MONASH University

Fiskville Firefighters' Health Study

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MONASH Centre for Occupational and Environmental Health

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1 Summary

In late 2011, concerns were raised about the possible health impacts of training practices at the Country Fire Authority (CFA) Fiskville Training College dating from the 1970s. The CFA commissioned a report into the materials and practices at Fiskville which recommended, among other things, that a health impact study should be carried out, taking into account different levels of exposure.[1] As part of this, the CFA commissioned Monash University to investigate the risk of cancer and mortality for individuals grouped according to the Joy Report, as being likely to have had a high, medium or low risk of chronic exposure to a variety of materials.[1]

The CFA assembled a data set of five women, and 611 men who had either been trainers or had been trained at Fiskville between 1971 and 1999. These individuals were categorised into High, Medium and Low groups by the CFA. Two women did not appear to have been involved in training at Fiskville and were excluded from the cohort. In addition, there were eight men who had no date of birth, who were excluded due to difficulty linking with the cancer and death registries. The final cohort of 606 people included three women, and had 95 men in the High group, 256 men in the Medium group (105 career firefighters and 151 volunteer firefighters) and 252 men in the Low group.

The cohort was linked to the National Death Index and Australian Cancer Database (both held by the Australian Institute for Health and Welfare) and to the Victorian Cancer Registry. No deaths or cancers were identified for the three women in the cohort. There were 28 deaths and 69 cancers identified among the men in the cohort.

Overall the incidence of cancer was not raised in the cohort as a whole. When compared to the Victorian population, higher than expected cancer rates were observed for melanoma and cancer of the testis in the High group and for brain cancer in the Medium group.

When compared to the Victorian population and to the Australian-born Victorian population, the overall cancer risk was significantly raised for the High group, it was similar to that of both these reference groups for the Medium group and was significantly reduced for the Low group.

When compared to the Low group, there was a statistically significantly increased cancer risk for the Medium and High groups, but the number of cancers in the Low group was very small, resulting in a lot of imprecision in the results and this is likely to impact on the robustness of these findings.

When compared to the general Australian population, the overall mortality was statistically significantly decreased for the whole cohort and for the Low and Medium groups within the cohort. This reduction in mortality may be due, at least in part, to the healthy worker effect. For the Low group and the volunteer firefighters in the Medium group in particular, the low mortality may also be a result of an ascertainment bias, that is some individuals who had died may have been less likely to have been identified and included in the cohort. The mortality for the career Medium group and the High group was also reduced but not statistically significantly so.

This study had several limitations, including small numbers in the cohort of firefighters and even smaller numbers when the Low, Medium and High group were examined separately, resulting in considerable imprecision in the findings. There are also concerns about the completeness of the cohort, especially for the Low group and Medium volunteer subgroup and for those who have already died. The lack of information on other lifestyle factors which are known to be related to cancer risk, limitations in the probabilistic matching with the cancer and mortality registries, and difficulty in assigning a start date for work at Fiskville from the variety of data sources provided mean that the findings should be interpreted cautiously.

To try to assess the impact of the several limitations in the completeness and quality of the data used in this study, several uncertainty analyses were undertaken, based on different assumptions about incomplete data. Most of these sensitivity analyses did not result in major differences in the pattern of the findings, which suggests that the study limitations may not have greatly affected the validity of the findings.

Undertaking future linkages when more cancers and deaths will have occurred will provide more robust findings.

2 Background

The CFA Training College, at Fiskville in Victoria, was used by CFA from 1970s onwards for general firefighting training, but had many other uses, including live-in training for CFA career firefighters, fire training for corporate clients and training with Metropolitan Fire Brigade firefighters.[1] Fiskville was also the main training centre for three adjoining CFA volunteer regions.

In late 2011, concerns were raised about the possible health impacts of training practices at the CFA Fiskville Training College. Following these concerns, CFA initiated an investigation into the materials and practices used at Fiskville. This was chaired by the former Deputy Chairman of the Victorian Environment Protection Authority and Adjunct Professor at RMIT, Robert Joy. One of the key recommendations of the Joy Report was to conduct a health impact study to examine any possible linkages between exposure to hazardous materials at Fiskville and health effects taking into account different levels of exposure.[1]

The CFA commissioned Monash University to undertake a study to investigate the risk of cancer and mortality of certain groups of people identified in the Joy Report, as being likely to have had a high, medium or low "relative risks of chronic (i.e. long-term) exposure" to a variety of materials.[1]

The Monash investigators had already been commissioned by the Australasian Fire and Emergency Service Authorities Council (AFAC) to carry out a national study of firefighters' mortality and cancer incidence known as the Australian Firefighters' Health Study and the Fiskville study became a substudy within that larger national study.

2.1 Exposures during firefighter training at Fiskville

The Joy Report presented information on the range and types of exposures at Fiskville. The following materials were listed in the Joy Report as likely to have been used in hot fire training: aviation fuel, crude oil, diesel, kerosene, liquefied petroleum gas, leaded and unleaded petrol, sump and waste oils, methanol, paint thinners, solvents, cars, crates, hay/straw, mattresses, pallets, plastics, tyres and wool. The report noted however, that there were few records from the 1970s about the exact materials used.[1] In addition a variety of firefighting foams were used in training and a number of other substances were used as demonstration materials in the HAZMAT shed, including aluminium, chlorine, magnesium shavings, red phosphorous, sodium and sulphur.

Hot fire training includes setting fire to materials in a variety of simulated scenarios and then training in fire suppression. Some work has been done overseas on the exposures

encountered in firefighting training when burning a variety of materials in different simulators. Exposures measured in the atmosphere and by biomonitoring has shown that exposure varies with the materials burned. For example burning plywood and chipboard gives rise to more pollutants than burning pure pine or spruce and the exposures measured during propane burning were the lowest.[2]

Most of the firefighter trainers in the Fiskville study are also likely to have experienced exposures relevant to usual firefighter duties prior to, alongside and/or after their training role. Most firefighter trainees will also have been exposed to similar hazards in the course of their firefighting activities.

During the course of their work, firefighters can routinely encounter a wide range of hazards. At a fire scene, firefighters are potentially exposed to various mixtures of particulates, toxic gases and fumes and many oxidation and pyrolysis products, including many known or possible carcinogens.[3-8]

Exposure can occur by inhalation, particularly if firefighting was carried out without the use of breathing apparatus (BA). However work on "smoke diving" in simulators by firefighters using BA, showed that exposure to polycyclic aromatic hydrocarbons (PAHs) through dermal routes could be significant.[9]

2.2 Health effects of firefighting

The scientific literature indicates that the overall mortality rate in firefighters may be lower than that of the general population, but this is probably explained by the healthy worker effect.[10-12] This effect is, at least in part, a result of the selection of fit and healthy people to become firefighters.

There is good evidence that firefighting is associated with an increased risk of cancer.[13] Several studies have shown an increased risk of the following cancers: testicular cancer, prostate cancer, non-Hodgkin lymphoma and multiple myeloma.[10, 11] There is also some evidence that firefighting is associated with the following cancers: leukaemia, malignant melanoma, mesothelioma and cancers of the buccal cavity/pharynx, stomach, colon, rectum, skin, brain and bladder.[10-12, 14-16]

There is limited evidence that there is an increase in cardiac mortality associated with firefighting particularly close to an alarm or turnout.[17-19]

Little evidence was found in the scientific literature about the risk of mortality or cancer incidence for volunteer firefighters.

3 Study Aims and Objectives

Following the recommendations of the Joy Report, the specific aims of the Fiskville study were, where sufficient numbers permitted, to:

- Investigate the overall mortality rate for CFA Fiskville trainers and trainees compared to the general Australian population.
- Compare the overall mortality rate between the High, Medium and Low groups.
- Investigate the overall cancer incidence for CFA Fiskville trainers and trainees compared to the general Victorian population.
- Compare the overall cancer incidence rate between the High, Medium and Low groups.

4 Study Design

4.1 Cohort definition and assembly

This study was a retrospective cohort study, involving a cohort that was assembled by the CFA from employee and volunteer human resources (HR) records, photographs of groups of trainees, information from issues of the in-house magazine 'The Fireman' and snowballing from personal contacts associated with Fiskville. HR records were incomplete from that period and that is why other, less complete, methods were used to supplement the available HR records. The cohort aimed to include all male and female firefighters who worked or trained at Fiskville for any period of time between 1971 and 1999, which was the period of interest identified in the Joy Report.[1]

Firefighters who were identified by the CFA as being at Fiskville during the study period were assigned by CFA into High, Medium or Low groups, based on whether a cohort member had worked in a particular job or had been a trainee at Fiskville (Table 1). This categorisation was based on the three groups defined in Table 7.1 of the Joy Report as ranked categories of risk of "chronic exposure" to flammable chemicals, combustion products, foams and recycled firewater.[1] The methods used by the CFA to identify the individuals to be included in the cohort and to compile the data set are described in the CFA-prepared document, which is attached as Appendix 1, entitled CFA Data Set Compilation Methodology for the "Cancer Incidence and Mortality Study – Fiskville".

The CFA offered all potential cohort members the opportunity to opt out of the study. Public Notices were placed in several newspapers and the message was further reinforced internally to all CFA members and in CFA's direct communication with potential cohort members. A small number of individuals (n=11) chose to opt out of the study, and accordingly the data pertaining to those individuals were not provided to Monash (Appendix 1). The cancer status of these individuals was not known but presumably they were alive in 2012 in order to opt out of the study, unless consent had been provided by a family member.

Table 1 shows the numbers of records sent to Monash. It does not include individuals who opted out of the study.

Table 1. After Table 7.1 "Qualitative Assessment of Relative Risks of Chronic Exposure of Various Groups – Fiskville [1971-1999]" [1]

Groups	Overall relative risk of chronic exposure	Number of records supplied to Monash
PAD Workers, Instructors (full-time)	High	96
Volunteer & paid Regional Staff Instructors	Medium	260
Paid Trainees (practical firefighting)	Low	260
Total		**616**

*PAD means Practical Areas for Drills

5 Ethics Committee Approvals

Monash investigators were granted approval from the Monash University Human Research Ethics Committee with a waiver of individual consent.[20] A waiver of the individual consent requirement can be approved by an Ethics Committee when gaining individual consent would likely result in flaws in the conduct of the study, and where the public interest outweighs any infringement of privacy. The CFA provided a letter of approval for the Ethics Committee authorising the release of personal identifying information and occupational history data to Monash University for the purposes of the study.

