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Australian Institute of Health and Welfare

Fourth study of mortality and cancer incidence in aircraft maintenance personnel

A continuing study of F-111 Deseal/Reseal personnel 2016

CANCER SERIES NO. 99



Authoritative information and statistics to promote better health and wellbeing

CANCER SERIES Number 99

Fourth study of mortality and cancer incidence in aircraft maintenance personnel

A continuing study of F-111 Deseal/Reseal personnel

2016

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Abbreviations

ACD	Australian Cancer Database
AIHW	Australian Institute of Health and Welfare
CI	confidence interval
Defence	Department of Defence
DISC	Data Integration Services Centre
DSRS	Deseal/Reseal
DVA	Department of Veterans' Affairs
HREC	Human Research Ethics Committee
ICD	International Statistical Classification of Diseases and Related Health Conditions
IRR	incidence relative risk
MCIS	Mortality and Cancer Incidence Study
MRR	mortality relative risk
Ν	Number
NDI	National Death Index
RAAF	Royal Australian Air Force
RAAF BOI	Royal Australian Air Force Board of Inquiry
SHOAMP	Study of Health Outcomes in Aircraft Maintenance Personnel
SIR	standardised incidence ratio
SMR	standardised mortality ratio
TUNRA	The University of Newcastle Research Associates

Summary

From 1974 to 2000, the Royal Australian Air Force (RAAF) put in place formal Deseal/Reseal (DSRS) programs, in addition to informal repair methods, to correct fuel leaks in Australia's F-111 fleet of aircraft. These programs were undertaken at RAAF Base Amberley in Queensland, and were suspended in early 2000 due to health concerns among DSRS personnel. A series of inquiries, investigations and scientific studies were commenced to determine the extent and impact of those health concerns.

As part of those investigations, the Mortality and Cancer Incidence Study (MCIS) was started to answer the following research question: did RAAF personnel involved either directly or indirectly in the F-111 DSRS maintenance programs (the DSRS-exposed Study Population) experience higher levels of mortality or cancer incidence compared with two groups of non-exposed RAAF personnel (the Comparison populations) – the RAAF Base Amberley (non-technical) Comparison Population and the RAAF Base Richmond (technical) Comparison Population?

This report presents the findings of the fourth iteration of that study (the 4th MCIS).

The Study Population and Comparison populations were modified from those in the 3rd MCIS to include new information about exposure arising from an administrative assessment process (Tier classification). This process defined DSRS-exposure levels (Tiers) based on the type, time period and duration of DSRS-related activities. Including these data in the 4th MCIS has improved both the accuracy and the completeness of the Study Population. For continuity, a supplementary analysis (the 3rd MCIS Update) was undertaken using 3rd MCIS data. The data presented refer to male personnel only.

Key findings

The results of the 4th MCIS show that involvement in the DSRS programs at RAAF Base Amberley was associated with a statistically significant 23–30% increase in the rate of cancer diagnosis, compared with both Comparison populations.

Involvement in the DSRS programs was also associated with a statistically significant 27% decrease in mortality compared with the Amberley Comparison Population, and a non-significant 6% decrease compared with the Richmond Comparison Population.

The key finding of increased rates of cancer incidence in the Study Population is tempered by the presence of methodological limitations that cannot be adjusted for in the study method. These relate to the incompleteness and voluntary selection of the Study Population, the unknown risk factor profiles and differing health surveillance experience of the Study and Comparison populations, and the heterogeneous nature of the DSRS exposure.

The combined effect of these limitations cannot be quantified. Evidence of this effect is observed in the elevated incidence of most cancer sites/types among the Study Population. This finding is unlikely to be related to a single set of exposures and is consistent with the limitations known to be present in this study.

Updating this study with an additional 10–15 years of cancer incidence data may improve the precision of the point estimates and provide greater statistical strength to the findings, particularly in relation to specific cancer sites/types. However, the limitations described above will remain, and must be considered when interpreting future results.

In brief

In 1963, Australia ordered 24 F-111 long-range strike reconnaissance aircraft from General Dynamics in the United States of America (DVA 2010a). These aircraft were delivered to Australia in 1973, and housed at the Royal Australian Air Force (RAAF) Base Amberley in Queensland.

The F-111 aircraft were selected for their long-range capability and strategic diversity, attributed to their unique design: integrated fuel tanks contained within the fuselage (to maximise fuel capacity) and not in separate fuel bladders as with other RAAF aircraft.

Shortly after delivery, the fuel tank sealant began to degrade and leak fuel. Repair of the sealant began in 1974, at first in an informal manner known as 'pick and patch'. This informal repair approach continued at the Squadrons while a series of formal maintenance programs known as Deseal/Reseal (DSRS) (started in 1977) were undertaken at the Depot (Figure A).

The integrated fuel tank design meant RAAF aircraft maintenance personnel needed to work within, or in close proximity to, the fuel tanks in order to remove the sealant (deseal) and apply new sealant (reseal).



In January 2000, maintenance work on the F-111 at RAAF Amberley was suspended when an F-111 Spray Seal program maintenance Unit Inquiry determined there were health-related problems associated with that work. In July 2000, Chief of Air Force convened a formal Board of Inquiry (BOI) and the F-111 fuel tank Spray Seal program was suspended.

The BOI determined that personnel working on all DSRS programs experienced long-term adverse health effects relating to chemical exposure, and recommended that a study on mortality and cancer incidence outcomes among F-111 aircraft maintenance personnel be undertaken.

The Mortality and Cancer Incidence Study (MCIS), started in 2002, is a retrospective cohort study developed by The University of Newcastle Research Associates (TUNRA). TUNRA published two reports — in 2003 (interim report) and in 2004 (2nd MCIS). The Australian Institute of Health and Welfare (AIHW) published the third report in 2009 (3rd MCIS). This current report presents the findings of the fourth iteration of the MCIS (4th MCIS), supplemented by results from the 3rd MCIS Update.

What is the purpose of this study?

The purpose of this study is to update the 3rd MCIS with additional years of mortality and cancer incidence data and to:

...determine whether the DSRS-exposed personnel (Study Population) experience higher than expected rates of mortality or cancer incidence compared with the RAAF non-exposed personnel (Comparison populations).

At the outset of the 4th MCIS, it was intended that only one data set would be constructed, linked and analysed, with only one set of results. That data set would extend the 3rd MCIS, published in 2009. However, new information relating to DSRS exposure was collected through the Tier classification process after the Study Population was first constructed for the 2nd and 3rd MCIS. It was important to incorporate these new data to create the most accurate and complete data set available, and equally important to ensure comparability and continuity with those previous MCISs.

Therefore, two analyses were conducted for this report: the *4th MCIS*, using all available data for improved accuracy and completeness, and the *3rd MCIS Update*, using original MCIS data for continuity.

Further information on the background and purpose of this study can be found in Chapter 1.

How was the study conducted?

Both the 4th MCIS and the 3rd MCIS Update were conducted in four broad steps:

- Step 1 source the available data for the studies
- Step 2-construct the data sets
- Step 3 link the data sets with the Australian Cancer Database and the National Death Index
- Step 4 compare the Study Population with the non-exposed RAAF Comparison populations to produce summary results.

More detailed information on the study methods can be found in Chapter 2 and at Appendix A.

Available data

The available data sources for this study were:

- two input data sets the 3rd MCIS data set and Tier classification data. These were used to derive the Study and Comparison populations for the 4th MCIS (3rd MCIS data set and Tier classification data, in combination) and the 3rd MCIS Update (3rd MCIS data set alone)
- two linkage data sets the Australian Cancer Database (ACD 1982-2010) and the National Death Index (NDI 1999-2012). These were used to determine the number of cancer diagnoses (incidence) and the number of deaths (mortality) in the Study and Comparison populations.

Defining the Study and Comparison populations

The Study Population includes all personnel who were involved in the formal DSRS programs or associated F-111 maintenance work and who made their involvement known, either by volunteering for the MCIS studies (3rd MCIS Update and 4th MCIS) or by applying for Tier classification (4th MCIS only). The two Comparison populations comprise non-technical personnel from RAAF Base Amberley and technical (aircraft maintenance) personnel from RAAF Richmond. These populations were selected specifically to match the characteristics of the Study Population in order to act as non-DSRS-exposed Comparison populations.

The Study Population is treated as a similarly exposed population, although it is recognised that individuals in this population had different experiences depending on the specific DSRS program with which they were involved, the duration of their involvement and their particular job category. Subgroup analysis to further investigate these factors is beyond the scope of this report, although analysis of firefighters (as a special group of interest) is included at Appendix F. The data presented are for male personnel only.

Constructing the data sets

The number and source of persons in the DSRS-exposed Study Population differs between the two analyses (4th MCIS and 3rd MCIS Update) as a result of the Tier classification process. This process meant that:

- 444 newly identified DSRS-exposed personnel were included in the 4th MCIS Study Population. These people were not included in the 3rd MCIS Study or Comparison populations as they were not identified during recruitment for the earlier studies; they were Tier assessed after those populations were constructed
- 873 DSRS-exposed personnel were retained from the 3rd MCIS Study Population. Some of these people were also Tier assessed
- 338 personnel from the 3rd MCIS non-exposed Comparison populations were reclassified as DSRS-exposed through the Tier assessment process. These people were moved to the 4th MCIS Study Population.

These changes mean that the Comparison populations also differ between the 3rd and 4th MCIS studies. It was not possible to add new RAAF Base Amberley and RAAF Base Richmond personnel to the 4th MCIS Comparison populations to replace those who were moved into the Study Population. Instead, the Comparison populations were reweighted to adjust for those changes and to ensure that they continue to act as matched non-exposed comparisons for the Study Population. The Comparison Population in the 3rd MCIS Update is the same as in the 3rd MCIS.

The 4th MCIS data set is considered the most accurate and complete data set available and the results of that analysis underpin the key findings. The results of the analysis of the 3rd MCIS Update data set supplement the key findings and provide a means of comparison with previous studies.

The construction of the 4th MCIS and the 3rd MCIS Update data sets from available data are summarised in Figure B.



Data linkage

Data linkage, also known as data integration, is a process that brings together information relating to an individual, from more than one source.

This process was used in this study to determine the number of personnel among the Study Population and non-exposed Comparison populations who had been diagnosed with cancer or had died. To do this, the 4th MCIS and the 3rd MCIS Update data sets were linked with the cancer (ACD 1982–2010) and mortality (NDI 1999–2012) linkage data sets, held at the AIHW.

The AIHW is one of only three accredited Commonwealth Integrating Authorities. All data linkage is carried out under stringent guidelines for data integration, and follows the requirements of the *Privacy Act 1988* and the *Australian Institute of Health and Welfare Act 1987*. These guidelines and acts ensure that personal identifiers (name, date of birth and sex) are separated from content data (cause of death, cancer type), and no analyst ever has access to both sets of information.

Results of the data linkage are presented in aggregated form and no individual is, or can be, identified. The linked data set created for this project will be securely stored at the AIHW for a period of at least 7 years.

Comparative analysis

Comparative analysis methods are used to determine whether the number of deaths or cancer diagnoses among the Study Population is higher than, lower than, or similar to those for the two Comparison populations. The key findings in this report are based on the *incidence relative risk (IRR)* or *mortality relative risk (MRR)* and these are calculated from weighted data.

The relative risk is derived by:

- 1. calculating the weighted number of cancers or deaths in each group
- 2. calculating the weighted number of person years in each group

- 3. dividing the weighted number of cancers or deaths by the weighted person years in each group
- 4. calculating the ratio of these rates to compare the Study Population with each Comparison Population.

If the relative risk is greater than 1.0, the number of cancers or deaths in the Study Population is *higher* than that for the Comparison Population(s). It the relative risk is less than 1.0, the number of cancers or deaths in the Study Population is *lower* than that for the Comparison Population(s).

