters likely to have had more fire fighting involvement.

In summary, the following analyses were carried out:

1. SIRs for men who were ever active fire fighters
2. SIRs for men who were ever active fire fighters for more than 1 year
3. SIRs for men who were ever full time active fire fighters
4. SIRs for women who were ever active fire fighters

Table 1 Numbers of individuals in each of the analysis categories

Category	Male	Female
Ever active fire fighter, full time or auxiliary	6,964	540
Ever active fire fighter full time or auxiliary > 1 year employment	6,297	-
Ever full time active fire fighter	3,531	-

It can be seen from Table 2 that almost 50% of the men in the cohort started employment after 1995, indicating that the cohort has only been followed for a short period. Over 80% of women in the cohort became active fire fighters after 1995. The earliest active fire fighting job recorded in the cohort was 1950.

Table 2 Years of first active employment as an auxiliary or full time fire fighter

	≤1980	> 1980 to 1990	> 1990 to 1995	> 1995 to 2000	>2000	TOTAL
Men	1,022	1,391	1,190	1,621	1,740	**6,964**
Women	0	16	77	215	232	**540**

From Table 3, it can be seen that about two thirds of male active fire fighters were under the age of 46 in 2006. Most cancers are more common in older people. In 2006, at the end of follow up, the average age for ever active male fire fighters in the cohort was 43.8 years and for female ever active fire fighters the average age was 37.6 years. This cohort includes fire fighters who are currently employed as well as retired fire fighters who were employed in or after 1995.

Table 3 Distribution of year of birth for ever active male fire fighters

Year of birth	number	%
1930-1939	240	3.4
1940-1949	793	11.4
1950-1959	1,453	20.9
1960-1969	2,397	34.4
1970-1979	1,620	23.3
1980-1989	461	6.6
TOTAL	**6,964**	**100.0**

6.5 Person-years in the cohort

Men who had held at least one active fire fighting job accrued 60,464 person-years; 57,791 person-years were accrued by men who had held at least one active fire fighting job for more than 1 year; and 30,971 person-years were accrued by men who had held at least one full time fire fighting job.

Women who had held at least one active fire fighting job accrued 3,574 person-years.

6.6 SIR calculations

The calculation of SIRs used the Queensland population age-, gender- and period-specific incidence data as provided by QCR. The expected number of cases of each type of cancer was calculated based on the Queensland general population incidence rates. The SIRs were estimated by the ratio of the observed to the expected values with 95% confidence intervals and rounded to one decimal place. [15, 16]

The calculations were carried out in the STATA [17] statistical software package, version 10. The person-years contributed by each employee to the cohort was calculated using the STSET, STSPLIT, and STPTIME commands in STATA. The SIRs were calculated using the STRATE command.

For the All Malignancy analysis, subjects continued to be at risk of cancer and contribute person-years until the 31st December 2006, or date of death, whichever was the earlier date. Each subject could therefore have one or more cancers over this follow up period and any dependence between or clustering of observations was adjusted for by using jack-knife confidence intervals (cluster option on the STRATE command in STATA).

For analyses by individual cancer categories, the subjects ceased to contribute person-years as of the 31st December 2006, or date of death, or date of first cancer of the cancer category being investigated, whichever was the earlier date. Each subject was only included up until the first diagnosis of a cancer in the category being investigated.

The expected numbers of incident cancers, based on the Queensland figures, was calculated by multiplying the number of person-years in each five year age group by the Queensland cancer incidence rates for that age group for each calendar year.

In epidemiology, the convention of 95% probability is used to interpret risk estimates. This convention accepts that there is a 1 in 20 chance that an increased or decreased risk has happened by chance. When multiple comparisons are carried out, it is possible that some chance findings may be found to be statistically significant. It is important therefore not to accept or dismiss a finding based on a single risk estimate, but to interpret the risk estimate in the context of the body of information in this and previous studies. [18-22] Reducing the number of comparisons to only those that are needed to address the research questions of interest reduces the problem.