Ethics committee approval was also granted by Human Research Ethics Committees (HREC) for each of the Australian State and Territory Cancer Registries and the Australian Institute of Health and Welfare (AIHW) HRECs. The AIHW is the custodian of the National Death Index (NDI) and the Australian Cancer Database (ACD), which were used to identify causes of death and cases of cancer in the study. In addition, approval was provided by State Cancer Registry data custodians and Chief Health Officers, where required. While Fiskville is located in Victoria and most of the cohort is still likely to be based there, some cohort members are likely to have moved interstate and the study team sought approval for a national search of cancer registries to identify cases of cancer diagnosed interstate.

After receipt of all necessary Cancer Registry ethics committee approvals, additional approval for data linkage was granted by the AIHW. In respect of the deaths that had been subject to coronial enquiry, approval was also granted by the National Coronial Information Service (NCIS) managed by the Victorian Department of Justice. Additional Coroner approvals were obtained for Western Australian and Victorian Coroner's cases.

6 Methods

6.1 Study advisory committee

The Monash investigators had already been commissioned by the Australasian Fire and Emergency Service Authorities Council (AFAC) to carry out a national study of firefighters' mortality and cancer incidence known as the Australian Firefighters' Health Study. This study had an Advisory Committee whose membership was drawn from AFAC, firefighter agencies, trade unions and volunteer firefighter organisations. When the Fiskville study began, the CFA nominated an individual to represent the Fiskville firefighters on this committee.

At his request, Mr Kieran Walshe the Independent Monitor for the Fiskville investigation was briefed about the study in April 2013.

6.2 Data extraction and quality assurance

The CFA supplied Monash University with records for individual firefighters assembled onto a password protected spreadsheet sent via secure file transfer services. The state and national Cancer and Death Registries require several personal identifiers, such as full name and date of birth, in order to link the individuals in the cohort with records held in these registries. The data identified individuals that the CFA believed were deceased and provided their date of death, where known. The data items requested from CFA are listed in Appendix 2.

The data were uploaded into a database and several quality checking procedures were applied. Details of the data handling and checking procedures are provided in Appendix 3.

There were eight individuals with missing dates of birth. The original file from CFA had ten missing birth dates, of these two were identified after the original data set had been provided by CFA.

6.3 Presence at Fiskville

Fiskville employment dates were provided from CFA HR systems for all members of the Low group and for most members of the Medium and High groups. The members of the Medium and High groups were sent a questionnaire by the CFA in which they provided self-reported dates of when they carried out training at Fiskville. Almost all of the members of the High and Medium group returned questionnaires. In some cases, the two or three sources provided conflicting information about when an individual was at Fiskville. In these cases,

each record was examined by Monash researchers and a HR defined Fiskville start date and a self-reported Fiskville start date were identified, being the earliest date of employment at Fiskville recorded.

A small number of records (n=10) had a Fiskville start date imputed by Monash investigators, because no HR start date or Fiskville self-reported employment period was provided with the data from CFA. These imputed start dates were based on the individual's birth date and likely age of first employment, or agency employment/volunteer commencement date. This imputation makes the person-years contributed by these individuals uncertain. The individuals were all volunteer firefighters in the Medium Group who did not have a HR start date and who did not provide a self-reported start date from the questionnaire. This may be because they had moved away and did not receive the questionnaire or were sick or had died.

There were 128 other individuals who only had a self-reported start date, i.e. no Fiskville start date in any HR database record.

Two ineligible women were removed from the cohort before linkage because the records supplied to Monash investigators did not show that they had worked as firefighter trainees or trainers at Fiskville.

6.4 Cohort start and end dates

For the analysis, each cohort member was followed in terms of person-years and cancer or mortality events from a cohort start date. The cohort start date for each cohort member at Fiskville was 01/01/1980 for the death analysis, and 01/01/1982 for the cancer analysis, or the date of first employment at Fiskville, whichever was the later date. This was the date from when each cohort member began to contribute person-years to the analysis. The 01/01/1980 and 01/01/1982 dates were chosen as these were the earliest dates for which the national death data and the national cancer data were available.

Any cancers and/or death occurring after the start date for each cohort member were included in the analyses up until 30/11/2011 for deaths, and 31/12/2012 for cancers, being the last dates for which the national death data and national cancer data respectively, were complete. A cohort member ceased to contribute person-years after their death. Population cancer and mortality reference data from these years were also obtained, so that comparison population risk estimates could be calculated.

The Joy Report states that Fiskville trainers did not start hot fire training until 1974. (page 70, [1]) There were two members of the High group who did not appear to have been employed at Fiskville after 1973. Both of these individuals were included in the linkage process.

6.5 Data linkage

The cohort data sent to the AIHW and the Victorian Cancer Registry (VCR) for linkage included: surname, given name(s) and previous name (where known), sex, date of birth and date of last contact. The linkage with the VCR was undertaken, as it was likely that most cancer cases were diagnosed in Victoria and also because the VCR had more recent cancer cases than the ACD. It also provided a check on the Victorian cancer linkage data provided by the AIHW.

Data were sent from Monash to the VCR and AIHW for cancer incidence linkage and to the AIHW for mortality linkage using a secure file transfer service. Linkage results were sent back to Monash using the VCR or AIHW secure file transfer service.

6.5.1 National Death Index

The cohort data was linked to the NDI by the AIHW. At the time of linkage in 2013, the NDI was nationally complete from 01/01/1980, until 30/11/2011 for cause of death coding. The NDI had collected deaths until mid-2013 but the cause of death was not coded so these individuals could not be included in the analyses presented here.

The NDI used a probabilistic linkage program to identify likely and possible matches with existing death records and scored each match with a weight as to the probability of it being a true match. The possible matches were supplied to the Monash researchers for a clerical review and final decision on which records were to be accepted as true matches.

6.5.2 Australian Cancer Database

The ACD was nationally complete from 01/01/1982 to 31/12/2010 except for the ACT and NSW, which were only complete until the end of 2009. Cancers diagnosed after this period outside of Victoria, (see below) were not included in the linkage.

The ACD also uses a probabilistic linkage program to identify possible matches with existing cancer incidence records and these were reviewed at the AIHW to identify likely matches which were then sent to Monash.

A clerical review was carried out by the AIHW for all Fiskville firefighters. The clerical review looked at all possible cancer linkages for each matched member of the cohort and selected the best matches. For privacy reasons the AIHW was not able to release identified individuals for the clerical review to be carried out by Monash investigators and a de-identified lists of cancer cases was returned to Monash University.

6.5.3 Victorian Cancer Registry

All the Fiskville cohort members' data were also sent to the VCR for linkage to the registry data and to identify early cancers not captured by the ACD. The VCR data were complete from 01/01/1982 to 31/12/2012 but the VCR includes some cancer cases diagnosed before 1982. The VCR-derived data were used as the base set of cancer data for these analyses because it was complete to a later date than the national data. (Additional interstate cancers from the ACD were added to these data.) Victorian cancer data were complete until the end of 2012, but cancer data from other states were only complete to the end of 2010 (end of 2009 for NSW/ACT).

6.5.4 Quality control measures for death and cancer linkage

Those cohort members who left CFA before 1980 were also compared to historic death records available from Victoria, Queensland, NSW and ACT in order to identify possible matches occurring before the NDI registration was complete in 1980. This was to remove deceased members from the cohort who would have never appeared in the national linkage because they had died before the NDI commenced. No cohort members who left before 1980 were identified as deceased through these searches.

The names of individual firefighters who appeared in the media in relation to Fiskville, were noted and their deaths and cancers (where identified) were cross checked with the VCR, ACD and NDI data to ensure that they had been correctly ascertained.

The data from the VCR and AIHW was also validated in the following ways:

- NDI cancer deaths were compared to the ACD/VCR cancer incidence matches to ensure that all cancer deaths had also been registered as incident cancers.
- Death notifications which were provided by the CFA were checked against possible death matches to ensure all deaths were correctly ascertained.

6.6 Classification of causes of death and cancer

The International Classification of Diseases (ICD) coding system has been used in this study to report causes of cancer and death, which enables comparison with other studies.

Cause of death for death notifications was coded by the Australian Bureau of Statistics (ABS) according to ICD-9 [21] for records up to the end of 1996, and according to ICD-10 [22] for records from 1997 onwards. Together with the introduction of the ICD-10, the ABS implemented the Automated Coding System (ACS) in 1997 for processing deaths. The ACS provides more consistent coding practices and has enabled more efficient production of statistics for multiple causes of death since 1997.

Applicable ICD-9 codes and ICD-10 codes were grouped in similar broad categories such as 'All Malignancies' or 'All Injury and Trauma' which includes all external causes (Table 2). All deaths were counted in the 'All Death Causes Combined' category and every death was assigned to a broad death category classification, including an 'Other' classification which captures all deaths that were not assigned to one of the major groups of deaths.

Table 2. Cause of death classification in ICD-9 and ICD-10 used in this study

Cause of death	ICD-9 codes (1983-1996)	ICD-10 codes (since 1997)
All Malignancies	140 - 208, 238.4, 238.6, 238.7, 273.3, 273.8, 273.9	C00 - C97, D45 - D46, D47.1, D47.3
All Circulatory	390 - 459	I00 - I99
All Respiratory	460 - 519	J00 - J99
All Digestive	520 - 579	K00 - K93
All Injury and Trauma	E800 - 999	V01 - Y98
All Other Causes		
All Death Causes Combined	000 - 999	A00 - Z99

All cancer incidence records at the VCR and nationally in the ACD were coded according to ICD-10. Therefore, categories of cancer-type, based on ICD-10 codes, were grouped to a broad cancer category (Table 3). Where the numbers of cancers were very low they were amalgamated into the 'Other and Unknown' category.

Where a cancer had spread, only the site of the original primary cancer was included in the results. However, if a person was diagnosed with more than one primary cancer then all of the cancers were included in the analyses.

Table 3. Cancer classification in ICD-10 used in this study

Cancer Categories	ICD-10 codes
Lip, Buccal Cavity and Pharynx	C00-C14
Digestive Organs (Oesophagus, Stomach, Colon, Rectum, Liver, Pancreas)	C15 - C25
Colorectal	C18-C21
Respiratory and Intra Thoracic System (Lung and Larynx)	C30 - C38
Melanoma	C43
Male Reproductive System	C60 - C63
Prostate	C61
Testis	C62
Urinary Tract (Kidney and Bladder)	C64 - C68
Brain and Nervous System	C70 - C72
Lymphoid, Haematopoietic and Related Tissue (LH cancer) (Non-Hodgkin Lymphoma, Multiple Myeloma, Leukaemia, Myelodysplastic Syndrome, Myeloproliferative Disease)	C81 - C96 D45 - D46, D47.1, D47.3
Other and Unknown	
All Malignancies	C00 - C97, D45 - D46, D47.1, D47.3

6.7 Analysis and statistics

6.7.1 Groups for statistical analyses

Each cohort member had been assigned by CFA to one of the three groups, High, Medium or Low and all person-years and cancer or death events were similarly assigned to those groups. If a cohort member had held a position in more than one of the groups, they were assigned to the higher group for the purpose of the analyses. People in the Medium group who held both a career and volunteer position were assigned to the career group.