The statistical significance of the difference in relative risk of mortality or cancer diagnosis between the Study Population and the Comparison populations indicates whether a true difference would exist between these groups in the real world, given the underlying assumptions of the statistical test used.

What are the key findings of this study?

Cancer incidence

Between 1982–2010, based on linkage with the Australian Cancer Database, there were 149 cancers diagnosed among personnel in the 4th MCIS Study Population. Prostate cancer was the most common cancer type (31 cancers diagnosed, 21%), followed by melanoma of the skin (26 cancers, 17%) and colorectal cancer (20 cancers, 13%).

In this time period, overall cancer incidence among the 4th MCIS Study Population was **statistically significantly**:

- higher (23%) compared with the Amberley Comparison Population (RR=1.23, confidence interval (CI)=1.03-1.48)
- higher (30%) compared with the Richmond Comparison Population (RR=1.30, CI=1.09–1.56) (Figure C).

Mortality

Between 1999–2012, based on linkage to the National Death Index, there were 52 deaths from all causes among the 4th MCIS Study Population. Cancers were the leading cause of death (29 deaths, 56%), followed by diseases of the circulatory system (8 deaths, 15%) and external causes (5 deaths, 10%).

In this time period, mortality was **statistically significantly** lower (27%) among the 4th MCIS Study Population compared with the Amberley Comparison Population (RR=0.73, CI=0.54–0.97) (Figure C). Mortality was 6% lower among the 4th MCIS Study Population compared with the Richmond Comparison Population; however, this difference was **not statistically significant** (RR=0.94, CI=0.70–1.26).

Mortality from cancer (N=29) was 6% lower among the 4th MCIS Study Population compared with the Amberley Comparison Population (MRR=0.94, CI=0.63–1.40), and 34% higher compared with the Richmond Comparison Population (MRR=1.34, CI=0.89–2.01). Neither of these comparisons was statistically significant.



What are the limitations and is further work needed?

The validity of the key finding in relation to cancer incidence may be affected by the presence of methodological limitations (potential confounding effects and biases), including:

- the study recruitment method and possible incompleteness of the Study Population
- differences in the demographic profile (such as age, sex and rank), risk factor profile (such as smoking and sun exposure), risk awareness, and health surveillance (including increased cancer screening) between the Study and Comparison populations
- the selective composition of the Comparison populations.

Some of the study limitations, such as differences in the demographic profiles, are measurable and can be adjusted for in the analysis. Others — most notably potential differences between the Study and Comparison populations in the prevalence of risk factors for cancer and levels of cancer screening — have not been measured and have therefore not been accounted for in the study method.

The combined effect of these limitations on the study findings is difficult to estimate. Detailed methods, technical notes and a discussion of potential confounding effects and biases are included in the report to aid this interpretation.

Updating this study with an additional 10–15 years of cancer incidence data may help to improve the precision of the point estimates and provide greater statistical strength to the findings, particularly in relation to specific cancer sites/types. However, the potential biases described above will remain and must be considered in interpreting those future results.

1 Introduction

1.1 Purpose and structure

This report presents the findings of the fourth in a series of studies to determine whether Royal Australian Air Force (RAAF) aircraft maintenance personnel involved in any of the four formal F-111 Deseal/Reseal (DSRS) programs or associated duties at RAAF Base Amberley between 1974 and 2000 (the DSRS-exposed Study Population) experience higher than expected rates of mortality or cancer incidence compared with non-exposed RAAF personnel (Comparison populations).

Previous Mortality and Cancer Incidence studies (MCISs) found that mortality varied, and cancer incidence was generally higher, among the exposed Study Population compared with the non-exposed Comparison personnel. The 3rd MCIS, published by the Australian Institute of Health and Welfare (AIHW) in 2009, showed that the incidence of cancer was 40–50% higher among the exposed Study Population than among Comparison populations. The increased incidence was statistically significant compared with the Richmond Comparison Population and nearing significance compared with the Amberley Comparison Population and the Australian male population (AIHW 2009).

The 3rd MCIS also showed that mortality among the Study Population from all causes of death in 1999–2004 was 30–50% higher than for the Amberley and Richmond Comparison populations. These results were not statistically significant.

The authors of that study determined that the findings were inconclusive. They recommended that a fourth study be undertaken to provide greater statistical certainty around the increased incidence of cancer among DSRS-exposed personnel (AIHW 2009). The 4th Mortality and Cancer Incidence Study (4th MCIS), commissioned by the Department of Veterans' Affairs (DVA), was undertaken by the AIHW to implement that recommendation.

The 4th MCIS was intended to be an update of the 3rd MCIS, using updated Australian Cancer Database (ACD) and National Death Index (NDI) data. Then an additional source of information on exposed personnel became available through the Tier classification process, which began in 2005. The additional data presented a methodological challenge — incorporating them created a more accurate and complete data set; however, by changing the composition of the Study Population, the 4th MCIS was no longer directly comparable with previous MCIS results (see Box 1.1).

Box 1.1: Rationale for the 4th MCIS and the 3rd MCIS Update

At the outset of the 4th MCIS, it was intended that only one data set would be constructed, linked and analysed, with only one set of results. However, additional information on DSRS exposure became available and was collected after the Study Population was constructed by The University of Newcastle Research Associates (TUNRA) for the first two MCISs. It was important to incorporate these new data to create the most complete data set available; it was equally important to ensure comparability and continuity with previous MCISs.

As a result, two analyses were conducted: the *4th MCIS* (using all available data for improved accuracy and completeness) and the *3rd MCIS Update* (using original MCIS data for continuity).

(continued)

Box 1.1 (continued): Rationale for the 4th MCIS and the 3rd MCIS Update

This report includes a description and summary analysis of both studies, although the *key findings reported in the Summary and the conclusion are based on the 4th MCIS only* and so include the additional exposure information. For more information on these studies and the broader MCIS series, see appendixes A and E.

Including the additional exposure information means that this 4th study is more complete, though not directly comparable with previous studies. To allow for some level of continuity within the series, two analysis data sets were created:

- 1. the 4th MCIS data set, incorporating the additional Tier classification information into the 3rd MCIS data set, which was then linked to the 1980–2012 mortality data (with key findings based on 1999–2012 data) and the 1982–2010 cancer incidence data
- 2. the 3rd MCIS Update data set, based on the unchanged 3rd MCIS data set, linked to an additional 8 years of mortality data (1980–2012, with key findings based on 1999–2012 data) and 7 years of cancer incidence data (1982–2010) compared with the 3rd MCIS.

As the most accurate, complete and robust data set, the 4th MCIS is the focus of this report and underpins the key findings in response to the purpose of the study. The exposed population is referred to as the 4th MCIS Study Population.

The 3rd MCIS Update supplements the key findings of the 4th MCIS and ensures continuity and comparability with findings from the previous MCISs. The exposed population is referred to as the 3rd MCIS Update Study Population.

This report is structured in three broad sections:

- 1. The first section comprises a Summary and an 'In brief' overview of the report.
- 2. The second section provides the following: the background to the health issues arising from the DSRS aircraft maintenance work, and a general timeline of inquiries and studies into those health issues (Chapter 1); a summary of the methods used in this study (Chapter 2); results of the 4th MCIS (Chapter 3); results of the 3rd MCIS Update (Chapter 4); a discussion (Chapter 5); and the report's conclusions (Chapter 6).
- 3. The third section outlines detailed methods and technical notes (Appendix A), data sources (Appendix B), supplementary tables to the analyses (appendixes C and D), a comparison of the methods and results of the mortality and cancer incidence studies (Appendix E), and a special subgroup analysis of firefighters (Appendix F).

1.2 F-111 fleet and maintenance programs

In 1963, Australia ordered 24 F-111 long-range strike reconnaissance aircraft from General Dynamics in the United States of America (USA) (DVA 2010a). While delivery was scheduled for October 1968, technical issues and loss of USAF F-111 aircraft in Vietnam meant that the order was not delivered to the RAAF Base Amberley in Queensland until June 1973. During this time, the 24 F-111 aircraft remained in storage at General Dynamics.

The long-range capability and strategic diversity of the F-111 is attributed to the plane's unique design: integrated fuel tanks contained within the fuselage, and not in separate fuel bladders as with other RAAF aircraft. The location of fuel tanks in the F-111 is shown in Figure 1.1.



Soon after the fleet of F-111 aircraft was delivered, the sealant in the planes' fuel tanks began to degrade, causing the fuel to leak. This problem was rectified by removing the old sealant by hand and replacing it with new sealant. From 1973–1977, these repairs of fuel tank leaks on the F-111 aircraft were 'ad hoc', with leaks repaired as they occurred. As the problem relating to the fuel leaks grew, the RAAF determined to address the repairs systematically. From 1977, F-111 aircraft were removed from service and underwent a formal Deseal/Reseal (DSRS) program. Between 1977 and 2000, four formal DSRS programs were carried out on the F-111 fleet of aircraft by aircraft maintenance workers at RAAF Base Amberley. These were:

- Program 1 (1977–1982)
- 'Wing DSRS' Program (1985–1992)
- Program 2 (1991–1993)
- 'Spray Seal' Program (1996–2000).

Each program employed different manual methods of fuel tank repair:

- Program 1, Program 2 and the 'Wing DSRS' Program involved either applying chemical solvents to the sealant or removing it with water jets and hand tools ('desealing'), and reapplying the sealant ('resealing').
- The 'Spray Seal' Program involved cleaning, preparing and recoating the existing sealant ('resealing'). 'Desealing' was only necessary where deterioration of the existing sealant was apparent.
- Program 1, Program 2 and the 'Spray Seal' program required whole body entry of maintenance personnel into the fuel tanks.

• The 'Wing DSRS' Program did not require whole body entry of personnel into the fuel tanks. Instead, a section of each wing was removed exposing the tanks sufficiently for personnel to carry out the DSRS process in open air.

As well as the formal programs, informal 'pick and patch' repair work on the fuel tanks was carried out as part of flight-line maintenance of the fleet. This work was undertaken by RAAF personnel from other squadrons, in a part-time or *ad hoc* capacity, between 1973 and 2000.

The United States Air Force also carried out DSRS work on its fleet of F-111 aircraft from 1975. Australia sent 9 F-111 aircraft from its RAAF fleet to Sacramento, California in the USA between May 1981 and December 1982 for maintenance under contract by the United States Air Force.

For a detailed discussion on the chemicals and processes involved in the DSRS programs, see *Report of the Board of Inquiry into F-111 (fuel tank) Deseal/Reseal and Spray Seal programs,* Volume 2 (RAAF 2001b).

1.3 Health concerns and inquiries

On 28 January 2000, Unit management halted the Spray Seal Program due to growing concerns about the number of F-111 fuel tank personnel reporting health problems. A Unit Inquiry quickly determined that there were problems associated with all the DSRS programs, dating back to 1977. Based on this finding, Chief of Air Force convened a Board of Inquiry (BOI) in July 2000.

RAAF Board of Inquiry

The BOI is a more formal process than a Unit Inquiry. The BOI was required to investigate and make findings in relation to each of the four formal DSRS programs (excluding 'pick and patch').

The BOI made extensive inquiries into the processes, procedures and chemicals used during the programs, and reported on the systemic causes of a breakdown in safety management.

The principal finding of the BOI was:

'...that in excess of 400 people [who had participated in the four formal DSRS programs] have suffered long-term health effects as a result of such exposure [to chemicals]...' (RAAF 2001a).

The BOI made 53 recommendations and 2 supplementary recommendations, all of which were accepted by the RAAF. The initial implementation of these recommendations has had a profound effect on how safety is managed not only in the RAAF, but also across the whole of the Australian Defence Force.