6.7 Statistical analysis quality check

The calculation of person-years and expected cancer incidence values were checked by selecting a sample of cancer categories, calculating the number of person-years per age group per year in the cohort through a SQL query in the database and applying the cancer incidence rates for that cancer category. The values were compared to that from the STATA calculation for person-years and expected values and were found to be acceptably accurate allowing for rounding error. The STATA code was checked by the Statistician and the Data Manager.

The definition of the cancer categories for the population data was checked by comparing cancer incidence counts and rates per category against the QCR Publication: Cancer in Queensland – Incidence and Mortality 1982 – 2005 – Statistical Tables.[13] There were very slight variances in the cancer incidence counts per category as this current study was using the 2006 data set, which had been modified since the 2005 report was published, but the totals and rates for various years and all categories were satisfactorily matched to the QCR report. The same cancer category definitions as used in the population were applied to the cohort.

The number of matched cancers in the database returned by QCR was compared to the number of cancers observed in each category and any discrepancies accounted for. There are several reasons why a cancer in the database was not counted in the analysis. For example, the cancer was not malignant (apart from benign brain tumours), the cancer occurred before the cohort start date (1st July 1995), the cancer occurred before the employee commenced employment with the QFRS, or the cancer was a re-occurrence of a previous cancer (same cancer category).

7 Results

7.1 Number of cancers in the cohort

A total of 217 cancers were identified among the ever active fire fighters, 208 among the 6,964 men (196 individuals) and 9 among the 540 women.

7.2 Results for men

The overall cancer SIR was not in excess among men who had ever held an active fire fighting job (see Table 4) and no individual cancer type or cancer group was found to be significantly in excess.

Of the cancer types with good or reasonable evidence from the literature, there was a non significant, but borderline, excess of melanomas SIR 1.24 (0.94–1.64) (n = 51), while all other types (including malignant brain tumours) were at or below expected levels. Among the other cancer groupings, there were no statistically significant findings. The most interesting finding in relation to the main study objectives was a non-statistically significant doubling of the expected number of benign brain tumours, SIR 2.12 (95% CI 0.69–6.59), but this was based on only 3 observed cases, so statistical power was low and the significance of the result was hard to assess.

Table 4 Cancer incidence by major anatomical site (with ICD-03 codes) in men who ever held an active fire fighting job in Queensland during the eligible period (n = 6,964)

Anatomical Site	ICD-03 Code	Observed	Expected	SIR (95%CI)
Benign brain tumours	C70-C72 behaviour = /0	3	1.4	2.12 (0.69–6.59)
Malignant tumours having good or reasonable evidence from the literature				
All malignancies	C00–C80, M800-M998	208	208.4	1.00 (0.87–1.15)
Brain & central nervous system	C70 – C72	5	4.6	1.09 (0.45–2.62)
Melanoma[†]	C44, M872-M879	51	41.0	1.24 (0.94–1.64)
Prostate	C61	33	35.6	0.93 (0.66–1.30)
Testis	C62	5	6.0	0.84 (0.35–2.01)
Bladder	C67	3	7.6	0.40 (0.13–1.23)
Non-Hodgkin lymphoma	M959, M967-M972	8	8.1	0.98 (0.49–1.97)
Multiple myeloma	C42.1, M973	<3 cases[‡]		No sig excess
Other common malignant tumours grouped by organ system				
Lip, head and neck	C00 – C14	10	13.8	0.73 (0.39–1.35)
Oesophagus and stomach	C15, C16	7	6.2	1.12 (0.54–2.36)
Colorectal	C18 – C20, C21.8	22	23.8	0.92 (0.61–1.40)
Liver, intra hepatic bile ducts, gallbladder	C22 – C24	4	2.8	1.41 (0.53–3.76)
Pancreas	C25	3	3.2	0.94 (0.30–2.91)
Larynx, trachea, bronchus, lung	C32 – C34	13	19.5	0.67 (0.39–1.15)
Kidney & other renal tract (not bladder)	C64 – C66, C68	10	6.9	1.45 (0.78–2.70)
Leukaemia & myleodysplastic diseases	M980-M994, M998	8	6.7	1.20 (0.60–2.40)