There were too few women (n=3) to estimate their risks in a meaningful way, so the statistical analyses present the results for men only.

The mortality and cancer incidence of the men in the whole cohort were identified. The men in the High, Medium and Low groups were then separately compared to the mortality of the general Australian population and the cancer incidence of the general Victorian population.

The risks for the Medium group were further examined when divided into career and volunteer firefighters because these two groups have different selection criteria to become firefighters and were likely to have had different firefighting exposure and employment histories.

6.7.2 Statistical analyses

The data for men were analysed by comparing the mortality of the cohort with that expected based on the Australian national population data, because the death linkage was undertaken at a national level. The population reference rates were taken from data published by the AIHW.[23]

The cancer incidence in the cohort was primarily obtained from the VCR and so it was compared to the cancer incidence of the general Victorian population, also provided by the VCR.[24] State rates of some cancers can differ e.g. for melanoma, so state cancer incidence rates were the most appropriate comparison for this cohort.

The numbers of observed deaths and cancer cases were compared to the numbers expected based on age and sex standardised rates from the reference populations and the risks (SMR: Standardised Mortality Ratio and SIR: Standardised Incidence Ratio) were estimated from this comparison using Stata software.[25] More details about the statistical methodology are presented in Appendix 4.[26]

The overall SMR was calculated for all men and separately for each of the High, Medium and Low groups and, where numbers permitted, SMRs were calculated for the major causes

of death categories. The SMRs for the Medium group separated into career and volunteer firefighters were also calculated.

The overall SIR was calculated for men and separately for each of the High, Medium and Low groups and, where numbers permitted, SIRs were calculated for the major cancer categories. The SIRs for the Medium group separated into career and volunteer firefighters were also calculated.

An internal comparison was undertaken for men in the three groups, to calculate the Relative Mortality Ratio (RMR) for overall mortality, and the Relative Incidence Ratio (RIR) for overall cancer risk among the High and Medium groups compared to the mortality and cancer incidence of the Low group.

6.7.3 Sensitivity analyses

The following sensitivity analyses were undertaken to investigate the effect on the risk estimates of the data limitations.

1. Investigation of lower than expected mortality for the Low group

The overall mortality risk for the Low group was calculated with follow up commencing only from 1998 because examination of the records for the Low group suggested that ascertainment of this group is likely not complete before this date.

2. Removing those with no Fiskville start date from HR records nor from self-report

Death and cancer incidence rates were re-calculated for those cohort members with a job history drawn from the one of the HR data sources or from a self-reported job history. This removed ten Medium group volunteer firefighters with no recorded Fiskville start date from any source.

3. Removing those with no Fiskville start date from HR records

Overall death and cancer incidence risks were re-calculated for only those cohort members with a job history extracted from one of the HR data sources, removing 139 individuals with no HR-sourced Fiskville start date. This excluded nine members of the High group and 130 members of the Medium group, of which 64 were volunteer and 66 were career firefighters.

5. Comparison of overall cancer risk with Australian-born Victorians

Monash was not provided with any country of birth data for cohort members. However if it is assumed that members of the cohort were more likely to have been born in Australia, comparison with cancer rates among Australian-born Victorian residents would be appropriate. It should be noted that the Victorian reference population data did not have

complete capture of country of origin data for all cancer cases, so there were considerable uncertainties in this analysis.

6. Extent of effect on mortality risk estimates of missing death matches

While CFA had provided Monash with a list of people in the cohort who they believed were deceased, three of these assumed deaths were not identified in the NDI linkage. There are many reasons why a death may not be identified in the NDI linkage, including having died overseas and uncertainties in the probability linkage process itself. Therefore, the overall mortality risk for the cohort was re-calculated to include all those individuals who were recorded as possibly deceased by CFA (and for whom a date of birth was available) in addition to those identified in the NDI linkage.

7. Number of missing cohort members needed to explain elevated cancer rate in High group

The number of missing cohort members needed to explain elevated cancer rate in High group was estimated. This was done by calculating the number of firefighters, that would have to be missing from the High group for the cancer incidence to be the same as that of the Victorian population i.e. result in an SIR of 1. This calculation assumed that the missing firefighters were of similar age and cohort start date to the rest of the High group.

7 Results

7.1 Composition of the cohort

There were 614 records, comprising 611 men and three women, submitted to VCR and AIHW for linkage. None of the women were found to have a death or cancer incidence record in the linkage. Therefore, no further analysis of the female members of the cohort was possible and all of the presented results are for men.

Table 4 presents a summary description of the men in the cohort including the person-years at risk, numbers of deaths and cancers and ages of the men at various time points. The average length of follow up of individual men in the cohort for mortality was 25.5 years.

Table 4. Description of men in the Fiskville cohort

	Low group	Medium group		High group	Whole cohort
		Career	Volunteer		
Number of men	257	105	154	95	611
Number of men with DOB	252	105	151	95	603
Mean age (SD) at cohort start date	26.6 (4.5)	31.9 (11.0)	32.8 (8.0)	32.9 (7.8)	30.1 (8.0)
Mortality					
Person-years of follow up	6193	2673	4021	2507	15392
Mean age (SD) alive by 30/11/2011	51.2 (7.2)	56.3 (8.8)	59.3 (8.8)	58.9 (9.3)	55.2 (9.0)
Number of deaths from NDI linkage	2	11	8	7	28
Mean age (SD) at death if deceased by 30/11/2011	52.4 (14.0)	66.7 (16.8)	61.5 (5.6)	63.7 (10.3)	63.4 (12.6)
Cancer incidence					
Person-years of follow up	6353	2684	4026	2517	15579
Mean age (SD) at diagnosis of first cancer	50.7 (9.8)	60.1 (8.8)	57.8 (9.3)	60.1 (10.0)	58.5 (9.7)
Number of cancers	6	16	22	25	69*
HR data					
Number with HR start date	257	96	33	86	472
Number with assumed HR start date	0	0	10	0	10

* Four men had more than one primary cancer

7.2 Completeness of cohort

7.2.1 High group

This group included all paid PAD workers and fulltime paid instructors. The CFA are confident that all the relevant people been identified from the database and from the group photographs taken at Fiskville.

The CFA notified Monash investigators that nine members of this group were deceased. Seven of these deaths occurred in the follow up time period of the study and all of these deaths were found in the NDI linkage. There were no missing dates of birth for the members of the High group, so linkage quality is likely to be high.

7.2.2 Medium group

The Medium group was made up of two sets of people:

1. Paid Regional Officers (ROs) and Assistant Regional Officers (ARO's) who, as part of their employment spent time as PAD operators or trainers at Fiskville in the relevant time frame. The CFA are confident that all the relevant individuals have been identified from the database and from the group photographs taken at Fiskville (Appendix 1).

2. Volunteer instructors identified by the CFA. The CFA are confident that the majority of these have been identified, but consider that it is possible that a small number of volunteer instructors have not been identified. Those volunteer firefighters who left the CFA before the RMS HR system, was set up in 1994, are more likely to be missing than more recent volunteer firefighters.

The CFA notified Monash investigators that 24 members of the Medium group were deceased. Of these, 22 deaths occurred within the study follow up period and 19 of these deaths were found in the NDI linkage. Linkage quality is likely to be low for the three deaths not found on the NDI linkage, one of which was missing a birth date and none of the records had a notified death date recorded so that it was possible that they had died before or after the study period or they had possibly died overseas. Dates of birth were missing for three members of the Medium group including for one of the unidentified deaths.

7.2.3 Low group

This group was made up of CFA career firefighters who commenced employment with CFA between 1971 and 1999 and were trained at Fiskville. The CFA are confident that the majority of these recruit firefighters have been identified.

The CFA notified Monash investigators that one member of this group was thought to be deceased and this person was identified on the NDI. Five members of the group were missing a birth date.

7.3 Mortality results

There were 28 deaths identified in the NDI linkage, and 16 of these were from cancer. There were no additional deaths identified before 1980 in searches of historic State-based registries, including that of Victoria, but four deaths were identified from the NDI after follow up ceased on 30/11/2011. No cause of death was available for these four deaths,.

The SMRs and 95% confidence intervals are presented in Table 5 for overall mortality and for the major death categories compared to the general Australian population. The overall SMR was significantly lower than expected for the whole cohort and for the Low and Medium groups. The SMR for the High group was similar to that of the Medium group but had wide confidence intervals and was not statistically significantly reduced. In the case of the Low group the overall SMR was extremely low, SMR 0.15 (95% CI 0.02 - 0.55). This SMR was so low that it suggests that there may have been a problem with sufficient historical ascertainment of people who met the criteria for inclusion in the Low group, especially in relation to people who had died.

Examination of the records for the Low group suggested that the group is more completely ascertained from 1998; that is there may be a greater proportion of firefighters missing from the records before this date. When 1998 was used as the date from which follow up commenced for the mortality analysis, the SMR increased slightly; SMR 0.23 (0.03 - 0.82) but was still very low, so ascertainment of people who have died is still likely to be a problem even with those at Fiskville since 1998.

When the mortality of the groups were examined by death category (Table 6), most categories showed lower than expected numbers of deaths with wide confidence intervals and none of the SMRs were significantly different from 1.0. There were no deaths from respiratory or digestive causes. The only major cause of death category where the observed number was greater than expected was for cancer mortality for the High group, but the small increase was not statistically significant.

The Medium group is made up of both career and volunteer firefighters and their risks were examined separately. Table 6 shows that the risk of death for career and volunteer firefighters in the Medium group was low and had wide confidence intervals compared to the general Australian population. The volunteer firefighters had a very reduced and statistically

significant low SMR. The career firefighters' SMR was also reduced, but this was not statistically significant and it was substantially higher than the SMR for the volunteer firefighters (0.7 vs 0.5), which is more in line with the all cause SMRs found in industrial cohorts. The numbers in both groups were small however and none of the individual causes of death was statistically significantly reduced.