Tier classification

In 2005, as part of the Australian Government's response to the findings of the RAAF BOI, the DVA publicly released work (Tier) definitions that describe three Tiers of exposure for 12 categories of work relating to F-111 fuel tank maintenance (DVA 2010b). The Tier classification process assesses personnel against Tier definitions according to the type of maintenance work they undertook, when the work was carried out and the cumulative time spent doing that work. These work definitions were designed and implemented for

administration of compensation, ex gratia payments, and health care for personnel whose work fitted the definitions. Personnel do not need a health condition to apply for Tier classification. Similarly, ex gratia payments were made to individuals regardless of their health status, or to their deceased estate. More information on this classification is available at Appendix A3 and at <http://www.dva.gov.au/factsheet-f111-02-tier-classification-andtier-definitions>.

Parliamentary Inquiry into RAAF F-111 Deseal/Reseal workers and their families

In May 2008, the Joint Standing Committee for Foreign Affairs, Defence and Trade (the Committee) began a Parliamentary inquiry into the adequacy of the health and support needs of RAAF DSRS workers and their families. In June 2009, the findings of that inquiry were tabled in the report *Sealing a just outcome: report from the Inquiry into RAAF F-111 Deseal/Reseal workers and their families* (JSCFADT 2009).

The Committee made 18 recommendations, including:

- expanding the scope of the Tier classification scheme to include individuals who worked in the informal maintenance programs ('pick and patch')
- removing time restrictions on applications for determination of Tier classification
- expanding the scope of permissible evidence in support of applications for determination of Tier classification.

The Australian Government accepted 14 of the recommendations in its May 2010 response (Australian Government 2010). As at June 2012, it had implemented those 14 accepted recommendations, wholly or in part, with modification/enhancement (ANAO 2013; DVA 2012).

1.4 Studies into health outcomes

Study of Health Outcomes in Aircraft Maintenance Personnel

During the BOI, the Department of Defence (Defence) commissioned an epidemiological study to assess whether adverse health outcomes reported by DSRS personnel were associated with their involvement in DSRS programs or activities. The study, known as the Study of Health Outcomes in Aircraft Maintenance Personnel (SHOAMP), was undertaken in three phases by TUNRA.

The first phase of the SHOAMP was a literature review (TUNRA 2003a). The second phase (discussed here) was a mortality and cancer incidence study (AIHW 2009; TUNRA 2003b, 2004a). The third phase was a study of general health and medical outcomes of DSRS personnel (TUNRA 2004b).

Mortality and Cancer Incidence studies

The second phase of the SHOAMP, the MCIS, is a retrospective cohort study to compare the health of personnel involved in the four formal F-111 DSRS programs (the Study Population) with the health of non-exposed personnel from RAAF Base Amberley and RAAF Base Richmond (the Comparison populations), as well as with the health of the Australian male population. The data presented refer to male personnel only.

The RAAF Comparison populations were carefully constructed to act as a non-DSRS-exposed comparison with the Study Population. The Comparison populations comprise two groups of personnel, from RAAF Base Amberley (the Amberley Comparison Population) and RAAF Base Richmond (the Richmond Comparison Population). The purpose of the Comparison populations is to help determine if any difference in the rate of mortality or cancer incidence between the Study Population and these Comparison populations is likely to be the result of DSRS-exposure. The Comparison populations are matched to the Study Population by age, sex, rank and posting/exposure category, and differ by occupation and environment/location.

The first two MCISs – SHOAMP, phase 2, MCIS interim report; and the SHOAMP, phase 2, MCIS second report (2nd MCIS) – were undertaken by TUNRA and published in 2003 and 2004, respectively (TUNRA 2003b, 2004a). These and other associated materials can be accessed on the 'Studies' page of the DVA's F-111 website

<http://www.dva.gov.au/benefits-and-payments/f-111-fuel-tank-maintenance/inquiriesand-studies/studies> (see also Box 1.2).

Box 1.2: Further information on the MCISs in relation to F-111 fuel tank maintenance

This study is the fourth in a series relating to mortality and cancer incidence outcomes. For detailed methods, results and conclusions of previous studies in the series, see:

- The University of Newcastle Research Associates 2003. Mortality and Cancer Incidence Study: interim report (First Study) (TUNRA 2003b)
 http://www.dva.gov.au/sites/default/files/files/benefits%20and%20payments/f11 1/Mortality_Final_report_Sept_2003.pdf>
- The University of Newcastle Research Associates 2004. Mortality and Cancer Incidence Study: second report (Second Study) (TUNRA 2004a)
 http://www.dva.gov.au/sites/default/files/files/benefits%20and%20payments/f11 1/TUNRA_MCIS_2nd_Report.pdf>
- AIHW 2009. Third study of mortality and cancer incidence in aircraft maintenance personnel: a continuing study of F-111 Deseal/Reseal personnel (AIHW 2009) <http://www.aihw.gov.au/WorkArea/DownloadAsset.aspx?id=6442454609>.

The DVA has a website dedicated to F-111 Fuel Tank Maintenance http://f111.dva.gov.au/index.htm. This website provides detailed information and support for personnel and their families, including on:

- F-111 Deseal/Reseal maintenance programs
- studies and inquiries into the health outcomes of those programs
- Australian Government response to those inquiries
- Tier classification.

The investigators of the 2nd MCIS found that cancer incidence was higher than expected among the F-111 DSRS population compared with the Amberley and Richmond Comparison populations, although there was not a statistically significant difference. The report included the recommendation to:

'...repeat these analyses in the future (in three to five years for example) when more outcome events are available; this should increase the power of the study' (TUNRA 2004a).

As a result of this recommendation, the AIHW was commissioned by the DVA to undertake the 3rd MCIS in 2005. The 3rd MCIS followed on from the TUNRA studies and included an additional 5 years of data – presenting mortality data from 1980–2004 and cancer incidence data from 1982–2003. This 3rd MCIS also presented separate analyses for mortality data from 1999–2004 to reduce the bias associated with non-identification of DSRS personnel before 1999.

The key finding of the 3rd MCIS was that cancer incidence was 44% higher in the exposed (DSRS) group compared with the Australian male population; however, this result was not found to be statistically significant (AIHW 2009). The non-significant finding led the AIHW to determine that the available data were inconclusive, and to recommend that:

'...this study be repeated in 2011 when more data will be available to provide greater statistical power and to improve certainty about the findings' (AIHW 2009).

This report presents the findings of the Fourth Mortality and Cancer Incidence Study (the 4th MCIS) and includes new information about exposure arising from the Tier classification program, begun in 2005. Tier data were not included in previous studies. For continuity and comparability with previous MCISs, a supplementary analysis (the 3rd MCIS Update) was also undertaken, using original MCIS data.

2 Methods

This chapter describes the methods specific to this study, for both the 4th MCIS and the 3rd MCIS Update, in four broad steps:

- Step 1 source the available data for the study
- Step 2 construct the data set, incorporating the Tier data into the 3rd MCIS data set
- Step 3-link the MCIS data with the ACD and the NDI
- Step 4 compare the Study Population with the non-exposed RAAF Comparison populations, to produce summary results.

The broad method for this study is depicted in Figure 2.1 and more detail is provided in the sections that follow.



2.1 Data sources

The available data sources for this study were:

- two input data sets the 3rd MCIS data set (developed by TUNRA) and Tier classification data – to derive the Study Population (and Comparison populations)
- two linkage data sets the NDI and the ACD for linkage purposes to determine the number of deaths and cancer diagnoses.

These data sources are summarised below and are presented in more detail at Appendix A (3rd MCIS data and Tier data) and Appendix B (NDI and ACD). A description of the completeness of available data for this study is presented in Box 2.1.

Australian population data are also used for standardised comparisons with the Australian male population, as supplementary findings in both the 4th MCIS and 3rd MCIS Update analyses. These data were sourced from the Australian Bureau of Statistics (see Appendix B).

Box 2.1: Completeness of available data for the Mortality and Cancer Incidence Studies

F-111 DSRS has developed a high public profile due to media attention in response to the RAAF BOI (2001), the Joint Standing Committee on Foreign Affairs and Trade Parliamentary Inquiry, and to health complaints voiced by F-111 personnel. Substantial efforts have been made through the SHOAMP and the Tier classification process to identify persons involved, either directly or indirectly, in the F-111 DSRS maintenance programs between 1974 and January 2000. However, records of these personnel are limited or incomplete; therefore, it is not known with certainty how many personnel participated in this work. As a result, the Study Population for the Mortality and Cancer Incidence Study series is considered to be incomplete (RAAF 2001b; TUNRA 2003b, 2004a).

Input data sets

The **3rd Mortality and Cancer Incidence Study data set (3rd MCIS)** was created by TUNRA at the outset of the study, in 2002. The data set contains information on the Study Population and the Comparison populations, including the strata information for weighting purposes. TUNRA supplied the data set to the AIHW in 2003 for the 3rd MCIS (AIHW 2009). This data set was used in combination with the Tier assessment data to create the Study Population for the 4th MCIS. The 3rd MCIS Update retains the 3rd MCIS data set, as supplied.

For detailed information on the underlying (3rd MCIS) data set, including the way the Comparison populations were selected, see the following publications available at ">http://www.dva.gov.au/benefits-and-payments/f-111-fuel-tank-maintenance/inquiries-and-studies/studies>">http://www.dva.gov.au/benefits-and-payments/f-111-fuel-tank-maintenance/inquiries-and-studies/studies>">http://www.dva.gov.au/benefits-and-payments/f-111-fuel-tank-maintenance/inquiries-and-studies/studies>">http://www.dva.gov.au/benefits-and-payments/f-111-fuel-tank-maintenance/inquiries-and-studies/studies>">http://www.dva.gov.au/benefits-and-payments/f-111-fuel-tank-maintenance/inquiries-and-studies/studies>">http://www.dva.gov.au/benefits-and-payments/f-111-fuel-tank-maintenance/inquiries-and-studies/studies>">http://www.dva.gov.au/benefits-and-payments/f-111-fuel-tank-maintenance/inquiries-and-studies/studies>">http://www.dva.gov.au/benefits-and-payments/f-111-fuel-tank-maintenance/inquiries-and-studies/studies>">http://www.dva.gov.au/benefits-and-payments/f-111-fuel-tank-maintenance/inquiries-and-studies/studies>">http://www.dva.gov.au/benefits-and-payments/f-111-fuel-tank-maintenance/inquiries-and-studies/studies>">http://www.dva.gov.au/benefits-and-payments/f-111-fuel-tank-maintenance/inquiries-and-studies/studies>">http://www.dva.gov.au/benefits-and-payments/f-111-fuel-tank-maintenance/inquiries-and-studies/studies>">http://www.dva.gov.au/benefits-and-payments/f-111-fuel-tank-maintenance/inquiries-and-studies

- The University of Newcastle Research Associates 2003. Mortality and Cancer Incidence Study: *interim report* (First Study) (TUNRA 2003b)
- The University of Newcastle Research Associates 2004. Mortality and Cancer Incidence Study: second report (Second Study) (TUNRA 2004a).

In the years since TUNRA developed the MCIS data set, the Tier classification system for ex gratia payments was introduced (2005) and broadened (2010). This system presents an additional data source for information about DSRS exposure and allows a larger and more

complete cohort of personnel involved in the DSRS programs and associated F-111 maintenance work to be compiled (DVA 2010b). It is important to note in this context that Tier ex gratia payments are made independent of this study and its findings.

Tier classification data were made available for the 4th MCIS as a result of determinations of applications for Tier classification – undertaken by the DVA and Defence – of personnel who believed they were exposed to any of the four formal F-111 DSRS programs, or associated work. Those personnel, classified as 'Tier exposed' through this process, were combined with the 3rd MCIS data to create the Study Population for the 4th MCIS. These data are not included in the 3rd MCIS Update.