[†] Squamous cell carcinomas and basal cell carcinomas are not included
[‡] Cells with fewer than 3 cases are not reported

Table 5 shows the number of cancer cases in men, by type of cancer that occurred within 10 years, between 10 and 20 years or more than 20 years after they were first employed in an active fire fighting role in Queensland. Most cancers occurred, as expected in people who had served for more than 20 years. This is not surprising as cancer is much more common in older people. Those cancers that occurred within 10 years of first being employed are less likely to be occupationally related than those occurring more than 10 years after first active fire fighting employment. It is common to lag the person years to investigate work-relatedness of cancers; that is, only to count person years after more than 5, 10 or 15 years of work. In this study however, a lag time of 10 years would exclude any employees who started working after 1996, about 50% of men and 80% of women, which would substantially reduce the number of people include in the analyses. Therefore a lagged analysis was not performed.

Table 5 Cancer cases since 01/7/1995 by major anatomical site in men presented by length of time since their first active fire fighting job commenced in Queensland

Anatomical Site	Number	Year after started active employment as a fire fighter		
		0-10	> 10 TO 20	> 20
Benign brain tumours		2	0	1
Malignant tumours having good or reasonable evidence from the literature				
All malignancies	208	50	51	107
Brain & central nervous system	5	3	1	1
Melanoma	51	19	16	16
Prostate	33	3	5	25
Testis	5	2	3	0
Bladder	3	0	1	2
Non-Hodgkin lymphoma	8	3	1	4
Multiple myeloma	<3 cases			
Other common malignant tumours grouped by organ system				
Lip, head and neck	10	1	2	7
Oesophagus and stomach	7	3	2	2
Colorectal	22	2	3	17
Liver, intra hepatic bile ducts, gallbladder	4	0	0	4
Pancreas	3	0	0	3
Larynx, trachea, bronchus, lung	13	4	3	6
Kidney & other renal tract (not bladder)	10	1	2	7
Leukaemia & myleodysplastic diseases	8	1	4	3

Most active fire fighters in the cohort had worked for at least 12 months, so had completed basic training. The pattern of findings for this group was therefore very similar to the findings for the group of all active fire fighters. Table 6 shows that the overall cancer incidence was as expected among active fire fighters with more than 12 months active employment, SIR 1.01 (0.88–1.16). There was a higher than expected number of benign brain tumours 3 observed vs 1.4 expected, but, as for the all active fire fighters group, the excess was not statistically significant, SIR 2.20 (0.71–6.82). The malignant brain tumour incidence was as expected SIR 1.12 (0.47–2.70).

The restriction to those who had served more than 12 months in the eligible study period slightly reduced the number of eligible fire fighters. Each of the SIRs slightly increased by around 3% compared to the equivalent SIR for all active fire fighters, but the confidence intervals were also correspondingly wider and there were no statistically significant findings.

Table 6 Cancer incidence by major anatomical site (with ICD-03 codes) in men who had served more than 12 months as an active fire fighter (n = 6297)

Anatomical Site	ICD-03 Code	Observed	Expected	SIR (95%CI)
Benign brain tumours	C70-C72 behaviour = /0	3	1.4	2.20 (0.71–6.82)
Malignant tumours having good or reasonable evidence from the literature				
All malignancies	C00–C80, M800-M998	205	203.5	1.01 (0.88–1.16)
Brain & central nervous system	C70 – C72	5	4.5	1.12 (0.47–2.70)
Melanoma[†]	C44, M872-M879	50	39.8	1.26 (0.95–1.66)
Prostate	C61	33	35.0	0.94 (0.67–1.33)
Testis	C62	5	5.7	0.88 (0.37–2.12)
Bladder	C67	3	7.4	0.40 (0.13–1.25)
Non-Hodgkin lymphoma	M959, M967-M972	8	7.9	1.01 (0.51–2.02)
Multiple myeloma	C42.1, M973	<3 cases[‡]		No sig excess
Other common malignant tumours grouped by organ system				
Lip, head and neck	C00 – C14	10	13.4	0.74 (0.40–1.38)
Oesophagus and stomach	C15, C16	7	6.1	1.15 (0.55–2.41)
Colorectal	C18 – C20, C21.8	22	23.4	0.94 (0.62–1.43)
Liver, intra hepatic bile ducts, gallbladder	C22 – C24	4	2.8	1.44 (0.54–3.84)
Pancreas	C25	3	3.1	0.95 (0.31–2.96)
Larynx, trachea, bronchus, lung	C32 – C34	13	19.2	0.68 (0.39–1.17)
Kidney & other renal tract (not bladder)	C64 – C66, C68	10	6.7	1.48 (0.80–2.76)
Leukaemia & myleodysplastic diseases	M980-M994, M998,	8	6.5	1.23 (0.62–2.46)