7.3.1 Mortality results for volunteer firefighters with Fiskville start dates

The SMRs and 95% confidence intervals are presented in Table 6 for overall mortality and for the major causes of death when those individuals without an HR Fiskville start date or a self-reported start date were removed from the analyses (n=10). All the individuals removed were volunteer firefighters. When the ten individuals without start dates were removed from the analyses, six deaths, including all five cancer deaths, were removed from the Medium volunteer group and the overall SMR was extremely low and was similar to that of the Low group.

7.3.2 Mortality results for cohort members with Fiskville start dates from HR records

When cohort members who did not have Fiskville start dates in their HR records were removed from the analyses (n=139), the overall mortality for the remaining cohort members was still significantly reduced when compared to that of the national population. For the members of the cohort with start dates obtained from HR records, the SMR for overall mortality was 0.52 (0.32 - 0.78) (Table 7), very similar to that of the whole cohort (Table 5).

All members of the Low group had HR recorded start dates so their SMR did not change. The SMR increased slightly for the Medium group with HR-recorded start dates but was no longer statistically significantly reduced, SMR 0.66 (0.35 - 1.14), unlike that for the entire Medium group (Table 5). The Medium group without HR recorded start dates accounted for 32% of the deaths (6/19) but 56% of the cancer deaths (5/9). None of the High group without HR recorded start dates had died.

The exclusion of these individuals resulted in some slight reduction in power but for the Low and High group did not change the overall findings. For the Medium group it is suggestive evidence of bias in that the cancer deaths were somewhat over-represented in those without HR-recorded start dates.

7.3.3 Extent of effect on mortality risk estimates of missing death matches

There were two members of the Medium group with death notifications from the CFA which fell within the study period, for whom a date of birth was available but who were not identified in the NDI linkage. If both these deaths had been identified in the NDI, the Medium group would have had an SMR of 0.66 (0.41 - 1.01), i.e. the mortality would not be statistically significantly lower than that of the Australian population. Without these two deaths the SMR was 0.60 (0.36 - 0.94).

The effect on the SMR for the whole cohort was very small, with the two additional deaths the SMR was 0.53 (0.36 - 0.76), so it was little changed from the original SMR 0.50 (0.33 - 0.72).

Table 5. Standardised Mortality Ratios (SMR)* and 95% confidence intervals (95% CI) for male deaths to 30/11/2011 compared to the national population

Cause of death categories	Low (N=252)			Medium (N=256)			High (N=95)			All (N=603)		
	O	E	SMR (95% CI)	O	E	SMR (95% CI)	O	E	SMR (95% CI)	O	E	SMR (95% CI)
All Malignancies	1	3.40	0.29 (0.01 - 1.64)	9	10.38	0.87 (0.40 - 1.65)	6	4.10	1.47 (0.54 - 3.19)	16	17.87	0.90 (0.51 - 1.45)
All Circulatory	0	2.53		7	9.77	0.72 (0.29 - 1.48)	1	3.28	0.30 (0.01 - 1.70)	8	15.58	0.51 (0.22 - 1.01)
All Respiratory	0	0.37		0	1.90		0	0.62		0	2.89	
All Digestive	0	0.61		0	1.34		0	0.51		0	2.45	
All Injury & Trauma	1	4.22	0.24 (0.01 - 1.32)	3	4.33	0.69 (0.14 - 2.03)	0	1.56		4	10.11	0.40 (0.11 - 1.01)
All Other Causes	0	1.92		0	3.94		0	1.40		0	7.26	
All Causes of Death	2	13.04	**0.15 (0.02 - 0.55)**	19	31.65	**0.60 (0.36 - 0.94)**	7	11.46	0.61 (0.25 - 1.26)	28	56.14	**0.50 (0.33 - 0.72)**

* Statistically significantly reduced SMR results are in bold **blue**

Table 6. Standardised Mortality Ratios (SMR)* and 95% confidence intervals (95% CI) for male deaths to 30/11/2011 compared to the national population among Medium group by employment status and presence of a Fiskville start date

Cause of death categories	Medium Career (N=105)			Medium Volunteer all (N=151)			Medium Volunteer with Fiskville start date (N=141)		
	O	E	SMR (95% CI)	O	E	SMR (95% CI)	O	E	SMR (95% CI)
All Malignancies	4	4.51	0.89 (0.24 - 2.27)	5	5.87	0.85 (0.28 - 1.99)	0	5.55	
All Circulatory	5	5.58	0.90 (0.29 - 2.09)	2	4.19	0.48 (0.06 - 1.72)	1	3.95	0.25 (0.01 - 1.41)
All Respiratory	0	1.15		0	0.74		0	0.71	
All Digestive	0	0.60		0	0.74		0	0.70	
All Injury & Trauma	2	1.85	1.08 (0.13 - 3.90)	1	2.48	0.40 (0.01 - 2.25)	1	2.35	0.43 (0.01 - 2.37)
All Other Causes	0	1.98		0	1.96		0	1.86	
All Causes of Death	11	15.67	0.70 (0.35 - 1.26)	8	15.98	**0.50 (0.22 - 0.99)**	2	15.12	**0.13 (0.02 - 0.48)**

* Statistically significantly reduced SMR results are in bold **blue**

Table 7. Standardised Mortality Ratios (SMR)* and 95% confidence intervals (95% CI) for male deaths to 30/11/2011 compared to the national population for individuals with an HR recorded start date

Cause of death categories	Low (N=252)			Medium (N=126)			High (N=86)			All (N=664)		
	O	E	SMR (95% CI)	O	E	SMR (95% CI)	O	E	SMR (95% CI)	O	E	SMR (95% CI)
All Malignancies	1	3.40	0.29 (0.01 - 1.64)	4	6.07	0.66 (0.18 -1.69)	6	3.53	1.70 (0.62 - 3.70)	11	13	0.85 (0.42 - 1.51)
All Circulatory	0	2.53		6	6.72	0.89 (0.33 - 1.94)	1	2.86	0.35 (0.01 - 1.95)	7	12.12	0.58 (0.23 - 1.19)
All Respiratory	0	0.37		0	1.38		0	0.54		0	2.29	
All Digestive	0	0.61		0	0.76		0	0.44		0	1.82	
All Injury & Trauma	1	4.22	0.24 (0.01 - 1.32)	3	2.22	1.35 (0.28 - 3.96)	0	1.39		4	7.83	0.51 (0.14 - 1.31)
All Other Causes	0	1.92		0	2.43		0	1.22		0	5.57	
All Causes of Death	2	13.04	**0.15 (0.02 - 0.55)**	13	19.57	0.66 (0.35 - 1.14)	7	9.99	0.70 (0.28 - 1.44)	22	42.6	**0.52 (0.32 - 0.78)**

* Statistically significantly reduced SMR results are in bold **blue**

7.4 Cancer incidence results

For the years 1982 to 2012 for which the VCR has complete coverage of reported cancers in Victoria, there were 66 primary incidence malignant cancers found in 62 cohort members. An additional three cancer matches in three cohort members were found in the national linkage to the ACD, which means that they occurred in people who had moved interstate. This means that there were 69 matched primary malignant cancers included in the analyses. The SIRs and 95% confidence intervals are presented in Table 8 for overall cancer incidence and for the major cancer subtypes.

In addition, the VCR returned five cancers which were not included in the analyses because they were outside the dates of the study follow up period. They were:

- One cancer match from 1979 was diagnosed before the relevant recorded Fiskville start date
- Four cancer matches from 2013

The observed number of all cancers was slightly in excess of the expected number of cancers, but the increase was not statistically significant. There was a significantly increased risk of brain cancer SIR 3.52 (1.14 - 8.22) and melanoma SIR 2.08 (1.14 - 3.50) for the cohort as a whole. There were no mesotheliomas identified in the cohort. There were six cancers in the 'Other and Unknown' group.

The overall cancer SIR for the High group was statistically significantly increased, SIR 1.85 (1.20 - 2.73). Observed cancers were higher than expected for all the cancer categories examined for the High group, except for the respiratory tract, but the only statistically significant excesses were for melanoma SIR 4.59 (1.68 - 9.99) and cancer of the testis SIR 11.87 (1.44 - 42.9). For the High group to have an overall cancer rate similar to that of the general population, sensitivity analyses suggest that the cohort would have to be missing approximately 80 male cancer-free firefighters of similar age and cohort start date.

The overall cancer risk for the Low group was statistically significantly reduced SIR 0.40 (0.15 - 0.87). The group did not show any higher than expected rates for any cancer type, apart from a small excess for melanoma, but this was not statistically significant.

The Medium group had a slight excess in the number of overall cancers compared with expected, but this was not statistically significant. There was a statistically significant excess of brain cancer SIR 5.74 (1.56 - 14.7) in this group. The Medium group was made up of career and volunteer firefighters, so their risks were examined separately. Table 9 shows

that there were no statistically significantly raised or lowered SIRs for any cancer type when the groups were examined separately, but the numbers for brain cancer were very small in both of the career and volunteer subgroups and there was a lot of imprecision in the SIRs for this type of cancer. There were no male reproductive cancers among the career firefighters, although three prostate cancer cases were expected.

7.4.1 Cancer incidence results for volunteer firefighters with Fiskville start dates

A sensitivity analysis was performed by exclusion of the ten volunteer firefighters without Fiskville start dates. The SIRs for the Medium group with and without these individuals are presented in Table 9. Five cancer cases were identified among volunteer firefighters with no Fiskville start date; these were two brain cancers, two digestive system cancers and one thyroid cancer. When these cancers were removed the overall cancer SIR for volunteer firefighters dropped, but was still not significantly significant. The SIR for brain and nervous system for the whole Medium group with a Fiskville start date remained raised; SIR 2.96 (0.36 - 10.71), but was not statistically significant.

7.4.2 Cancer incidence results for cohort members with Fiskville start dates from HR records

A sensitivity analysis was performed by exclusion of all those with no HR-derived start date (n=139) (Table 10). The overall SIR for those with an HR start date was not significantly raised, SIR 1.20 (0.90 - 1.57). This is similar to the overall SIR reported in Table 8 for the whole cohort.

The SIR for the brain and nervous system cancers in the Medium group was now no longer statistically significantly raised, because two of the four brain cancers in this group were from individuals with no HR recorded start date.