Linkage data sets

The **NDI** is a complete record of fact of death and cause of death for Australia, and is held at the AIHW for data linkage purposes. The 4th MCIS and 3rd MCIS Update data sets were linked to the NDI to identify those personnel in the Study and Comparison populations who had died, and their underlying cause of death.

The 3rd MCIS analysis determined that the presence of a methodological bias (survivor bias) in the study had an impact on the interpretation of the mortality analysis pre-1999. This bias results from an unknown number of personnel who would have been part of the Study Population but died before 1999 (when health issues were first raised) and who were therefore not identified as ever working in the DSRS programs. This means that the observed death rate in the Study Population before 1999 is lower than it should be. This bias persists in the 4th MCIS. In an attempt to minimise the effect of survivor bias on the results, the key findings for mortality in this report are based on analysis of 1999–2012 data only, although data are available for analysis from 1980 to 2012. For more information, see Appendix A.

The **ACD** contains information on all Australians who were diagnosed with cancer (excluding basal cell and squamous cell carcinomas of the skin) between 1982 and 2011. The 4th MCIS and 3rd MCIS Update data sets were linked to the ACD to identify those personnel in the Study and Comparison populations who had been diagnosed with cancer, and their primary cancer site/type.

2.2 Constructing the data sets from available data

The availability of the Tier classification data from the DVA expanded the scope of this study (compared with that for previous MCISs), allowing additional personnel to be included in the Study Population. This included persons not previously included in the MCIS data set and some changes to the exposure category for existing MCIS personnel. The inclusion of Tier classification data represents an important enhancement to the study: increasing the size and statistical power of the data set, and improving case ascertainment. A consequence of this changed scope and altered methodology is that this 4th study is not directly comparable with previous studies.

To account for the additional data, and ensure the recommendations of the previous study could be achieved, two data sets were constructed for analysis: the 4th MCIS data set and the 3rd MCIS Update. These are described in this chapter and more completely at Appendix A.

Fourth MCIS

The 4th MCIS data set incorporates the additional Tier data into the 3rd MCIS data set, and is considered to be the most accurate, complete and robust F-111 DSRS-exposed Study Population to date. The analysis of this data set underpins the key findings of this study.

The 4th MCIS data set comprises 18,033 individual male personnel:

- 1,655 personnel in the 4th MCIS Study Population
- 16,378 personnel in the two non-exposed RAAF Comparison populations:
 - 7,407 Amberley non-technical personnel (includes 259 personnel also in the Richmond Comparison Population)
 - 9,230 Richmond technical personnel (includes 259 personnel also in the Amberley Comparison Population).

Third MCIS Update

The 3rd MCIS Update retains the same personnel and exposure classifications as the previous MCIS studies. Analysis of this data set ensures continuity and comparability with earlier studies using updated mortality and cancer incidence data, and supplements the key findings of the 4th MCIS.

The 3rd MCIS Update data set comprises 17,589 male personnel, retained from the 3rd MCIS data set, including:

- 873 personnel in the Study Population
- 16,716 personnel in the two non-exposed RAAF Comparison populations:
 - 7,576 Amberley non-technical personnel (includes 267 personnel also in the Richmond Comparison Population)
 - 9,407 Richmond technical personnel (includes 267 personnel also in the Amberley Comparison Population).

Study and Comparison populations

The Study and Comparison populations are described in Box 2.2. More detailed information on these populations and on the methods used to construct the data sets from available data are available at Appendix A.

Box 2.2: Defining the Study and Comparison populations

Study Population

The F-111 DSRS-exposed population was first defined by TUNRA at the start of the retrospective cohort study. It included (male) RAAF personnel who were known to have been involved in any of the four formal DSRS programs or associated F-111 maintenance work (including 'pick and patch'). These personnel were identified through formal records, or by volunteering for the study. The scope of the exposed population was expanded for the 4th MCIS to include additional personnel in the DSRS-exposed Study Population.

(continued)

Box 2.2 (continued): Defining the Study and Comparison populations

This expanded scope included personnel new to the study as well as those previously counted in the Comparison populations who applied for Tier assessment and were classified as Tier 1-, Tier 2- or Tier 3-exposed through that process. This population is referred to as the *Study Population* throughout the report and has the same meaning (although comprising different individuals) for both the 4th MCIS and the 3rd MCIS Update.

For more information on the Study Population and Tier classification, see Appendix A.

Comparison populations

The Comparison populations were constructed to act as non-DSRS-exposed individuals for comparison with the Study Population, as was first defined by TUNRA. The purpose of the Comparison populations – the RAAF Base Amberley Comparison Population and the RAAF Base Richmond Comparison Population – is to help determine if any difference in the rate of mortality or cancer incidence between the Study Population and these populations is likely to be the result of DSRS exposure. These Comparison populations were matched to the Study Population by age, sex, rank, and posting/exposure category. They differed by occupation – technical aircraft maintenance or non-technical – and environment/location – RAAF Base Amberley (Queensland) or RAAF Base Richmond (New South Wales):

- The RAAF Base Amberley (non-technical) Comparison Population was sourced from individuals with similar environmental exposures, but different occupational exposures.
- The RAAF Base Richmond (technical) Comparison Population was sourced from individuals with similar occupational exposures, but different environmental exposures.

The introduction of Tier classified personnel into the Study Population for the 4th MCIS meant that the Comparison populations were no longer completely matched. To adjust for this change, the Comparison populations were reweighted.

For more information on the Comparison populations and the weighting method, see:

- appendix A in this current report
- appendixes F and G in the 2nd MCIS report (TUNRA 2004a).

Female personnel

The data presented in this report refer only to *male* personnel. Female personnel were considered for this study; however, the small number of exposed female personnel in the Study Population is insufficient for meaningful comparison with female personnel in the non-exposed Comparison populations.

2.3 Data linkage and privacy

Data linkage, also known as data integration, is a process that brings together information relating to an individual from more than one source.

To determine the number of personnel among the Study Population and non-exposed Comparison populations who had been diagnosed with cancer or had died, the 4th MCIS and 3rd MCIS Update data sets were linked with the cancer and mortality linkage data sets, held at the AIHW: the ACD and the NDI. This linkage was carried out by the Data Linkage Unit at the AIHW, one of only three accredited Commonwealth Integrating Authorities, under strict privacy guidelines (Box 2.3).

The data sets were linked using a probabilistic linkage process using full name, date of birth and sex (males only) to find matches between the data sets. Separate linkages were performed for the ACD and the NDI, and additional variables (including cause of death and cancer type) were added to the 4th MCIS and 3rd MCIS Update data sets as a result of the linkage.

More detailed information on the linkage protocol and privacy provisions related to this study can be found at Appendix A5–Data linkage, Appendix A7–Data storage and record retention and Appendix A8–Privacy principles.

Box 2.3: Data linkage and privacy at the Australian Institute of Health and Welfare

The AIHW is one of only three accredited Commonwealth Integrating Authorities. This accreditation requires the AIHW to adhere to stringent criteria and abide by the National Statistical Service *High level principles for data integration involving Commonwealth data for statistical and research purposes* and *Best practice guidelines*. As well as these guidelines, data linkage at the AIHW is carried out under the protections of the *Privacy Act 1988*, and the *Australian Institute of Health and Welfare Act 1987* (which carries additional privacy protections for companies and deceased people).

The AIHW data linkage protocols prescribe strict separation of identifiers and content data within the AIHW Data Linkage Unit, so that no one analyst will ever have access to both. On completion of the data matching process, personal identifiers (full name, sex and date of birth) are no longer required.

Results of the linkage are presented in aggregated format and no individual is, or can be, identified. The linked data set created for this project will be securely stored at the AIHW for a period of at least 7 years.

For more information on data linkage at the AIHW, see <http://www.aihw.gov.au/data-linking/>.

2.4 Comparative analysis methods

The linkage method identifies the number of personnel in each group who have died or been diagnosed with cancer. These data are then weighted or standardised using the methods described below to derive comparative summary statistics. These summary statistics are used to determine whether the number of deaths or cancers in the Study Population is higher than, lower than or similar to that for the non-exposed Comparison populations. This, in turn, provides a measure of the strength of the association between the exposure to DSRS programs (and associated activities) and the occurrence of mortality or cancer incidence. The same methods are applied to the 4th MCIS and 3rd MCIS Update data sets.

Key findings in this report are based on the weighted comparative method. This method produces the *incidence relative risk* (IRR) or *mortality relative risk* (MRR) summary statistics, derived by:

- 1. calculating the weighted number of cancers or deaths in each group
- 2. calculating the weighted number of person years in each group

- 3. dividing the weighted number of cancers or deaths by the weighted number of person years in each group
- 4. calculating the ratio of these rates to compare the Study Population with each Comparison Population.

A second method, the standardised method, is used to compare the Study Population with the Australian male population. This method produces the *standardised incidence ratio* (SIR) or *standardised mortality ratio* (SMR).

The statistical significance of the difference in relative risk, or standardised ratios, between the Study Population and the non-exposed Comparison Population(s) is determined by the 95% confidence intervals around the rate or ratio.

Key statistical terms used in this report are described in Box 2.4 and more detailed methods are presented at Appendix A6–Data analysis methods. These terms are also described in the Glossary.

Box 2.4: Key statistical terms

The purpose of this report is to examine available data to determine if there is sufficient statistical evidence of a difference in *mortality* or *cancer incidence* between the Study Population and the Comparison Population(s). These differences are estimated from the data and expressed as the *relative risk* (or *standardised ratio*) point estimates. The level of certainty and precision around these point estimates is expressed as a *95% confidence interval* and the likelihood that they reflect the true population rate differences is described in terms of *statistical significance*. These key statistical terms, and their use in this study, are explained here.

Cancer incidence: The number or rate of *new cases* of cancer diagnosed in a population during a given time period (1982–2010).

Mortality: The number or rate of *deaths* in a population during a given time period (1999–2012).

Incidence relative risk (IRR) and **mortality relative risk (MRR):** The ratio of the observed incidence or mortality rate in the Study Population to the estimated (weighted) rate in the Comparison Population(s). If those rates are the same, the IRR or MRR (point estimate) is 1.0. If the rate in the Study Population is *higher* than in the Comparison Population(s), the point estimate is greater than 1.0. If the rate in the Study Population is *lower* than in the Comparison Population(s), the point estimate is greater than 1.0. If the rate is less than 1.0.

Standardised incidence ratio (SIR) and **standardised mortality ratio (SMR):** The ratio of the incidence or mortality rate in the Study Population compared with the Australian male population, adjusting for any difference in age structure between the two populations. The interpretation of the point estimate is similar to that for the IRR or MRR.

95% confidence interval: The range of values around the point estimate in which there is 95% certainty that the true value of the difference lies. The width of the confidence interval indicates the precision of the point estimate and is related to the size of the sample and the number of events (cancer incidence or deaths) observed. A narrow interval indicates a more precise estimate, related to a larger sample size, and a wide interval indicates a less precise estimate, related to a smaller sample size.

(continued)

Box 2.4 (continued): Key statistical terms

Statistical significance: A measure of the strength of statistical evidence that a true difference exists, given the underlying assumptions of the statistical test used. In this study, the statistical significance of the point estimate is determined by whether the 95% confidence interval includes or excludes 1.0. If the confidence interval includes 1.0, it is considered there is insufficient evidence of a difference in the rates of the Study and Comparison populations. If the confidence interval excludes 1.0, it is considered that there is sufficient evidence in rates between the Study and Comparison populations. While it can be stated that the difference is statistically significant (at the 95% confidence level), it is important to recognise that there is a 5% likelihood that the rates are the same in each population. Statistical significance is not absolute, but an indication of the strength of the statistical finding.