[†] Squamous cell carcinomas and basal cell carcinomas are not included
[‡] Cells with fewer than 3 cases are not reported

About half of the active fire fighters had ever been employed in a full time capacity. Table 7 shows that the overall cancer SIR among men who had held full time jobs, SIR 1.00 (0.84–1.20), was similar to that reported for all active fire fighters. Because of the halving of the number of individuals in this analysis, some cancer types (including benign brain tumours) have fewer than 3 observed cases and so the specific results are not presented. As for the findings for all active fire fighters, no cancers or cancer types were in significant excess.

Table 7 Cancer incidence by major anatomical site (with ICD-03 codes) in men ever employed as a full time fire fighter in Queensland (n = 3531)

Anatomical Site	ICD-03 Code	Observed	Expected	SIR (95%CI)
Benign brain tumours	C70-C72 behaviour = /0	<3 cases‡		No sig excess
Malignant tumours having good or reasonable evidence from the literature				
All malignancies	C00–C80, M800-M998	129	129.4	1.00 (0.84–1.20)
Brain & central nervous system	C70 – C72	<3 cases‡		No sig excess
Melanoma†	C44, M872-M879	32	24.0	1.33 (0.94–1.88)
Prostate	C61	22	23.8	0.92 (0.61–1.40)
Testis	C62	<3 cases‡		No sig excess
Bladder	C67	3	4.9	0.62 (0.20–1.92)
Non-Hodgkin lymphoma	M959, M967-M972	5	4.9	1.01 (0.42–2.44)
Multiple myeloma	C42.1, M973	<3 cases‡		No sig excess
Other common malignant tumours grouped by organ system				
Lip, head and neck	C00 – C14	6	8.3	0.72 (0.32–1.60)
Oesophagus and stomach	C15, C16	3	4.0	0.75 (0.24–2.33)
Colorectal	C18 – C20, C21.8	13	15.3	0.85 (0.49–1.46)
Liver, intra hepatic bile ducts, gallbladder	C22 – C24	<3 cases‡		No sig excess
Pancreas	C25	3	2.1	1.45 (0.47–4.49)
Larynx, trachea, bronchus, lung	C32 – C34	8	12.8	0.63 (0.31–1.25)
Kidney & other renal tract (not bladder)	C64 – C66, C68	6	4.4	1.38 (0.62–3.07)
Leukaemia & myleodysplastic diseases	M980-M994, M998,	5	4.1	1.23 (0.51–2.96)

† Squamous cell carcinomas and basal cell carcinomas are not included
‡ Cells with fewer than 3 cases are not reported

7.3 Results for women

There were few women eligible to be in the cohort. Only 540 women were ever active fire fighters and they experienced 9 cancers of all types, whereas 7.4 were expected. The overall SIR was 1.21 (0.65–2.53). There were too few cases to report on specific types of cancer or those grouped by organ system.

7.4 Previous investigations of brain tumour occurrence

Queensland Health had previously investigated the incidence of malignant brain tumours at the Atherton fire station.[1] That investigation did not include benign brain tumours.