Table 8. Standardised Incidence Ratios (SIR)* and 95% confidence intervals (95% CI) for male cancer incidence to the end of 2012 compared to the Victorian population

Cancer Categories	Low (N=252)			Medium (N=256)			High (N=95)			All (N=603)		
	O	E	SIR (95% CI)	O	E	SIR (95% CI)	O	E	SIR (95% CI)	O	E	SIR (95% CI)
Lip, buccal cavity & pharynx	0	0.86		1	1.54	0.65 (0.02 -3.62)	1	0.62	1.61 (0.04 - 8.98)	2	3.01	0.66 (0.08 - 2.40)
Digestive	0	2.87		9	7.19	1.25 (0.57 - 2.38)	3	2.93	1.02 (0.21 - 2.99)	12	12.99	0.92 (0.48 - 1.61)
Colorectal	0	1.70		4	4.26	0.94 (0.26 - 2.40)	2	1.79	1.12 (0.14 - 4.05)	6	7.75	0.77 (0.28 - 1.68)
Respiratory	0	1.13		3	3.56	0.84 (0.17 - 2.46)	1	1.48	0.68 (0.02 - 3.77)	4	6.17	0.65 (0.18 - 1.66)
Melanoma	3	2.10	1.43 (0.29 - 4.18)	5	3.31	1.51 (0.49 - 3.52)	6	1.31	**4.59 (1.68 - 9.99)**	14	6.72	**2.08 (1.14 - 3.50)**
Male reproductive	2	3.86	0.52 (0.06 - 1.87)	7	9.82	0.71 (0.29 -1.47)	7	3.95	1.77 (0.71 - 3.65)	16	17.63	0.91 (0.52 - 1.47)
Prostate	2	3.16	0.63 (0.08 - 2.28)	7	8.90	0.79 (0.32 - 1.62)	5	3.50	1.43 (0.46 - 3.34)	14	15.56	0.90 (0.49 - 1.51)
Testis	0	0.64		0	0.48		2	0.17	**11.9 (1.44 - 42.9)**	2	1.29	1.55 (0.19 - 5.60)
Urinary tract	0	0.86		1	1.98	0.50 (0.01 - 2.81)	1	0.79	1.27 (0.03 - 7.07)	2	3.63	0.55 (0.07 - 1.99)
Brain & nervous system	0	0.45		4	0.70	**5.74 (1.56 - 14.7)**	1	0.28	3.63 (0.09 - 20.3)	5	1.42	**3.52 (1.14 - 8.22)**
Lymphoid & Haematopoetic (LH)	0	1.94		4	3.58	1.12 (0.30 - 2.86)	4	1.41	2.83 (0.77 - 7.24)	8	6.94	1.15 (0.50 - 2.27)
Other & unknown	1	1.01	0.99 (0.03 - 5.51)	4	1.90	2.11 (0.57 - 5.39)	1	0.75	1.34 (0.03 - 7.45	6	3.66	1.64 (0.60 - 3.57)
Overall	6	15.05	**0.40 (0.15 - 0.87)**	38	33.57	1.13 (0.80 - 1.55)	25	13.51	**1.85 (1.20 - 2.73)**	69	62.14	1.11 (0.86 - 1.41)

* Statistically significantly elevated SIR results are in bold **red**, statistically significantly reduced SIR results are in bold **blue**

Table 9. Standardised Incidence Ratios (SIR) and 95% confidence intervals (95% CI) for male cancer incidence among Medium Group by employment status and presence of Fiskville start date to the end of 2012 compared to the Victorian population

Cancer Categories	Medium Career (N=105)			Medium Volunteer all (N=151)			Medium Volunteer with Fiskville start date (N=141)		
	O	E	SIR (95% CI)	O	E	SIR (95% CI)	O	E	SIR (95% CI)
Lip, buccal cavity & pharynx	1	0.57	1.74 (0.04 - 9.72)	0	0.96		0	0.91	
Digestive	5	2.73	1.83 (0.59 - 4.27)	4	4.46	0.90 (0.24 - 2.30)	2	4.23	0.47 (0.06 - 1.71)
Colorectal	3	1.56	1.93 (0.40 - 5.63)	1	2.71	0.37 (0.01 - 2.06)	1	2.56	0.39 (0.01 - 2.17)
Respiratory system	1	1.40	0.71 (0.02 - 3.97)	2	2.16	0.93 (0.11 - 3.35)	2	2.05	0.98 (0.12 - 3.53)
Melanoma	3	1.23	2.45 (0.50 - 7.15)	2	2.08	0.96 (0.12 - 3.47)	2	1.98	1.01 (0.12 - 3.66)
Male-reproductive	0	3.52		7	6.3	1.11 (0.44 - 2.29)	7	6.01	1.17 (0.47 - 2.40)
Prostate	0	3.28		7	5.62	1.25 (0.50 - 2.57)	7	5.34	1.31 (0.53 - 2.70)
Testis	0	0.21		0	0.27		0	0.26	
Urinary-tract	0	0.79		1	1.20	0.84 (0.02 - 4.66)	1	1.14	0.88 (0.02 - 4.90)
Brain & Nervous System	2	0.26	7.59 (0.92 - 27.4)	2	0.43	4.62 (0.56 - 16.67)	0	0.41	
Lymphoid & Haematopoetic (LH)	3	1.39	2.16 (0.45 - 6.31)	1	2.19	0.46 (0.01 - 2.54)	1	2.08	0.48 (0.01 - 2.67)
Other & unknown	1	0.77	1.30 (0.03 - 7.22)	3	1.13	2.66 (0.55 - 7.77)	2	1.07	1.87 (0.23 – 6.75)
Overall	16	12.66	1.26 (0.72 - 2.05)	22	20.91	1.05 (0.66 - 1.59)	17	19.86	0.86 (0.50 - 1.37)

Table 10. Standardised Incidence Ratios (SIR)* and 95% confidence intervals (95% CI) for male cancer incidence by group to the end of 2012 compared to the whole Victorian population for those firefighters with HR recorded start dates

Cancer Categories	Low (N=252)			Medium (N=126)			High (N=86)			All (N=464)		
	C	E	SIR (95% CI)	C	E	SIR (95% CI)	C	E	SIR (95% CI)	C	E	SIR (95% CI)
Lip, buccal cavity & pharynx	0	0.86		1	0.77	1.29 (0.03 - 7.21)	1	0.54	1.84 (0.05 - 10.3)	2	2.17	0.92 (0.11 - 3.32)
Digestive	0	2.87		6	3.84	1.56 (0.57 - 3.40)	3	2.53	1.19 (0.24 - 3.47)	9	9.23	0.98 (0.45 - 1.85)
Colorectal	0	1.70		3	2.24	1.34 (0.28 - 3.91)	2	1.53	1.30 (0.16 - 4.71)	5	5.48	0.91 (0.30 - 2.13)
Respiratory	0	1.13		1	1.99	0.50 (0.01 - 2.79)	1	1.27	0.79 (0.02 - 4.40)	2	4.39	0.46 (0.06 - 1.65)
Melanoma	3	2.10	1.43 (0.29 - 4.18)	5	1.63	3.06 (1.00 - 7.15)	6	1.14	**5.25 (1.93 - 11.4)**	14	4.87	**2.87 (1.57 - 4.82)**
Male reproductive	2	3.86	0.52 (0.06 - 1.87)	4	5.00	0.80 (0.22 - 2.05)	6	3.38	1.77 (0.65 - 3.86)	12	12.25	0.98 (0.51 - 1.71)
Prostate	2	3.16	0.63 (0.08 - 2.28)	4	4.52	0.89 (0.24 - 2.27)	4	3.06	1.31 (0.36 - 3.35)	10	10.74	0.93 (0.45 - 1.71)
Testis	0	0.64		0	0.24		2	0.15	**13.0 (1.58 - 47.1)**	2	1.03	1.94 (0.23 - 7.00)
Urinary tract	0	0.86		1	1.07	0.93 (0.02 - 5.21)	1	0.68	1.47 (0.04 - 8.19)	2	2.61	0.77 (0.09 - 2.77)
Brain & nervous system	0	0.45		2	0.35	5.76 (0.70 - 20.8)	1	0.24	4.15 (0.11 - 23.1)	3	1.04	2.90 (0.60 - 8.47)
Lymphoid & Haematopoetic (LH)	0	1.94		3	1.87	1.60 (0.33 - 4.68)	4	1.23	3.26 (0.89 - 8.35)	7	5.04	1.39 (0.56 - 2.86)
Other & unknown	1	1.01	0.99 (0.03 - 5.51)	0	1.02		1	0.65	1.54 (0.04 - 8.55)	2	2.68	0.74 (0.09 - 2.69)
Overall	6	15.05	**0.40 (0.15 - 0.87)**	23	17.55	1.31 (0.83 - 1.97)	24	11.66	**2.06 (1.32 - 3.06)**	53	44.26	1.20 (0.90 - 1.57)

* Statistically significantly elevated SIR results are in bold **red**, statistically significantly reduced SIR results are in bold **blue**

7.4.3 Overall cancer risk compared to Australian-born Victorians

Table 11 shows the cancer risk in the cohort when compared to the rates for the general Victorian population and when compared to the rates for Australian-born Victorians. When compared to Australian-born Victorians the SIRs were slightly reduced but the pattern remained, with the High group still showing a statistically significant excess of cancer and the Low group a significant reduction.

Table 11. Comparison of male cancer SIRs* compared to all Victorians and to Australian-born Victorians

Groups	Compared to all Victorians	Compared to Australian-born Victorians
Low	**0.40 (0.15 - 0.87)**	**0.35 (0.13 - 0.76)**
Medium	1.13 (0.80 - 1.55)	0.99 (0.70 - 1.36)
High	**1.85 (1.20 - 2.73)**	**1.61 (1.04 - 2.38)**
Whole cohort	1.11 (0.86 - 1.41)	0.97 (0.75 - 1.23)

* Statistically significantly elevated SIR results are in bold **red**, statistically significantly reduced SIR results are in bold **blue**

7.5 Internal analyses

The overall mortality and cancer incidence rates for the Medium and High groups were compared to the Low group as the reference population. In both of the following analyses, there were fewer deaths/cancers in the Low group.

Table 12 shows that although the relative mortality was higher for the Medium and High groups when compared to the Low group. There was a lot of imprecision and no statistically significant difference between Relative Mortality Ratio (RMR) for the three groups after adjustment for age and calendar year.

Table 12. All cause RMR for the Medium and High groups compared to the Low group

All cause mortality	Number of deaths	RMR (95% CI)*
Low	2	1
Medium	19	3.49 (0.77 - 15.9)
High	7	3.25 (0.64 - 16.5)

* adjusted for age and calendar year

Comparing the cancer incidence rates between the groups by calculating the Relative Incidence Ratio (RIR), showed that there was a significant and level-related difference between the High and Medium groups' cancer incidence when compared with the Low group after adjustment for age and calendar year (Table 13).