2.5 Understanding the results and key findings of the comparative analysis

This section presents an annotated figure, based on fictional data, to aid interpretation and understanding of the comparative analysis and key findings of the 4th MCIS.

Note that the purpose and key findings are presented at the start of each results chapter, and complete data tables for the analyses are available at appendixes C and D. The interpretation and implications of the results are discussed in Chapter 5.

Figure 2.2 is provided to assist readers in understanding the presentation of results in Chapter 3. This annotated figure describes the relative risk, 95% confidence interval and statistical significance for general 'conditions'. The interpretation applies equally to cancer incidence (the IRR) and mortality (the MRR) and can be extrapolated to the interpretation of the standardised ratios (the SIR and SMR). Note that the same summary statistics are also presented in tabular form (Chapter 4).



3 Fourth MCIS: results

This chapter presents the findings of the 4th MCIS data set for cancer incidence and mortality (boxes 3.1 and 3.2), in response to the overarching purpose of this study:

To determine if the DSRS-exposed personnel in the 4th MCIS Study Population experience higher than expected rates of mortality or cancer incidence compared with the RAAF Base Amberley (non-technical) and the RAAF Base Richmond (technical) non-exposed Comparison populations.

3.1 Cancer incidence

Linkage of the 4th MCIS data set to the 1982–2010 ACD shows that there were 149 cancers diagnosed among the 4th MCIS Study Population in that time period:

- 31 diagnoses of prostate cancer (21% of all cancers)
- 26 diagnoses of melanoma of the skin (17%)
- 20 diagnoses of colorectal cancer (13%)
- 72 diagnoses from all other cancers (48%) (Appendix Table C1).

Box 3.1: Key findings of the 4th MCIS—cancer incidence

In the 1982–2010 linked data set, cancer incidence was **statistically significantly higher** among the 4th MCIS Study Population compared with:

- the Amberley Comparison Population (23% higher) (IRR=1.23, CI=1.03-1.48)
- the Richmond Comparison Population (30% higher) (IRR=1.30, CI=1.09–1.56).

Personnel in the 4th MCIS Study Population also had **statistically significantly higher** incidence of:

- non-Hodgkin lymphoma compared with the Amberley Comparison Population (N=11, IRR=2.94, CI=1.37-6.30)
- lung cancer compared with the Richmond Comparison Population (N=13, IRR=1.96, CI=1.04-3.68)
- eye cancer compared with Amberley (N=4, IRR=19.17, CI=1.99–184.45) and Richmond Comparison populations (N=4, IRR=6.10, CI=1.47–25.27).

The small number of eye cancers in the Study Population (N=4) means that caution should be used when interpreting the findings. See Section 5.1 and Appendix E for more information.

Amberley Comparison Population

In the 1982–2010 linked data set, the incidence of all cancers combined among the 4th MCIS Study Population was 23% higher than the rate observed for the weighted Amberley Comparison Population. **This difference was found to be statistically significant** (IRR=1.23, CI=1.03–1.48) (Figure 3.1, Appendix Table C1). The incidence of specific cancer types among the 4th MCIS Study Population was observed to be generally higher compared with the Amberley Comparison Population. The findings for two cancer types were statistically significant:

- the incidence of non-Hodgkin lymphoma was more than 2 times as high among the 4th MCIS Study Population compared with the Amberley Comparison Population (N=11, IRR=2.94, CI=1.37-6.30)
- the incidence of eye cancer was more than 19 times as high among the 4th MCIS Study Population compared with the Amberley Comparison Population (N=4, IRR=19.17, CI=1.99–184.45) (Appendix Table C1).

The small number of eye cancers in the Study Population (N=4) means that caution should be used when interpreting the findings. See Section 5.1 and Appendix E for more information. Selected cancer types for which there were at least 5 cases in 1982–2010 are shown in Figure 3.1.



Richmond Comparison Population

In the 1982–2010 linked data set, the incidence of all cancers combined among the 4th MCIS Study Population was 30% higher than the rate observed for the Richmond Comparison Population. **This difference was found to be statistically significant** (IRR=1.30, CI=1.09–1.56) (Figure 3.2, Appendix Table C1).

The incidence of specific cancer types among the 4th MCIS Study Population was observed to be generally higher compared with the Richmond Comparison Population.

The findings for two cancer types were statistically significant:

- the incidence of lung cancer was nearly 2 times as high among the 4th MCIS Study Population compared with the Richmond Comparison Population (N=13, IRR=1.96, CI=1.04-3.68)
- the incidence of eye cancer was around 6 times as high among the 4th MCIS Study Population compared with the Richmond Comparison Population (N=4, IRR=6.10, CI=1.47-25.27) (Appendix Table C1).

As for the comparison with the Amberley Comparison Population, the small number of eye cancers (N=4) means that caution should be used when interpreting the findings of this analysis. See Section 5.1 and Appendix E for more information. Selected cancer types for which there were at least 5 cases in 1982–2010 are shown in Figure 3.2.



3.2 Mortality

Linkage of the 4th MCIS data set to the 1999–2012 NDI shows that there were 52 deaths from all causes among the 4th MCIS Study Population in that time period:

• 29 deaths from *neoplasms* (cancer) (56% of all deaths)

- 8 deaths from *diseases of the circulatory system* (15%)
- 5 deaths from *external causes of morbidity and mortality* (10%)
- 10 deaths from all other causes of death (19%) (Appendix Table C2).

Box 3.2: Key findings of the 4th MCIS—mortality

In the 1999–2012 linked data set, mortality was **statistically significantly lower** among the 4th MCIS Study Population compared with the Amberley Comparison Population (27% lower) (MRR=0.73, CI=0.54–0.97).

There was **no statistically significant difference** between the 4th MCIS Study Population compared with the Richmond Comparison Population (6% lower) (MRR=0.94, CI=0.70–1.26).

Mortality from cancer (N=29) was 6% lower among the 4th MCIS Study Population compared with the Amberley Comparison Population (MRR=0.94, CI=0.63–1.40) and 34% higher compared with the Richmond Comparison Population (MRR=1.34, CI=0.89–2.01). Neither of these comparisons was found to be statistically significant.

Amberley Comparison Population

In the 1999–2012 linked data set, mortality from all causes of death among the 4th MCIS Study Population was 27% lower than that observed for the Amberley Comparison Population. **This difference was found to be statistically significant** (MRR=0.73, CI=0.54–0.97) (Figure 3.3, Appendix Table C2).

Mortality among the 4th MCIS Study Population was observed to be generally lower compared with the Amberley Comparison Population for most broad causes of death, and the magnitude of these differences was between 10–60% (Appendix Table C2). None of these differences was found to be statistically significant. Selected broad causes of death, for which there were 5 or more deaths in 1999–2012, are shown in Figure 3.3.


Figure 3.3: Mortality among the 4th MCIS Study Population compared with the RAAF Base Amberley (non-technical) Comparison Population, by selected broad causes of death, 1999–2012

Richmond Comparison Population

In 1999–2012, mortality from all causes of death among the 4th MCIS Study Population was 6% lower than (that is, similar to) that observed for the Richmond Comparison Population. **This difference was not found to be statistically significant** (MRR=0.94, CI=0.70–1.26) (Figure 3.4; Appendix Table C2).

Mortality among this group was observed to be generally lower compared with the Richmond Comparison Population for most broad causes of death. The magnitude of these differences was between 10–60%, and none were found to be statistically significant (Appendix Table C2).

There was one exception to this general finding: mortality from cancers was observed to be 34% higher (although not statistically significant) among the 4th MCIS Study Population compared with the Richmond Comparison Population (MRR=1.34, CI=0.89–2.01) (Figure 3.4). Selected broad causes of death, for which there were 5 or more deaths in 1999–2012, are shown in Figure 3.4.



Mortality from cancer

In the 1999–2012 linked data set, there were 29 deaths (56%) from cancer among the 4th MCIS Study Population, making it the leading cause of death for that population. Those deaths included 7 from lung cancer, and 3 each from colorectal cancer, leukaemia and non-Hodgkin lymphoma.

Compared with the Amberley Comparison Population, the 4th MCIS Study Population had higher mortality from leukaemia, lung cancer and non-Hodgkin lymphoma and lower mortality from colorectal cancer and all cancers combined (Table 3.1).

The increase in mortality from non-Hodgkin lymphoma among the 4th MCIS Study Population compared with the Amberley Comparison Population was **found to be statistically significant** (N=3, MRR=5.55, CI=1.01–30.47) (Table 3.1). This finding is based on a very small number of cases (N=3), however, and should be interpreted with caution. See Section 5.1 and Appendix E for more information.

Compared with the Richmond Comparison Population, the 4th MCIS Study Population had higher mortality from all selected cancer sites/types (colorectal, leukaemia, lung and non-Hodgkin lymphoma) and from all cancers combined (Table 3.1).

Table 3.1: Mortality from cancer among the 4th MCIS Study Population compared with the Amberley Comparison Population and the Richmond Comparison Population, by selected cancer types/sites, 1999–2012

		Amberley Comparison Population		Richmond Compa	arison Population
Cancer type/site ^(a)	Observed ^(b)	MRR ^(c)	95% CI ^(d)	MRR ^(c)	95% CI ^(d)
Neoplasms	29	0.94	0.63–1.40	1.34	0.89–2.01
Colorectal cancer	3	0.67	0.20–2.26	1.34	0.38–4.72
Leukaemia	3	1.84	0.48–7.08	3.38	0.80–14.22
Lung cancer	7	1.10	0.48–2.51	1.45	0.63–3.33
Non-Hodgkin lymphoma	3	*5.55	1.01–30.47	3.09	0.75–12.71

* statistically significant difference at the 95% confidence level.

95% CI 95% confidence interval

MRR (weighted) mortality relative risk

(a) A complete list of ICD-9 and ICD-10 codes used to define the cancer mortality groupings is presented in Appendix Table B1.

(b) The observed (actual) mortality among the 4th MCIS Study Population.

(c) The MRR of the Study Population compared with the Amberley or Richmond Comparison Population. The MRR is the ratio of the observed mortality rate in the Study Population to the estimated (weighted) rate in the Comparison Population(s). If those rates are the same, the MRR is 1.0. If the rate in the Study Population is higher than in the Comparison Population(s), the MRR is greater than 1.0. If the rate in the Study Population is lower than in the Comparison Population(s), the MRR is less than 1.0.

(d) The 95% CI indicates the range of values around the MRR in which there is 95% certainty that the true value of the difference lies. If the CI includes 1.0, it is considered there is insufficient evidence of a difference in the rates of the Study and Comparison populations. If the CI excludes 1.0, it is considered that there is sufficient evidence of a difference in rates between the Study and Comparison populations (a statistically significant finding).

Source: Appendix Table C2.

3.3 Comparison with Australian male population

This section presents additional analyses of the 4th MCIS data set – a standardised comparison of the Study Population with the Australian male population – and complements the findings of the weighted comparisons with the two RAAF Comparison populations. Results are presented for cancer incidence and mortality (including mortality from cancer) and detailed findings are available at Appendix C.

High-level standardised comparison results for firefighters – a specific group of DSRS-exposed personnel – are presented at Appendix F.

Cancer incidence

In the 1982–2010 linked data set, the incidence of all cancers combined among the 4th MCIS Study Population was 39% higher than would be expected if that group experienced the same rate of cancer diagnosis as the Australian male population. **This difference was found to be statistically significant** (SIR=1.39, CI=1.16–1.61) (Appendix Table C3).

The incidence of specific cancer types was observed to be generally higher for the 4th MCIS Study Population compared with the Australian male population, although none of these differences were statistically significant.