In the current study, 82 employees of QFRS who worked at Atherton for any period between 1995 and 2006 were identified from the employment records. This matched the number of employees found in the Queensland Health report.[1]

The Queensland Health report identified 3 malignant brain tumour cases among those who had worked at Atherton, but one was diagnosed in 1992 which was outside the eligible time period of the current study. The two other malignant brain tumour cases were identified in the match by QCR and are included in the current analysis. No other brain cancer cases (malignant or benign) were found among those members of the cohort who had worked at Atherton. Three further malignant brain tumours were found in male fire fighters who had worked various different sites in Queensland.

Of the 3 benign brain tumours which were identified, none occurred among active fire fighters who had ever been employed at Atherton according to the employment histories provided.

8 Discussion

8.1 Cancer Incidence

The overall cancer SIRs for men and women fire fighters were around 1.00, i.e. they match the expected numbers for men and women of this age distribution in the Queensland community. The SIRs for most of the individual male cancers with good or reasonable evidence of a link with fire fighting were also below or close to 1.00, apart from those discussed further below.

There was a non-statistically significant doubling of incidence of benign brain tumours among men who ever worked in an active fire fighting job during the period of the study, but the number of cases was small, so the confidence intervals are wide and this result did not reach statistical significance. None of these cases had worked at Atherton in the study period.

The incidence of malignant brain tumours is not raised in any of the groups of male fire fighters analysed.

Among male active fire fighters there is a non significant but borderline excess of melanomas SIR 1.24 (0.94–1.64) (n = 51). Melanoma is a cancer that has been found to be in excess in previous reviews of studies of fire fighters.[6, 7] The incidence of the category of kidney and urinary tract cancers is a little higher than expected (about 50% higher), but is not statistically significant, and is based on few observed cases (n = 10). None of the other cancer incidence categories which were analysed in this study had higher than expected results.

Restricting the male analysis to those fire fighters with more than 12 months active fire fighting slightly increased the SIRs, including those for melanoma and kidney and urinary tract cancers. The increase was small, however, and the results still did not reach statistical significance for these cancers. Restricting the analysis to full time active fire fighters showed a pattern consistent with the findings for all active fire fighters, but the numbers of cancers became very small, resulting in wider confidence intervals for the SIRs. These subgroup analyses of full time fire fighters and those working in excess of 12 months suggest that risk of cancer did not increase with increased fire fighting time.

8.2 Confounders and possible sources of bias

Information on other potential risk factors for cancers, which could potentially confound our findings, such as sun exposure, cigarette smoking, alcohol intake and dietary factors, was not recorded in the Queensland Department of Emergency Services database, nor in the population cancer data and thus cannot be adjusted for in the analysis. These are only likely to be important factors where the pattern among fire fighters (such as smoking rates) is significantly different from those in the general community. We are unable to access any information sources which could compare these factors in fire fighters and the general Queensland community.

Sources of bias include participation bias, i.e. where entry into the cohort is not complete and where those included have a different risk of cancer than those not included. To minimise this bias, we included all eligible fire fighters who were in the Queensland Department of Emergency Services personnel database between 1st July 1995 and 31st December 2006, so we are confident that enumeration of the cohort is complete. This would not be the case if we had relied on volunteers to enter the cohort, as cancer rates in volunteers are likely to be different from non-volunteers, meaning the inclusion of only volunteers may have affected the findings and their interpretation.

Fire fighters (and any cancers which they developed) who had left employment with QFRS prior to 1995 could not be included as it was not possible to ascertain the complete number of employees nor the required identifying factors for the cancer match. This was a further reason for the low statistical power of the study.

The *Healthy Worker Effect* is usually seen more strongly in mortality studies than in cancer incidence studies. The *Healthy Worker Survivor Effect* may have occurred among the population hired before 1995, so that less healthy individuals had left the workforce, before the cohort was established.[4] The cohort would need to be followed for longer to reduce the effect of this potential bias.

We did not undertaken a death registry linkage, so employees continued to contribute person-years until the 31st December 2006 or death date for those people for which it was recorded on the employment records. This is likely to have resulted in a small over estimate of person-years and expected values, as some of the employees are likely to have died after they left employment, but

were still assumed to be alive up until the end of the study period. Therefore, the calculated SIRs may have been slightly lower than would have been the case if all deaths (and dates) were known and the person-years adjusted accordingly.