Table 13. All cause RIR** for the Medium and High groups compared to the Low group

All cause cancer	Number of cancers	RIR (95% CI)*
Low	6	1
Medium	23	**2.66 (1.09 - 6.51)**
High	24	**4.22 (1.67 - 10.7)**

* adjusted for age and calendar year

** Statistically significantly elevated RIR results are in bold **red**

8 Discussion

8.1 Cohort cancer incidence

Overall the incidence of cancer was not raised in the cohort as a whole. However, there was a significantly elevated number of cases of melanoma and of cancers of the brain and nervous system for the cohort as a whole.

The High group had a statistically significant elevation in overall cancer incidence mainly because of elevations in the cancer rates for melanoma and cancer of the testis. The sensitivity analyses suggest that this group would have to be missing 81 firefighters to account for this number of cancers overall. There were only 95 firefighters in this group however. The CFA have confidence that this group has been completely identified and it is very unlikely that the CFA's recruitment strategy would have missed almost half of the PAD operators and full-time instructors.

Within the cohort, the overall cancer incidence was not elevated for volunteer firefighters in the Medium group and was significantly reduced for the Low group. The overall cancer rate was elevated but not statistically significantly so for the career firefighters in the Medium group.

The Medium group did not have an overall excess of cancer, but five of the cancer cases were among the ten individuals with no HR or self-reported start date which raises the question of whether there was a selective inclusion of cancer cases i.e. that there was a cancer reporting bias operating.

The number of brain cancers was statistically significantly elevated for the Medium group but not for the other two groups. These results are based on very small numbers, as would be expected for this rare cancer. Two of these cancers were among ten volunteer firefighters with no Fiskville start date from HR records or from self-report. When these ten individuals were removed, the SIR for cancer of the brain and nervous system for the Medium group was still raised, but not significantly so.

The exclusion of individuals from analyses on the basis of no start date may be more likely to exclude those who have died because they would not have been able to self-report a start date. Exclusion of these individuals may therefore be a source of bias which would reduce the observed mortality and cancer incidence.

The exclusion of High and Medium group firefighters from analyses on the basis of no HR start date may also be more likely to exclude those who have died because they had been removed from the database and were not recalled by fellow firefighters. Exclusion of these individuals could therefore be a source of bias which would similarly reduce the observed

mortality and cancer incidence. If these individuals are included however, there may be a bias in recalling those who had died of cancer and preferentially including them in the cohort which would overestimate risk. Low group members were not asked to self-report a start date and no such dates were missing from HR records.

The cancer linkage was completed to 2012 in Victoria, but only to 2010 for the rest of Australia, and only until 2009 for NSW and ACT. Therefore, there may be additional cancers missing for the years 2010 to 2012 that were diagnosed in other states, however, as there were only three cancers matched interstate overall, it is unlikely that many, if any, cancers from those years are missing.

No published studies of the cancer incidence and/or mortality of firefighter trainers or trainees were identified. However elevated rates of cancer types in excess in this study, brain and nervous system, melanoma and testicular cancer have been observed in other studies of firefighters.[10] Other studies of firefighters have shown an increased risk of other cancers: prostate cancer and LH cancer (non-Hodgkin lymphoma, multiple myeloma and leukaemia).[10] This study found higher than expected numbers of prostate and LH cancers but the increase was not statistically significant. This study may not have been sufficiently powered to examine the subtypes of LH cancers. There is some evidence that firefighting is also associated with increased risk of other cancers including mesothelioma and cancers of the buccal cavity/pharynx, stomach, colon, rectum, skin and bladder but excesses were not identified in this study.[10-12, 14-16]

8.2 Comparison of cancer incidence with Australian-born Victorians and all Victorians

Information on country of birth was not available for the cohort members. However, it is possible that the members of the CFA are more likely to be Australian born than the general Australian population so it was decided to compare the overall cancer rates with that of Australian-born Victorians as a further sensitivity analysis. Table 11 shows that although the SIRs are somewhat reduced, the pattern remains, with the High group showing a statistically significant excess of cancer and the Low group a significant reduction.

It was decided *a priori* not to examine rates of specific cancer categories because there was a concern about missing data for the population figures. Country of birth was not recorded in a proportion of cancer cases notified to VCR, in particular for melanoma and prostate cancer. The comparison data provided by VCR imputed the missing data for these two cancers assuming that it was at random in proportion to the Victorian population, i.e. not

related to country of birth. The missing country of birth was not imputed for the other cancers because they had a relatively small proportion of missing data.

The need to impute county of birth for the population data means that the findings from this analysis should be treated with caution.

8.3 Cohort mortality

The overall mortality of the cohort was low compared to that of the general Australian population, and was particularly reduced for the Low group and the volunteer firefighters in the Medium group.

Mortality in the Medium career and High groups was also low, at less than 60% of the mortality expected when compared to the national population. None of the major categories of death were statistically significantly elevated for the groups examined, but numbers were small.

Industrial cohorts usually have a mortality rate lower than that of the general population because of the healthy worker effect which is discussed below in Section 8.5.2. As a comparison, the Health Watch cohort of Australian petroleum industry workers had an SMR of 0.72 (95% CI 0.69 - 0.75).[27]

One important aspect of the SMR findings is that the very low overall SMRs for the Low group and the volunteer firefighters in the Medium group suggest that there has been incomplete assembly of the cohort for those two groups in particular, especially in relation to inadequate identification of those who had died. This has important implications for interpreting the mortality results for these two groups. This is discussed further in Section 8.5.1.

8.4 Internal comparisons

Internal analyses comparing the mortality and cancer incidence between the three groups of firefighters, was a way to limit the impact of the healthy worker effect in this study. The three groups all contained career firefighters although half the Medium group was made up of volunteer firefighters. The Low group was used as the comparison or reference group.

Even though the mortality of the Low group was very reduced, when age and calendar year were taken into account, there was no statistically significant difference in mortality between the three groups. The cancer RIR was however, statistically significantly elevated for the

Medium group and elevated further for the High group when compared to the Low group, even after adjustment for age and calendar year.

In both of the analyses, the number of deaths/cancers in the Low (reference) group was very small, although larger for the cancer incidence analysis (six cases). This results in wide confidence intervals. In addition, as discussed below, there is likely to have been historic under-ascertainment of employees in the Low group, which appears to have resulted in their risk of death and also possibly cancer incidence being underestimated. These Relative Mortality Ratio (RMR) and Relative Cancer Incidence Ratio (RIR) findings therefore must be treated with caution.

8.5 Sources of uncertainty in the risk estimates

8.5.1 Possible ascertainment bias

The mortality rates for the Low group and the volunteer firefighters in the Medium group were very reduced, indeed, the SMRs were so low that they suggest that there had been an ascertainment bias. That is, the HR records were not retained on the HR system for individuals who had left (perhaps because they had died) and these individuals were less likely to be recalled by fellow firefighters. If they had died some time ago, for example before CFA records were centralised in 1993, volunteer firefighters would have been less likely to be remembered by those interviewed in the cohort assembly process.

When the mortality rate of the Low group was estimated using a cohort start date of 1998 or later, rather than the 1980 or later start date, the resulting SMR was slightly higher; this again suggests that there has been some incomplete historical ascertainment of employees. It was estimated that there would have to be eleven more deaths in the Low group and twice as many deaths in the Medium volunteer group to have the same death rate as the general Australian population.

The CFA has estimated that they had identified over 90% of the relevant career and volunteer firefighters. In terms of the Low group, the CFA identified 205 trainees from photographs but there were no photographs available for 17 of the years between 1971 and 1999, and none between 1974 and 1982 (see Appendix 5). The CFA did not run recruit courses every year but it is possible that some recruits from these early years have not been identified. There were 62 recruit firefighters identified in the HR systems who were not on photographs. This may be because the individuals were not present for their group photograph and/or that the available photographs were not a complete record of training courses.

Recruit firefighters who were not on the current HR system because they had left before it was established, and were not on photographs could have been missed.

In addition, not all the recruit firefighters on the available photographs were able to be identified. It is likely that those who no longer had contact with the CFA would have been less likely to have been identified and this would obviously include those who have died.

For the Medium group volunteer firefighters, after removal of the individuals with neither a Fiskville HR start date nor a self-reported start date, the all cause mortality was, like that for the Low group, extremely low suggesting that volunteer ascertainment was not complete and there was an ascertainment bias operating here too. All five cancer deaths in the Medium volunteer group were among the ten who had no Fiskville start date which suggests there may have been a bias in their inclusion. That is those individuals who died of cancer were more likely to be remembered and to be included in the cohort than those who died of causes other than cancer.

However, of the ten volunteer firefighters with no HR or self-reported start date, six had died and presumably the CFA did not receive a completed questionnaire for these individuals. The start dates were obtained for many of the Medium group firefighters from these questionnaires which means that excluding these individuals could bias the findings.

8.5.2 Healthy worker effect

When the mortality of occupational cohorts is compared with that of the general population, the mortality rate in the occupational cohort is typically lower. This is the well established healthy worker effect.[28] One cause of the healthy worker effect is the relative social and economic advantage of employed people. Another factor is that people with life-threatening conditions, such as cancer and other chronic illnesses which increase the risk of death, are less likely to enter the workforce after diagnosis, further lowering the mortality rate in the workforce compared with the general population. This healthy hire effect is thought to be particularly evident in career firefighters who are selected in part on the basis of their high level of physical fitness.[28] Those firefighters who become ill may leave the workforce as they can no longer carry out this physically demanding job. Over time, when personnel records are transferred from old to new systems, the records of those firefighters no longer employed, such as those who have left because of ill health, are typically not transferred and this could be a source of healthy worker bias in the records provided to Monash.

8.5.3 Identification of deaths and cancer cases

Matching the cohort names to those in the NDI, VCR and ACD is a probabilistic process. Some deaths and cancer may be missed e.g. where names are spelt wrongly or dates of birth are wrong either in the cohort or in the comparison databases. The linkage process included similarly spelled names and common shortenings e.g. Bob for Robert, so few cases should be missed. It is also possible that matches have been made with people who were not in the cohort but who had similar names and dates of birth i.e. there may be deaths/cancer cases in the analyses that should not have been included. Monash investigators carried out a thorough clerical review of the possible death matches and are confident that all of the good matches were included. The clerical review of possible matches for cancer cases was done by the VCR and the AIHW and they reviewed all the Fiskville matches individually.

The NDI did not provide a match for three members of the Medium group who, according to the information provided by the CFA, had died. Individuals who died are not included in the NDI data. Exclusion of these three deaths, if they occurred within the follow up period, would reduce the observed risks. Three cancer cases diagnosed interstate were however, identified and included. Cancer diagnosed and treated overseas would also not be included in this study.