Mortality

In the 1999–2012 linked data set, mortality from all causes of death among the 4th MCIS Study Population was observed to be 36% lower than would be expected if that group experienced the same level of mortality as the Australian male population.

This difference was found to be statistically significant (N=52, SMR=0.64, CI=0.46-0.81) (Appendix Table C4).

Mortality from all broad causes of death was observed to be generally lower for the 4th MCIS Study Population compared with the Australian male population. **This difference was found to be statistically significant** for two broad causes:

- diseases of the circulatory system (N=8, SMR=0.40, CI=0.12-0.69)
- external causes of morbidity and mortality (N=5, SMR=0.37, CI=0.05-0.69) (Appendix Table C4).

Mortality from cancer

Mortality from cancer was similar among the 4th MCIS Study Population and the Amberley Comparison Population, compared with the Australian male population. Mortality from cancer was 19% lower among the Richmond Comparison Population compared with the Australian male population. **This difference was found to be statistically significant** (N=127, SMR=0.81, CI=0.67-0.95) (Appendix Table C4).

4 Third MCIS Update: results

This chapter presents the results of the 3rd MCIS Update data set. This analysis uses the same Study Population as previous MCISs, with updated mortality and cancer incidence data. The results of this analysis enable direct comparison with previous MCISs and are supplementary to the findings of the 4th MCIS. As such, these results are presented in less detail than for the 4th MCIS. Complete data tables are available at Appendix D.

4.1 Cancer incidence

Linkage of the 3rd MCIS Update data set to the 1982–2010 ACD shows that there were 75 cancers diagnosed among the 3rd MCIS Update Study Population in that time period. The most commonly diagnosed cancer was melanoma of the skin (18 new cases, 24% of all cancers), followed by prostate cancer (17 cases, 23%) and colorectal cancers (11 cases, 15%) (Table 4.1).

The incidence of all cancers among the 3rd MCIS Update Study Population was found to be around 20% higher compared with the RAAF Comparison populations:

- 20% higher than the Amberley Comparison Population (IRR=1.20, CI=0.94–1.53)
- 22% higher than the Richmond Comparison Population (IRR=1.22, CI=0.96–1.55) (Table 4.1).

These differences were not found to be statistically significant.

The incidence of selected cancer types among the 3rd MCIS Update Study Population was observed to be generally higher compared with the RAAF Comparison populations, except for non-Hodgkin lymphoma, which was found to be lower compared with the Richmond Comparison Population.

Lip cancer was found to be more than 5 times as high among the 3rd MCIS Update Study Population when compared with the Amberley Comparison Population (N=4, IRR=5.44, CI=1.55-19.08) and the Richmond Comparison Population (N=4, IRR=5.41, CI=1.62-18.05) (Table 4.1). These differences were found to be statistically significant. The small number of lip cancers in the 3rd MCIS Update Study Population (N=4) means, however, that caution should be used when interpreting the findings. See Section 5.1 and Appendix E for more information.

		Amberley Comparison Population		Richmond C Popul	d Comparison Sulation	
Cancer type/site ^(a)	Observed ^(b)	IRR ^(c)	95% Cl ^(d)	IRR ^(c)	95% CI ^(d)	
All cancers	75	1.20	0.94–1.53	1.22	0.96–1.55	
Eye	1	7.60	0.51–112.51	2.24	0.26–19.38	
Colorectal	11	1.64	0.86–3.12	1.31	0.70–2.46	
Prostate	17	1.36	0.81–2.27	1.21	0.73–1.99	
Lip	4	*5.44	1.55–19.08	*5.41	1.62–18.05	
Lung	7	1.40	0.63–3.11	2.14	0.95–4.81	
Myeloid leukaemia	2	2.05	0.44–9.62	2.23	0.49–10.26	
Non-Hodgkin lymphoma	3	1.29	0.38-4.35	0.83	0.26–2.68	
Melanoma of the skin	18	1.55	0.94–2.57	1.60	0.97–2.63	

Table 4.1: Cancer incidence among the 3rd MCIS Update Study Population, by selected cancer types/sites, 1982–2010

* statistically significant difference at the 95% confidence level.

95% CI 95% confidence interval

IRR (weighted) incidence relative risk

(a) All cancers defined by ICD-O-3 codes C00–C99, D45, D46, D47.1 and D47.3, excluding those codes for basal cell carcinoma and squamous cell carcinoma of the skin. For a complete list of codes, see Appendix Table B2.

(b) The observed (actual) incidence among the 3rd MCIS Update Study Population.

(c) The IRR of the Study Population compared with the Amberley or Richmond Comparison Population. The IRR is the ratio of the observed mortality rate in the Study Population to the estimated (weighted) rate in the Comparison Population(s). If those rates are the same, the MRR is 1.0. If the rate in the Study Population is higher than in the Comparison Population(s), the MRR is greater than 1.0. If the rate in the Study Population is lower than in the Comparison Population(s), the MRR is less than 1.0.

(d) The 95% CI indicates the range of values around the IRR in which there is 95% certainty that the true value of the difference lies. If the CI includes 1.0, it is considered there is insufficient evidence of a difference in the rates of the Study and Comparison populations. If the CI excludes 1.0, it is considered that there is sufficient evidence of a difference in rates between the Study and Comparison populations (a statistically significant finding).

Source: Appendix Table D1.

4.2 Mortality

Linkage of the 3rd MCIS Update data set with the 1999–2012 NDI shows that there were 27 deaths from all causes among the 3rd MCIS Update Study Population. *Neoplasms* (cancers) were the most common broad cause of death (12 deaths, 44% of all deaths), followed by *diseases of the circulatory system* (4 deaths, 15%) (Table 4.2).

Mortality from all causes of death among the 3rd MCIS Update Study Population was found to be lower compared with the RAAF Comparison populations:

- 28% lower than the Amberley Comparison Population (MRR=0.72, CI=0.48–1.06)
- 7% lower than the Richmond Comparison Population (MRR=0.93, CI=0.63-1.38) (Table 4.2).

These differences were not found to be statistically significant.

Mortality from selected broad causes of death was observed to be generally lower among the 3rd MCIS Update Study Population compared with the RAAF Comparison populations. The exceptions were higher mortality from:

• *diseases of the respiratory system* and *diseases of the digestive system* compared with the Amberley Comparison Population

• *neoplasms, diseases of the respiratory system* and *diseases of the digestive system* compared with the Richmond Comparison Population (Table 4.2).

These differences were not found to be statistically significant.

Table 4.2: Mortality among the 3rd MCIS Update Study Population, by selected broad causes of death, 1999–2012

		Amberley Comparison Population		Richmond Comparison Population	
Cause of death ^(a)	Observed ^(b)	MRR ^(c)	95% CI ^(d)	MRR ^(c)	95% Cl ^(d)
All deaths	27	0.72	0.48–1.06	0.93	0.63–1.38
Neoplasms (cancers)	12	0.74	0.41–1.33	1.06	0.59–1.93
Diseases of the circulatory system	4	0.50	0.18–1.37	0.56	0.20–1.53
Diseases of the respiratory system	2	1.40	0.31–6.25	1.90	0.42-8.55
Diseases of the digestive system	2	1.30	0.29–5.74	1.67	0.38–7.43
External causes of morbidity and mortality	2	0.32	0.08–1.31	0.35	0.08–1.41

* statistically significant difference at the 95% confidence level.

95% CI 95% confidence interval

MRR (weighted) mortality relative risk

(a) A complete list of ICD-9 and ICD-10 codes used to define the mortality groupings is presented in Appendix Table B1.

(b) The observed (actual) mortality among the 3rd MCIS Update Study Population.

(c) The MRR of the Study Population compared with the Amberley or Richmond Comparison Population. The MRR is the ratio of the observed mortality rate in the Study Population to the estimated (weighted) rate in the Comparison Population(s). If those rates are the same, the MRR is 1.0. If the rate in the Study Population is higher than in the Comparison Population(s), the MRR is greater than 1.0. If the rate in the Study Population is lower than in the Comparison Population(s), the MRR is less than 1.0.

(d) The 95% CI indicates the range of values around the MRR in which there is 95% certainty that the true value of the difference lies. If the CI includes 1.0, it is considered there is insufficient evidence of a difference in the rates of the Study and Comparison populations. If the confidence interval excludes 1.0, it is considered that there is sufficient evidence of a difference in rates between the Study and Comparison populations (a statistically significant finding).

Source: Appendix Table D2.

5 Discussion

5.1 Cancer incidence

In the 1982–2010 linked data set, cancer incidence was **statistically significantly higher** among 4th MCIS Study Population compared with:

- the Amberley Comparison Population (23% higher) (IRR=1.23, CI=1.03-1.48)
- the Richmond Comparison Population (30% higher) (IRR=1.30, CI=1.09-1.56).

The statistical significance of the overall increase in cancer incidence was supported by the generally higher incidence of most specific cancer sites/types, and the **statistically significantly higher incidence of**:

- non-Hodgkin lymphoma compared with the Amberley Comparison Population (N=11, IRR=2.94, CI=1.37-6.30)
- lung cancer compared with the Richmond Comparison Population (N=13, IRR=1.96, CI=1.04-3.68)
- eye cancer (N=4) compared with the Amberley Comparison Population (IRR=19.17, CI=1.99–185.45) and the Richmond Comparison Population (IRR=6.10, CI=1.47–25.27).

The increased incidence of eye cancers among the 4th MCIS Study Population was found to be statistically significant compared with both the weighted Amberley and Richmond Comparison populations. The number of observed cases for the 4th MCIS Study Population is small (N=4), however, and the confidence intervals around the estimates are wide.

It is well established that a study with low statistical power (small number of observed events, such as deaths or new cases of cancer) has both a reduced chance of detecting a true effect and a reduced likelihood of reporting a statistically significant result that reflects a true effect (Button et al. 2013). In the context of the results of this study, those statistically significant findings based on a small number of observed events (with a wide confidence interval) when compared with those statistically significant findings based on a large number of observed events (with a narrow confidence interval) are:

- less likely to reflect a true difference
- more likely to have inflated the magnitude of that difference.

This is demonstrated in the case of eye cancer when the 4th MCIS Study Population is compared with the Amberley Comparison Population: the number of events is small (N=4), the confidence interval is wide (1.99–184.45) and the magnitude of the difference is large (IRR=19.17). These factors combine to indicate that the precision and strength of the statistically significant result are low. Accordingly, this finding is presented with a note of caution, so that users of this report can consider whether the finding is suitable for their purposes. This lack of precision and strength is also demonstrated in trends over time, where those estimates based on small numbers fluctuate, while those based on larger numbers are more stable. For more information, see Appendix Figure E3.

Comparing the Study Population with the Australian male population indicated statistically significantly higher incidence of all cancers combined, and generally higher incidence from most cancer site/types.

The analysis of the 3rd MCIS Update data set showed a broadly similar pattern of results (including similar point estimates) to the results of the 4th MCIS, although the observed differences (rate ratios) were generally smaller and there were fewer statistically significant findings using the 3rd MCIS Update data set.

5.2 Mortality

Between 1999–2012, mortality from all causes of death was **statistically significantly lower** among the 4th MCIS Study Population compared with the Amberley Comparison Population (27% lower) (RR=0.73, CI=0.54–0.97). There was **no statistically significant difference** compared with the Richmond Comparison Population (6% lower) (RR=0.94, CI=0.70–1.26).

The significant finding of lower all-cause mortality among the 4th MCIS Study Population compared with the Amberley Comparison Population was not supported by a significant finding in any broad cause of death. However, mortality from non-Hodgkin lymphoma was found to be statistically significantly higher among the Study Population compared with the Amberley Comparison Population (N=3, RR=5.55, CI=1.01–30.47). This finding, similar to the incidence of eye cancer, is based on a small number of deaths (3) with wide confidence intervals, and caution should be used when interpreting the findings. For more information, see Appendix Figure E3.