There was some uncertainty about whether some employees, particularly those whose occupational status was temporary or casual, should have been categorised as full time. For the ever full time fire fighter analysis in this report, the numbers in this uncertain category would have been small and so the possible misclassification is likely to have been minimal.

8.3 Other potential study limitations

It is possible that some people who were eligible to be in the cohort may have left Queensland and, if they had been diagnosed with cancer, their cancers would have been diagnosed overseas or in other states and reported to other cancer registries. As this study only matched with data in the QCR, this means that cancer cases occurring in such people would not appear in the findings of this study. Therefore, the findings reported here could potentially underestimate the true incidence ratios. As this is unlikely to involve many cases, it is unlikely that this would have had a large effect on the findings, but it is a factor which influences the strength of the conclusions.

The statistical power of this study is limited by the number of employees eligible to be included, which was influenced by the fact that we could only start the study period in 1995. The follow up time is short so that few cancer cases would be expected among this population. Power was particularly low for the women fire fighters in the cohort. Only about 7% of the active fire fighters were women (n = 540), so we could not analyse this group for specific types of cancer and results could only be presented for all cancers. There was a greater ability to analyse by specific cancer types for the males in the cohort, but power was still low for most of the cancer types.

The complete job history was provided for all fire fighters who were in employment on 1st July 1995; some fire fighters in the cohort had a long exposure history. The earliest active fire fighting job recorded in the cohort was 1950. However, many of the active fire fighters, almost 50% of the men and over 80% of women in the cohort, started employment as an active fire fighter after 1995. This limits the power of the study to detect work-related cancers. Most solid tumours have a 5-10 year latent period between first exposure and disease diagnosis.[23] A longer follow up of this cohort is therefore desirable.

We have not conducted analyses to examine the sensitivity of the results with regards to latency periods (being from time of first exposure to a specific agent to cancer diagnosis) as recommended in the Queensland cluster investigation document.[2] Latency periods of (say) 5,10 and 20 years can be used in examining cancer risk, but given that the follow up time of this cohort is only 11 years, the resulting low number of cases and person-years means it is not feasible.

In addition we do not have a specific exposure under investigation as a risk factor apart from work as a fire fighter and no specific occupational risk factors (such as exposure to vehicle fires) have been investigated. Fire fighters can be exposed to a number of different substances in the course of their work including particulate matter, volatile organic compounds, carbon monoxide and diesel exhaust.[24] Apart from limiting the analysis to include those with only more then one year of active fire fighting service, or only fulltime work, we have not examined any further the risk with duration of employment, or with any specific workplace exposures, or the number and types of fire fighting incidents attended. The availability and quality of exposure incident data was not examined as it was beyond the scope of this current study. However, it was unlikely to be feasible to examine such issues in this cohort given the relatively small cohort size and length of follow up time. The study was too small to enable rates for different exposure groups to be calculated except on the basis of broad occupational status and duration, which are at best crude estimates of exposure.

It is probable that fire fighters would be outside for at least part of the day and hence could experience more exposure to sunlight than the general Queensland population. Sunlight is of course a known risk factor for melanoma.[25]

The other potential study limitation is the likelihood of chance findings, based on a large number of analyses being done. We limited the number of analyses to be undertaken and this minimised the likelihood of statistically significant findings occurring by chance. Another important factor was classifying the cancer types in the study hypothesis into those with greater or lesser evidence from the literature.

9 Conclusions

Overall cancer incidence was as expected for the males and females in the cohort and no individual cancer type or group was found to be significantly in excess for men.

The rate of malignant brain tumours were found to be as expected in the cohort. Benign brain tumours were found at about double that expected, but the number was small (n = 3) and this excess was not statistically significant. None of these cases had ever worked at Atherton.

Melanoma was found in a borderline statistically significant excess in male active fire fighters.

Kidney and urinary tract cancers were also a little elevated, but numbers were low and the findings were not statistically significant.