8.5.4 Choice of population reference data for cancer risks

The choice of the comparison population is important in accurately assessing the cohort's risk of cancer and mortality. The cancer incidence of the cohort and its sub-groups were compared to the Victorian population. This was thought a more appropriate comparison than with the Australian national rates because some cancer rates vary by state, notably melanoma.[29, 30]

If the majority of the cohort were born in Australia, rather than overseas, comparison of cancer rates with this section of the community would be appropriate. Monash investigators have no evidence of where members of the cohort were born or their ethnicity or Aboriginal status. This and the limitations consequent upon the missing and imputed country of birth in the Victorian population cancer incidence data make this comparison somewhat uncertain. It may be prudent to consider that the risks may be somewhere between those measured by comparison with the Victorian population as a whole and those found in comparison to the Australia-born Victorian population. However, it is reassuring that the rates are similar and follow the same pattern with respect to the groups.

8.5.5 Latent period

It is generally considered that there is a latent period between first exposure and diagnosis of cancer. The latent period can be short, perhaps ten years for leukaemia,[31] around 10-15 years for many solid tumours[32] and can be 30-40 years for mesotheliomas.[33] In view of this latency, it is unlikely that many cancers would have arisen before 1982 when the VCR is complete. However if exposure started for example in 1995, any solid tumours arising would only perhaps start being diagnosed in the next few years.

8.5.6 Start date at Fiskville

Monash investigators used a start date based on each individual's job history to make the person-years contributed to the study as accurate as possible. However, there was some difficulty in assigning a start date at Fiskville from the variety of data sources available. Some individuals had three possible start dates, a self-reported one, and different HR start dates from the two HR systems. This means that the number of person-years of follow up was somewhat uncertain. If the start date for all individuals was assumed to be 1971 regardless of the individual Fiskville start dates, the person-years would have been overestimated and the risks would have been underestimated. If the start dates were set later than they should have been, risk would have been overestimated.

8.5.7 Exposure at Fiskville and elsewhere

The High, Medium and Low groups identified by the Joy Report formed groups with likely different extents of exposure. However, data on the extent of exposure was not available on an individual and quantified basis. There were two firefighters in the High group, whose service at Fiskville appeared to have been complete before 1974 when hot fire training started at Fiskville.[1]

The cohort contained firefighters who could have been allocated to more than one group, e.g. Fiskville trainers who were also volunteer firefighters. Appendix 3 provides details of how these cases were handled. It is possible that there was misclassification between groups, with individuals who should have been in the Medium group being allocated to the High group and perhaps, although less likely, *vice versa*.

Monash investigators did not attempt to factor duration of exposure at Fiskville into this assessment because periods of service at Fiskville were too uncertain.

For most cohort members, the period at Fiskville represents only a fraction of their firefighting service. Members of the cohort are likely to have been exposed to a number of

agents including smoke in the course of the rest of their paid and/or voluntary service. This means that, in terms of exposure to firefighting activities and exposures, there is also scope for misclassification. Non-differential misclassification usually leads to a reduction in the observed risks,[34] although this would be mainly applicable to the internal analyses.

8.5.8 Other possible confounding factors

There may have been other confounding factors that affected the observed risk estimates for certain health outcomes that could not be measured or accounted for in this study design. This study could not take into account smoking, alcohol, diet or other lifestyle factors, nor non-firefighting job exposures, for example in previous jobs and for jobs held by volunteer firefighters. These factors may increase or decrease risk of some cancer and mortality outcomes. For melanoma, sun exposure is an important risk factor, but no information was available on this for the cohort members.

8.5.9 Statistical power of the study

The power of this study to determine any effect was limited by the small numbers employed at Fiskville as trainers and instructors and the short period of follow up for some members of the cohort. This means that it is only possible to identify relatively large increases or decreases in specific cancers or causes of death. The study was sufficiently powered however, to identify significantly increased risks of melanoma, brain cancer and testicular cancer in subgroups of the cohort even though these increases were based on small numbers.

There were only three women in the cohort so no risk estimates could be calculated for women, although no deaths or cancers were found for them.

8.5.10 Multiple comparisons

The formal test for statistical significance is that the 95% confidence intervals around the risk estimate should not include one. This implies that there is less than a one in 20 probability that the finding is due to chance, i.e. is due to random variation. However when more than 20 risk estimates are made, it becomes more likely that one of these may be a chance finding.[35]

The number of risk estimates was restricted in this study *a priori*. There were seven categories of cause of death, including an overall risk estimate, for each of the three groups

and the overall cohort. There were ten cancer categories including an overall cancer risk estimate, for each of the three groups and the overall cohort. It is possible therefore that one or more statistically significant finding is due to chance.

8.6 Further research

Now that the cohort has been assembled and a database constructed for linkage to the NDI, the ACD and the VCR, regular linkages into the future can be undertaken in a very cost-effective manner. As the number of cancers and deaths accumulate due to the cohort aging and additional years of follow up, this will increase precision of the risk estimates and future linkages are therefore likely to give more robust estimates of cancer and mortality risk. Further work could also be directed at checking and improving the ascertainment of people in the Low group and volunteer firefighters in the Medium group. Another area of research would be to try to improve the job histories, specifically the period spent at Fiskville, and for this information to be included in analysing the results of future linkages for the Fiskville cohort.

9 Conclusions

When compared to the Victorian population, higher than expected cancer rates were observed for melanoma and cancer of the testis in the High group and for brain cancer in the Medium group.

When compared to the Victorian population and to the Australian-born Victorian population, the overall cancer risk was significantly raised for the High group, it was similar to that of both these reference groups for the Medium group and the overall cancer risk was significantly reduced compared to both these reference groups for the Low group.

When compared to the Low group, there was a statistically significantly increased cancer risk for the Medium and High groups, but the number of cancers in the Low group was very small and there may be under-ascertainment in this group. This results in a lot of imprecision in the results and this is likely to impact on the robustness of these findings.

When compared to the general Australian population, the overall mortality was statistically significantly decreased for the whole cohort and for the Low and Medium groups within the cohort. This reduction in mortality may be due, at least in part, to the healthy worker effect. The mortality for the career Medium group and the High group was also reduced but not statistically significantly so.

For the Low group and the volunteer firefighters in the Medium group, the low mortality may also be a result of an ascertainment bias. That is, it appears likely that individuals who had died were less likely to have been identified and included in the cohort. It also possible however, that those individuals who died of cancer were more likely to be recalled than other individuals who had died of other diseases.

The analyses here are based on small numbers, and there are several other limitations in the study which mean that the results should be interpreted cautiously.

Now that the cohort has been assembled regular linkages into the future can be undertaken in a very cost-effective manner. The larger number of cancers and deaths will give more robust estimates of cancer and mortality risk.

Abbreviations

95% CI	95% Confidence Interval
ABS	Australian Bureau of Statistics
ACS	Automated Coding System used by ABS to code deaths
ACT	Australian Capital Territory
AFAC	Australasian Fire and Emergency Service Authorities Council
AIHW	Australian Institute of Health and Welfare
ARO	Assistant Regional Officers
BA	Breathing Apparatus
CFA	Country Fire Authority
HAZMAT	Hazardous Materials Incidents
HR	Human resources
HREC	Human Research Ethics Committees
IARC	International Agency for Research on Cancer
ICD-10	International Classification of Disease Version 10
ICD-9	International Classification of Disease Version 9
ID	Identification number
LH	Lymphoid & Haematopoetic cancer
MonCOEH	Monash University Centre for Occupational and Environmental Health
MUHREC	Monash University Human Research Ethics Committee
NCIS	National Coronial Information Service
NHMRC	National Health and Medical Research Council
NSW	New South Wales
PAD	Practical Areas for Drills
PAHs	Polycyclic Aromatic Hydrocarbons
RIR	Relative Incidence Ratio
RMR	Relative Mortality Ratio
RMS	CFA computerised HR system
RO	Regional Officers
SIR	Standardised Incidence Ratio
SMR	Standardised Mortality Ratio
VCR	Victorian Cancer Registry

Appendix 1 CFA Fiskville Data collection methodology

CFA Data Set Compilation Methodology for CFA's 'Cancer Incidence and Mortality Study – Fiskville'
11 April 2013

1. Purpose of this Document

This document provides a decsription of the methodology CFA's Health & Welfare team followed to identify and verify the details of individuals to be included in the "Cancer Incidence and Mortality Study – Fiskville"

2. Objectives of the Study

CFA commissioned Monash University to undertake the "Cancer Incidence and Mortality Study – Fiskville" to examine any linkages between the risk of exposure to hazardous materials at Fiskville during the period 1971-1999 and incidences of cancer and death. The study design is in accordance with Recommendation 5 of Professor Joy's "Report of the Independent Fiskville Investigation" (the Report), which states:

> *That any subsequent study of possible linkages between exposure of persons during training at Fiskville to materials such as flammable liquids and health effects evaluate the usefulness of the qualitative assessment of relative risk of exposure of different groups developed in Chapter 7 (see page 96 of the Report).*

3. CFA Personnel to be included in the study

In accordance with Professor Joy's recommendation, the study group includes CFA Personnel who were at Fiskville between 1971 and 1999 that have been categorised as having 'High', 'Medium', and 'Low' risk of exposure based on the groups defined in Table 7.1 on page 96 of the Report. As at the date of this document, CFA has identified the following data for inclusion in the study:

Groups	Overall Risk of Exposure	Number of Records
PAD Workers	High	95
Instructors (full-time)	High	
Instructors (volunteer and regional staff)	Medium	260
Paid trainees (practical firefighting)	Low	260

The time parameters for the study pre-date computerised record keeping. As a result, identifying the individuals in the above groups and verifying their data proved quite difficult in many instances. This required searches of archived paper records and extensive enquiry within existing CFA networks. This process has taken nearly ten months as at the date of this document, and CFA will continue to search for information where gaps exist. CFA will provide Monash University with periodic updates as additional information becomes available.

4. Sources of data used to identify individuals

a) Personnel and volunteer databases

CFA's current database for paid staff is called 'Pay Global', and it is held centrally at CFA headquarters. It was set up in 2005 from an earlier database (Lattice) which was used between 1993 and 2005. Lattice was also held centrally at CFA headquarters. Prior to 1993, personnel data was held in individual paper records, many of which were held decentrally at CFA's regional offices.

CFA's current volunteer database is called 'Resource Management System' (RMS), which was established in 1994 and is maintained decentrally by CFA's Regions. Although it is primarily for volunteers, this database also contains some information about CFA's career firefighters. RMS holds volunteer's and career firefighter's service histories. During the period 1991 to 1994 a decentralised system called 'Drover' was developed for each Region for keeping volunteer records. During 1994 the 'Drover' databases from each Region were consolidated, cleansed and migrated to RMS. Prior to 1991 card and paper records were held within the Regions.