The key findings of the 4th MCIS in relation to mortality are supplemented by similar findings from both the comparison of the 4th MCIS Study Population with the Australian male population, and analysis of the 3rd MCIS Update data set.

5.3 Limitations

The key findings of this 4th MCIS report are underpinned by the most complete Study Population available, accurate linkage of that population to the ACD and the NDI, and a robust comparative analysis methodology. In this study, the exposure has been defined as involvement in the DSRS programs, and the outcome is mortality or cancer incidence. The results of this study are presented for the Study Population as a whole, and must not be used to infer individual risk.

There are a number of study limitations in the form of potential confounding effects and biases. These are types of error that may lead to incorrect estimation of the true effect of the exposure or outcome being studied.

These potential confounding effects and biases provide the context in which the results of this study must be interpreted; some of these are described briefly in this chapter. For more detailed information, see:

- Study of health outcomes in aircraft maintenance personnel, phase 2: mortality and cancer incidence study, interim report July 2003 (TUNRA 2003b)
- *Study of health outcomes in aircraft maintenance personnel, phase 2: mortality and cancer incidence, study second report April 2004 (TUNRA 2004a).*

Potential confounding effects

In this study, potential confounders include demographic characteristics (age, sex, rank and posting category), individual risk profiles (for example, tobacco smoking and sun exposure) and the heterogeneous nature of the exposure and exposed (Study) Population.

The demographic characteristics have been accounted for in the selection and composition of the RAAF Comparison populations – the Amberley (non-technical) Comparison Population and the Richmond (technical) Comparison Population – and in the weighting of the comparative statistics. These adjustments are methodological in nature and are described more completely at Appendix A6 – Data analysis methods.

The weighting method used to adjust for the demographic characteristics (age, sex, rank and posting category) cannot adjust completely for the individual risk profiles of personnel involved in the DSRS programs (and related duties). For example, there is no information on the smoker status or sun exposure profile of personnel – both known risk factors for specific cancers under investigation. The General Health and Medical Study did examine some risk factors including smoker status, and found broad similarities at the population level between the DSRS personnel and the Comparison populations (TUNRA 2004a, 2004b).

It is recognised that the chemical exposures across and within the formal DSRS programs and informal 'pick and patch' activities were heterogeneous in nature and that individuals in the Study Population had different exposures depending on the specific DSRS program(s) with which they were involved, the duration of their involvement, and their job category. This means that the individuals making up the Study Population do not have a singular, consistent or constant exposure profile (Bowling 2009). Some of the chemicals to which the Study Population were exposed (directly or indirectly) due to their involvement in the DSRS programs are known to cause cancer in humans. These are benzene, hexavalent chromium (Chromium VI) and silica, which are strongly associated with lung cancer; leukaemia; lymphoma; and pulmonary, gastrointestinal, sinus and nasopharyngeal cancers (Bowling 2014; IARC 1987; JSCFADT 2009; TUNRA 2003a). Other DSRS chemicals are possible human carcinogens and associated with a broader list of cancers, including those of the liver, pancreas, brain and central nervous system, genitourinary tract, and skin (TUNRA 2003a).

While it stands to reason that increases in those cancers strongly associated with exposure to known human carcinogens could be expected in a population exposed to those chemicals, subgroup analysis was not in scope for this report. It is therefore not possible to associate the incidence of specific cancers with those specific chemical exposures. Further, the analyses presented in the MCIS series consider DSRS-exposed personnel only as a similarly exposed homogenous population. This means that differences in the exposure profile of individuals are not adjusted for in this analysis, and the level of the exposure effect that could be measured using the Study Population is diluted.

The observed elevated incidence of most cancer sites/types among the Study Population is unlikely to be related to a single set of exposures and is consistent with a range of study design limitations known to be present in this study (see Appendix Table C1). These factors are discussed in the following section.

Potential biases

The main potential biases in this study relate to:

• the way the cohort was created (for example, no complete record of personnel, Tier classification, self-selection)

- the nature of the ongoing scrutiny of the Study Population and their health status (for example, heightened individual awareness of risk and intensive health surveillance, including frequent medical follow-up and higher rates of health [cancer] screening)
- the inability to completely adjust for the risk profile of individuals (particularly among the Tier-classified records) in the analysis.

The Study Population for the MCIS is known to be incomplete. In the first instance, it relied on the compilation of information collected for the BOI, and from individuals who self-identified in response to media campaigns and DVA-administered health schemes (TUNRA 2003b). In the most recent iteration (4th MCIS), it included personnel self-selecting for the Tier classification process. There is no complete record of all personnel employed in these programs between 1974 and January 2000 (RAAF 2001b; TUNRA 2003b, 2004a).

The introduction of the Tier classification system is a point of difference between the 3rd MCIS (and 3rd MCIS Update) and the 4th MCIS. The Tier classification system introduced 782 new records to the 4th MCIS Study Population, 338 of which came from the Amberley and Richmond Comparison populations. The remaining 444 records were for personnel who had not previously been captured in the MCIS data set.

The current total of 1,655 personnel determined through the Tier classification process to have been exposed to the DSRS programs or associated activities represent 58% of the 3,100 personnel estimated by Defence to have been exposed (ANAO 2013). It must be noted that the 3,100 estimate by Defence was all inclusive and intended to ensure the potential impact on personnel was not underestimated; it may, however, be an overestimate of the total number of DSRS-exposed personnel.

The addition of Tier-assessed personnel to the 4th MCIS data set is an enhancement of the Study Population. Improved case ascertainment resulted in the addition of new personnel to the Study Population and the transfer of others from the Comparison populations. This increased the size and power of the Study Population to detect statistically significant differences in cancer incidence.

While this expanded scope is considered to be the most complete and accurate for the study, the additional data provided for the 4th MCIS from the Tier classification process are based on the Tier exposure definition only. This is different from the definition of exposure used in the earlier MCISs. It is possible that these additional records for DSRS-exposed personnel are fundamentally different from those in the 3rd MCIS Update data set and that this difference may be driving the significant findings of this fourth study.

Comparison of those exposed personnel identified through the Tier classification process with those retained from the 3rd MCIS shows that there is sufficient similarity in the strata variables – age group, exposure/posting category and rank – and the observed number and relative risk of deaths and cancer incidence to suggest that the additional records included through the Tier classification process is not a major source of bias. In contrast, the number of differences in the statistical significance of specific cancer types (eye cancer, lip cancer, non-Hodgkin lymphoma) in the 4th MCIS compared with the 3rd MCIS demonstrates the sensitivity of the analysis to the size and composition of the Study Population relative to the Comparison populations.

For more information on the comparison between the 4th MCIS and the 3rd MCIS Update Study populations, see appendix tables A2 and A3. For a more detailed comparison of the key findings of the 4th MCIS and the 3rd MCIS Update, see Appendix E.

The propensity for individuals to participate in a study such as this is increased if they relate to the area of study or if there are incentives to participation. This can lead to bias in the Study Population. The nature of the MCIS means that individuals who are already unwell (experiencing symptoms or who have active disease) may be more likely to participate. In the context of this study, participation relies on individuals contacting the DVA to identify themselves as having worked on the DSRS programs or associated activities, including applying for Tier classification. The effect of this would be a bias toward increased cancer incidence compared with the randomly selected Comparison populations.

The personnel in the Study Population are also likely to have a different awareness of their risk profile in relation to their DSRS exposure and differing access to health services (before, during and after the period of exposure) than personnel in Comparison populations. These differences stem from the high profile of the exposure and of this study, and the specific health-care provisions and ex gratia payments available to personnel exposed to the DSRS programs and associated F-111 maintenance work (DVA 2010b; JCSFADT 2009).

Increased awareness of health risks among the Study Population, and increased surveillance and monitoring of the Study Population by health professionals (with particular emphasis on cancer screening and testing), are factors that may change the course of cancer diagnosis among the Study Population compared with the RAAF Comparison populations. The elevated incidence of most cancer sites/types among the Study Population compared with the RAAF Comparison populations, observed in the findings of the 4th MCIS and the 3rd MCIS Update, is evidence in support of this effect (Appendix Table C1). See also the section titled 'Potential confounding effects' earlier in this chapter.

This potential bias may also contribute to the lower than expected mortality among the Study Population, if health conditions are recognised and treated earlier than in the Comparison populations, and if personnel diagnosed with those conditions are included in the 'at risk' population even though these conditions would not have resulted in death. This is particularly relevant for early diagnosis of asymptomatic cancers, such as prostate cancer.

Similarly, the intense focus on the Study Population may also increase the likelihood of identifying rare cancers and of those observed cases being found to be statistically significant. This possibility is demonstrated in the statistically significant finding for lip cancer in the 3rd MCIS Update, compared with the non-significant finding in the 4th MCIS.

In the 3rd MCIS Update, there were 4 cases of lip cancer, and the relative incidence rate was found to be statistically significantly higher among the Study Population compared with both the Amberley Comparison Population (RR=5.44, CI=1.55–19.08) and the Richmond Comparison Population (RR=5.41, CI=1.62–18.05) (Appendix Table D1). In the 4th MCIS, there are still 4 cases of lip cancer among the Study Population; however, the increased size of the cohort (nearly doubled compared with the 3rd MCIS Update) means that this is no longer a significant finding.

This analysis demonstrates the effect of intense observation of small and fluctuating incidence counts for rare cancer types. That is, making a large number of comparisons (for example, by type of cancer) over an extended period of time increases the likelihood of observing a rare event, and concluding that the occurrence of that event was not due to chance.

This same rationale can be applied to the statistically significant increase in the incidence of eye cancer among the 4th MCIS Study Population. While the current analysis is based on only a small number of cases, it is certainly one that warrants further observation over time.

5.4 Potential for further work

Analysis undertaken to compare the exposed personnel identified through the Tier classification process and those retained from the 3rd MCIS indicates that the populations are similar. The increased size of the Study Population in the 4th MCIS compared with the 3rd MCIS Update appears to provide a sufficient increase in statistical power to produce statistically significant findings for the incidence of all cancers combined.

To assist in planning any further MCIS, a modified power analysis was performed on selected cancer types/sites to determine the number of observed cancers (sample size) in the 4th MCIS Study Population that would be required to produce a statistically significant result, compared with the Amberley Comparison Population. The selected cancer sites/types had at least 10 observed cancers between 1982 and 2010, a lower-bound 95% confidence interval of between 0.7 and 1.0 and had previously been associated with solvent or sealant (chemical) exposure.

The year in which that result would be achieved is referred to in this context as the 'estimated incident year for significance'. The method and results of this power analysis are presented at Appendix A6–Data analysis methods.

Based on the findings from this analysis and assuming the current rates of cancer incidence in the exposed and Comparison Population remain the same, sufficient statistical power to derive significance (if it exists) for three cancer sites (colorectal, prostate and lung) among the 4th MCIS Study Population, compared with the Amberley Comparison Population, may be available with an additional 10–15 years of incidence data (to incident year 2020–25):

- colorectal cancer (1982–2013)
- prostate cancer (1982–2020)
- lung cancer (1982–2023) (Appendix Table A6).

These incidence data are expected to be available for linkage by the mid-2020s.

Power analysis estimates are based on the best information currently available and do not account for potential changes in the underlying risk profile or size of the Comparison Population. Results from the power analysis should therefore not be taken as recommendations, but rather used as additional information available to help assess timing for further research.

Extended follow-up using the same data set and methodology as the 4th MCIS will not account for inherent bias in the Study Population; this must be taken into consideration in any future analysis. In addition, the DVA continues to receive and make determinations on applications for Tier classification. This means that any future analyses of this population would include updated Tier classification data that may introduce F-111 DSRS-exposed personnel not found in the 4th MCIS data set.