Restricting the analysis to those fire fighters likely to have more fire fighting experience (those working for at least 12 months and those who have ever worked full time) made little difference to the overall cancer patterns, suggesting that more fire fighting work did not increase cancer risks. However these are crude measures of exposure and few fire fighters had worked for less than 12 months so little difference was expected in the risks for these groups.

Enumeration of the cohort is thought to be very complete but it is possible that some cancers may have been registered overseas or interstate and thus would not have been included in the study. A slight underestimation of the SIR may also have occurred if some of the eligible fire fighters had died after leaving employment. It is not likely that these possible sources of error would have had a major impact on the risk estimates. Possible bias from sun exposure, smoking, alcohol or diet cannot be ruled out.

The small size of the cohort, particularly the small number of women, limits the ability of the study to definitively rule out excess cancer incidence for specific cancer types. However, this study provides some reassurance that no excesses of cancer have occurred in Queensland fire fighters since 1995, although the above limitations affect the strength of this conclusion to some degree.

More definitive results in relation to brain tumours, melanoma and urinary tract cancers, would be obtainable through a national fire fighter cancer and mortality study, particularly if this was to include a prospective element collecting data on fire fighters' occupational exposure and information on lifestyle factors.

10 Abbreviations

CI	95% confidence interval
MM	multiple myeloma
MonCOEH	Monash Centre for Occupational and Environmental Health
NHL	non-Hodgkin lymphoma
NHMRC	National Health and Medical Research Council
IARC	International Agency for Research on Cancer, a WHO organisation
ICD 03	International Classification of Diseases for Oncology, 3rd edition
OR	odds ratio compares the risk or odds of an outcome such has cancer between exposed and unexposed groups
QCR	Queensland Cancer Registry
QFRS	Queensland Fire and Rescue Service
RR	relative risk, is calculated by dividing the probability or risk of an event such as cancer in one group with the probability of the risk in another group
SCERH	Monash University Standing Committee on Ethics in Research involving Humans
SIR	standardised incidence ratio is a ratio of the number of cases observed in the cohort compared with the calculated "expected" number which would arise in a comparison group of the same age and sex
SRE	summary risk estimate, overall risk estimated from a meta analysis

11 Appendix 1 – Employment Categorisation

11.1 The cohort employment records

The 10,413 individual records were reviewed and any duplicates (same Surname / First Name / Date of Birth, etc) were merged into the one cohort record with a unique Queensland Fire Fighter cohort identification number. Around 10% of the employees provided has worked terms of employment with different employment numbers, so a unique set of 9,415 employees was identified, from which the fire fighter cohort was identified. The Queensland Fire Fighter cohort identification number was linked to one or more QFRS employment identification numbers, so a complete employment history was recorded, even if the employee had worked under different employment identification numbers.

Most employees had held more than one job or position title across more than one occupational status in the database.

11.2 Full time vs auxiliary employment

Full time and auxiliary employment categories were identified using the occupational status provided in the employee job history. Auxiliary fire fighters were defined as those who ever held a job with an occupational status of auxiliary. Full time fire fighters were those who ever held a job with any other designation that was not auxiliary, except for those jobs with volunteer, board or exchange occupational designation.

There were cases where the occupational status for an individual's job was permanent, higher duties, etc, but the position title included the term "auxiliary". In these cases, the job was categorised on the basis of the occupational status i.e. as a full time job rather than auxiliary. There were 175 participants matching this criterion where the occupational status for at least one of their jobs was not certain. However, the majority of these individuals held at least one other job which was designated as auxiliary. Only 11 of these 175 participants were categorised as "never auxiliary".

11.3 Occupational status as casual or temporary employment

526 employees held at least one job where the occupational status was casual. Of these, only 87 held position titles categorised as active fire fighting roles, mainly in training. These 87 employees have been included in the active fire fighters analyses.

1,173 employees held at least one job where the occupational status was temporary. 794 of these temporary jobs were in active fire fighting roles and all of the subjects in these jobs held another non-temporary active fire fighting job, so were therefore included in the ever active fire fighter analyses. 448 worked in another active job that was neither temporary nor auxiliary, and were included in the full time fire fighter analyses.

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