When PayGlobal, Lattice and RMS were established, in the main only the data for employees or volunteers who were currently with CFA at the time was uploaded into the systems (historical data for past employees and volunteers was generally not uploaded). As a result, there is some risk that individuals who left employment before 1993 may not have been identified. CFA has sought to mitigate this risk via enquiry within existing networks.

b) Photographs

It has been common practice since 1971 in CFA for photographs to be taken of career fire-fighters at the conclusion of their recruit training course at Fiskville. Many of these photos still hang on the walls of the main auditorium building at Fiskville.
CFA accessed these photos when compiling data for this study. 18 photographs were located and 203 Recruit Firefighters were identified from these photographs. The photographs included the names of the training officer and the trainees in each group photo (in some cases only the initial of their first name and surname were displayed). These photos were used to identify individual fire-fighter trainers and trainees and cross checked with Lattice, RMS and other reviews as outlined in 8(a) to 8(h).

c) The Fireman

The Fireman is a private monthly newspaper publication with close links to CFA and its brigades. It provides extensive coverage of activities at CFA brigades and of CFA personnel and is a valuable source of information on a variety of issues impacting on CFA and brigades.

During the years covered by the Health Study, on an annual basis The Fireman included details of senior CFA officers including Regional Officers, Assistant Regional Officers and Fiskville appointments. This information was provided by CFA to The Fireman.

Past copies of The Fireman were sourced and the names of those individuals involved in hot fire training at Fiskville and fitting within the risk of exposure groups were extracted.

5. Personal contacts

CFA assigned a highly respected, long-serving and well known figure among the CFA volunteers (Peter Davis) to contact individuals and gather data for the study. He started with names of Assistant and Regional Officers obtained from The Fireman and names provided by Districts and contacted other long serving volunteers to ensure, as far as possible, that all relevant individuals had been identified.

6. Completeness of Data Sets

a) High

The High group consists of PAD workers and fulltime paid instructors identified from the job title and site recorded in personnel databases and The Fireman.
Following the Joy report, originally 116 were included in the high group, 7 of these were deceased and there has been a further death since that time. 109 individuals were sent an Information Pack on CFA's offer of a voluntary 5 Year Health Surveillance Program. The information Pack included a questionnaire seeking details of the period of time they had worked at Fiskville. Following further discussions and receipts of the completed questionnaires, 23 individuals were subsequently removed from the high list. A further individual has since been included following a review of his involvement at Fiskville.

The names of individuals in the High group have been thoroughly canvassed with other individuals in this group. CFA has a high level of confidence that all the relevant people have been identified.

b) Medium

The Medium group contains:

I. Paid Regional Officers (RO's) and Assistant Regional Officers (ARO's) who, as part of their roles, took groups of volunteers to Fiskville for training and acted as PAD Operators or Instructors in the relevant time frame. Individuals were identified from The Fireman and cross checked in Lattice and RMS. The names of the RO's and ARO's were also checked with several known former RO's.

100 people were identified in this group, and all were sent a questionnaire and asked to

confirm the time that they spent working at Fiskville. 94 of the questionnaires were returned. Of those not returned, follow up phone calls were made.

II. Volunteers who, as part of their role, occasionally instructed at Fiskville. Whilst volunteers are recorded in RMS, the system does not identify whether they acted as Volunteer Instructors. Emails were forwarded to all Regional Directors requesting names of any Volunteer Instructors which they had in their records. Phone or email contact was also made with known Volunteer Instructors seeking names of other Volunteer Instructors during the relevant time frame. Other names were obtained from phone contacts with a Fiskville Hotline CFA established for people to phone and leave details of their involvement at Fiskville. These people were contacted by phone and the detail of their involvement was sought together with the names of any other Volunteer Instructors. In view of the considerable follow-up with known Volunteer Instructors, CFA is confident that the majority have been identified.

III. In total 125 Volunteer Instructors were sent a questionnaire and asked to confirm the period that they spent at Fiskville. 120 of the questionnaires were returned. CFA are reasonably confident that the majority of the relevant Volunteer Instructors have been identified through personal contacts, Fiskville Hotline and Regional Offices.

c) Low

The Low group is comprised on CFA Career Firefighters who attended Recruit Courses at Fiskville during the period 1971-1999. CFA identified 205 people in this category from photographs. The names from the photographs were cross checked with RMS and Lattice. 236 people in this category were found in RMS and 250 were found in Lattice. 62 of the Recruits identified from Lattice and RMS were not found in photographs. Discussions were also held with various Recruits who trained during this period which identified further individuals, who were cross checked with Lattice and RMS. CFA is confident that the majority of Recruit Firefighters have been identified.

7. Opting Out

A small number of individuals chose to opt out of the study. 11 chose to opt out of the study, 2 from the 'High' exposure group and 9 from the 'Medium' exposure group.

8. Deceased

Eight members of the high group are thought to be deceased; date of birth is missing for 1 of these individuals.
Twenty-four members of the medium group are thought to be deceased; dates of birth are missing for 2 of these individuals.

One member of the low group is thought to be deceased; and the date of birth is known for this person.

CFA is reasonably confident that all avenues have been exhausted to locate the date of birth for the deceased including research and review of:

a) historic paper records;
b) archived records (personal files recalled from archives);
c) RMS;
d) Lattice;
e) PayGlobal ;
f) Contact and discussions with other long serving members;
g) On-line searches in the Death Notices of The Herald Sun; and
h) Microfiche records.

CFA will continue to seek information for people who are thought to be deceased and where their dates of birth are unknown. CFA will submit any further information to Monash as it is found.

Appendix 2 Data items requested from CFA

The following data items were obtained

1. A data set containing personal information including (where available):

- CFA ID or registration number
- Surname
- First name
- Middle name (if available)
- Preferred name (if available)
- Date of birth
- Sex
- Last known postcode
- Live status (any death notification)
- Other jobs (if known)

2. A data set containing service history information for all employees or volunteer members including (where available):

- CFA ID or registration number
- Occupational status (e.g. permanent, part-time, exchange, volunteer, temporary)
- Job /position code
- Job /position title
- Job start date
- Job end date
- Job location
- Platoon/ Area
- Additional job code/title/dates/location/platoon data relevant to position changes over time

Appendix 3 Data handling and cleaning processes

Data handling

The data were loaded into a study database which has two components, the front end and back end. The back end contains all the data and this is stored in an SQL Server database on a secure Monash University server. A comprehensive data dictionary was prepared and stored with this database. Identifiers such as names and dates of birth were kept separate from the de-identified data set, which contains details of causes of death and cancer diagnoses. The records are linked by a common study-specific identification number (Fire-ID). Analysis is undertaken on a de-identified data set.

The front end was written in Microsoft Access and access to the data was limited only to staff working on the study and constituted a password login with user access and data modification rights controlled by the MonCOEH data manager.

The data were checked for completeness by the research team before being collated and passed to VCR and AIHW for linkage. A copy of this data set was also supplied to CFA and reflects the numbers reported in Appendix 1.

The date of last contact for individual cohort members was the date when the data set was sent from the CFA for current employees or current volunteer firefighters, or the date when the employee/volunteer resigned for former firefighters. Where no job history was provided, the date when the CFA HR data system was created was used as the date of last contact.

Data cleaning

The original data set was archived unchanged and a copy was loaded into the study database and the following cleaning procedures carried out to produce the final data set. At each step, clarification was sought from the CFA where there was missing or conflicting information.

- Duplicates were merged and the cohort member was moved to the higher group if in more than one group e.g. if a PAD trainer and a volunteer trainer at different periods the person would be allocated to the High group
- Additional cohort members from the national cohort who had Fiskville employment in the relevant time frame were identified
- Birth dates and employee / volunteer identifiers were checked against the national cohort data set.
- Missing birth dates and death deaths were followed up with the CFA
- Missing or implausible birth dates and employment start and end dates were checked and confirmed.

Appendix 4 Analysis methodology

There are two main ways to analyse the cohort data these are summarised below:[26]

1. The Standardised Mortality Ratio and
2. Standardised Incidence Ratio which compare the cohort data with the Australian population.

The Standardised Mortality Ratio (SMR) compares the actual number of deaths from a particular cause in the cohort with the expected number of deaths in the cohort if the death rate in the cohort was the same as that of the Australian population. To find the expected number of deaths, the numbers of person-years were calculated in the cohort grouped by age group and calendar time, and the Australian death rates were applied to this population. The actual number of deaths is divided by the expected number of deaths to calculate the SMR. If the death rate in the cohort is the same as that of the Australian population, the SMR is equal to 1 (sometimes reported as a percentage i.e. 100). If the SMR is greater than 1 then the death rate in the cohort is greater than that of the Australian population. The same calculations can be done for incident cancers as a group and for individual cancers of interest, to calculate a Standardised Incidence Ratio (SIR).

The Relative Mortality Ratio (RMR) compares the mortality rates in the High and Medium groups with that of the Low group. This is calculated by dividing the number of deaths in a group with the number of person-years in the same group. The Low group is the comparison group, and the rate ratio for the other groups is calculated as the rate in each group divided by the rate in the comparison group. A rate ratio of 1 indicates that the exposed group has the same rate of death as the comparison group. Similar calculations will be made for incident cancers. The Relative Incidence Ratio (RIR) compares the cancer incidence rates for the High and Medium groups with that of the Low group. Such internal comparisons can only be done where there are sufficient numbers in the groups being compared. The big advantage of doing internal comparisons is that it helps to overcome the healthy worker effect, firefighters, as a group, can be expected to be fitter when they are taken into a firefighter agency, than the majority of the Australian community.

The SMR and SIR will be accompanied by 95% confidence intervals. If the confidence intervals do not include 1, the risk will be considered statistically significantly increased or decreased.

Appendix 5 Photographs of recruits by year

RECRUIT COURSE 1971 - 1999	
Year	**Available**
1971	No *
1972	No
1973	Yes
1974	No
1975	No
1976	No
1977	No
1978	No
1979	No
1980	No
1981	No
1982	No
1983	Yes
1984	Yes
1/1985	Yes
2/1985	Yes
1/1986	Yes
2/1986	Yes
1/1987	Yes
2/1987	Yes
1/1988	Yes
2/1988	Yes
1989	Yes
1990	Yes
1991	No
1992	No
1993	Yes
1994	No
1/1995	Yes
2/1995	Yes
3/1995	Yes
1996	No
1997	No
1998	No
1/1999	Yes

* Only one person attended a recruit course in 1971 (no photo)

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