6 Conclusions

The broad purpose of the 4th MCIS was to determine whether DSRS-exposed personnel (the Study Population) had a higher rate of mortality or cancer incidence compared with non-exposed Comparison personnel (RAAF Comparison populations).

This study shows that incidence from all cancers combined was statistically significantly higher among the Study Population than among the Amberley Comparison Population (23% higher) and the Richmond Comparison Population (30% higher). In contrast, mortality from all causes of death was statistically significantly lower among the Study Population than among the Amberley Comparison Population (27% lower), and lower but not statistically different from the Richmond Comparison Population (6% lower).

The results of the 3rd MCIS Update showed a broadly similar pattern of results (including similar point estimates) although with fewer statistically significant findings.

There are a number of methodological limitations inherent in this study — in the form of potential confounding effects and biases — that may artificially inflate the comparative rate of cancer incidence among the Study Population. These relate to the incompleteness and voluntary selection of the Study Population, the unknown risk factor profiles and differing health surveillance experience of the Study and Comparison populations, and the heterogeneous nature of the DSRS exposure.

The combined effect of these limitations is difficult to quantify. Evidence of this effect is observed in the elevated incidence of most cancer sites/types among the Study Population. This finding is unlikely to be related to a single set of exposures and is consistent with the study design limitations known to be present in this study.

The noteworthy increase in specific cancer types, including eye cancer, lymphoma and lung cancer, among the 4th MCIS Study Population compared with the Comparison populations, warrants further follow-up and investigation. Further studies conducted with a longer follow-up time (10–15 years of additional cancer incidence data) may result in an increased number of observed cancer cases and the recruitment of additional Tier-classified personnel to the Study Population. The increased sample size may improve the precision of the point estimates and provide greater statistical strength to the findings, particularly for those specific cancer sites/types.

However, ongoing analysis will not account for the inherent bias in the Study Population, and this must be considered when interpreting the findings of any future analyses.

Appendix A: Methodology and technical notes

A1 Overview of the fourth Mortality and Cancer Incidence Study

The 4th MCIS is a retrospective cohort study that originally intended to repeat the 3rd MCIS. However, additional data are available from Tier assessments undertaken by the DVA and Defence. The Tier assessment identified two types of personnel:

- 1. those who were exposed to any of the four formal F-111 DSRS programs (Tier exposed) or associated duties
- 2. those who were not exposed (Tier rejected).

Some of those personnel identified through the Tier assessment process as being Tier exposed had not previously been included in the MCIS Study Population. As a result, the Scientific Advisory Committee, convened by the DVA, proposed that multiple analyses should be conducted to ensure improved accuracy and completeness of the Study Population, and continuity with previous studies in the MCIS series. These analyses include:

- 1. a new analysis using data from the 3rd MCIS and additional Tier assessment data, linked with mortality data from 1980–2012 (with key findings based on 1999–2012 data) and cancer data from 1982–2010. This is referred to as the *4th MCIS* and, as the most complete data set available, underpins the key findings of the report
- 2. an update to the 3rd MCIS using the original data provided, linked with mortality data from 1980–2012 (with key findings based on 1999–2012 data) and cancer data from 1982–2010. This is referred to as the *3rd MCIS Update* and, ensuring continuity with previous studies in the MCIS series, supplements the key findings of the 4th MCIS.

A2 Scope

The first step in this retrospective cohort study is to identify the Study Population and the Comparison Population (AIHW 2009). A brief description of these populations is presented here.

Study Population

Aircraft maintenance personnel who were involved in any of the four formal F-111 DSRS programs or associated duties are considered to be DSRS-exposed and referred to as the Study Population. The 4th MCIS Study Population attempts to include all personnel with possible involvement in, or exposures associated with, the F-111 DSRS programs conducted at RAAF Base Amberley between 1974 and 2000.

Comparison populations

The Comparison populations were selected to be as similar as possible to the Study Population with respect to all factors except exposure. They were drawn from RAAF Base Amberley (Queensland) and RAAF Base Richmond (New South Wales) over the same time period as the DSRS programs and associated activities (1974–2000). These populations are referred to in this study as the 'Amberley Comparison Population' and the 'Richmond Comparison Population', respectively, and combined as the Comparison populations. They are described further here.

The personnel available to be included in the Amberley Comparison Population consisted of Air Force personnel posted at RAAF Base Amberley at the time the F-111 DSRS programs were conducted who were in 'non-technical musterings' (job categories). For a complete list of the mustering categories and description of the process for defining the Amberley Comparison Population see appendixes D and F, respectively, of the 2nd MCIS (TUNRA 2004a). This group provides a comparison of individuals with similar environmental exposures, being co-located on the same RAAF Base, but who were not exposed to the aircraft maintenance duties in general, and to F-111 DSRS specifically. This group should therefore not have been exposed to other chemicals or hazards inherent in any form of aircraft maintenance; for example, other substances used in aircraft to which F-111 DSRS workers may have been exposed.

The personnel available to be included in the Richmond Comparison Population consisted of all Air Force personnel posted at RAAF Base Richmond at the time of the DSRS programs or activities who were in 'technical musterings'. For a complete list of the mustering categories and a description of the process for defining the Richmond Comparison Population see appendixes E and G of the 2nd MCIS (TUNRA 2004a). This group allows for the comparison of cancer diagnosis and/or mortality for F-111 DSRS-exposed individuals over and above any adverse effects of general aircraft maintenance.

Not all available personnel are included in the Comparison populations. The construction of the Amberley and Richmond Comparison populations involved matching available personnel with the exposed cohorts for four key characteristics: sex, age group, period of posting or exposure, and rank.

Those personnel who could not be matched by these characteristics are classified as 'Unmatched records' and have been excluded from subsequent analysis in the 4th MCIS. Further explanation of these records is given in Section A3 – Available data.

A3 Available data

The data available to construct the 4th MCIS and 3rd MCIS Update data sets are:

- 1. 3rd MCIS data
- 2. Tier classification data.

These available data are described in this section of the appendix. Note that available data on female personnel and unmatched comparison personnel were excluded from the studies, and are described in 'Exclusions'.

Third MCIS data

The AIHW was provided with the same data for the 3rd MCIS in 2003 as were used in the 2nd MCIS conducted by TUNRA (TUNRA 2004a). These data are held by the AIHW.

Tier classification data

Additional data were made available for the 4th MCIS as a result of Tier classification undertaken by the DVA and Defence of personnel independently determined to have been exposed to any of the four formal F-111 DSRS programs or associated duties. The Tier classification process identified two types of personnel:

- 1. those who were exposed to any of the four formal F-111 DSRS programs, and associated work (Tier exposed)
- 2. those who were not exposed (Tier rejected).

At the lockdown of the Tier classification database (30 June 2014), 1,770 personnel had been Tier assessed and a determination made on their Tier classification. A total of 261 were Tier rejected and not considered as exposed under the Tier exposure definition. All personnel who have been accepted for any of the three levels of Tier under any of 12 different job categories according to the Tier exposure definitions are considered to be exposed. A comprehensive description of the Tier exposure definitions is listed in Appendix Table A1.

The Tier classification data used to construct the 4th MCIS were extracted by the DVA at 30 June 2014. Most applications for Tier classification were received soon after the Tier scheme was announced (in August 2005), followed by another surge of applications soon after the announcement that the Tier definitions would be broadened (in May 2010). In recent years, only a few applications have been received by the DVA each week, and the DVA continues to receive and make determinations on applications for Tier classification. This means that any future analyses of this population would include updated Tier classification data, and introduce F-111 DSRS-exposed personnel not found in the 4th MCIS data set.

Background

As part of a 2005 Australian Government response to the BOI, the DVA publically released work definitions for Tier exposure to identify personnel who may have been exposed to any of the four separate F-111 DSRS programs carried out between 1977 and 2000 (DVA 2010b). These work definitions were originally designed and implemented to administer compensation, ex gratia payments, and health care for personnel who carried out F-111 fuel tank maintenance work. The Tier definitions are an administrative response by government to recommendations by the BOI and subsequent Parliamentary inquiry to identify workers. These payments are independent of this study and its results.

The additional data provided for the 4th MCIS are based on the Tier exposure definition only. It is important to note that this is different from the definition of exposure used in the earlier MCISs. Personnel are classified as Tier 1, 2 or 3, by category of work, by application of the Tier definitions (Appendix Table A1).

Table A1: Tier definitions

Category	Tier 1 definition (formal deseal/reseal programs only)	Tier 2 definition (formal deseal/reseal programs only)	Tier 3 definition
1. Fuselage deseal/reseal or respray programs and 'pick and patch' maintenance	A person who spent at least 30 cumulative working days on the fuselage deseal/reseal or respray programs during the period 1977–1982, 1991–1993 and 1996–2000, whose duties involved working inside F-111 fuel tanks.	A person who spent between 10 and 29 cumulative working days on the fuselage deseal/reseal or respray programs during the period 1977–1982, 1991–1993 and 1996–2000, whose duties involved working inside F-111 fuel tanks.	Personnel who were employed in F-111 fuel tank maintenance, or other maintenance or directly related tasks, prior to January 2000 where their work included physical entry to the fuel tank to conduct that maintenance or task.
	Additional Information	Additional Information	Additional information
	Personnel who worked inside body fuel tanks of the F-111 aircraft for extended periods of time for a cumulative period of not less than 30 working days, removing sealant and/or resealing the tanks.	Personnel who worked inside body fuel tanks of the F-111 aircraft for extended periods of time for a cumulative period of between 10 and 29 working days, removing sealant and/or resealing the tanks.	Personnel described in this category include those who worked as direct participants in the formal F-111 deseal/reseal programs carrying out deseal and reseal tasks, including training, inside fuel tanks. It also includes
This category includes only personnel employed in the formal F-111 deseal/reseal and respray programs over the period 1977 to 1982, 1991 to 1993 and 1996 to 2000. This does not include motor transport drivers employed as fuel tank drivers who may have been responsible for de-fuelling F-111 aircraft prior to deseal/reseal activities being undertaken.	This category includes only personnel employed in the formal F-111 deseal/reseal and respray programs over the period 1977 to 1982, 1991 to	This category includes only personnel employed in the formal F-111 deseal/reseal and respray programs over the period 1977 to 1982, 1991 to 1993 and 1996	personnel who worked inside fuel tanks carrying out ad hoc 'pick and patch' fuel tank maintenance outside those formal programs.
	to 2000. This does not include motor transport drivers employed as fuel tank drivers who may have been	This category applies regardless of what location the work occurred (e.g. RAAF Base Amberley, RAAF Base Edinburgh, in the United States or at other locations).	
	esponsible for de-fuelling F-111 aircraft prior to eseal/reseal activities being undertaken.	responsible for de-fuelling F-111 aircraft prior to deseal/reseal activities being undertaken.	This category is phrased broadly. The principal trade groups in this category carrying out maintenance work on the fuel tank itself was the airframe fitter trade (later renamed aircraft technician). Other maintenance tasks were regularly carried out inside F-111 fuel tanks by:
			aircraft metal worker trade
			surface finisher trade
			• electrical fitter trade.
			A number of other trade groups may also have carried out maintenance and other directly related tasks inside F-111 fuel tanks including:
			non-destructive inspection technicians
			instrument fitters
			photographers.

Category	Tier 1 definition (formal deseal/reseal programs only)	Tier 2 definition (formal deseal/reseal programs only)	Tier 3 definition
1. Fuselage deseal/reseal or respray programs and 'pick and patch' maintenance			The trade groups listed here are not exhaustive and it is possible that personnel from other trade groups carried out work inside F-111 fuel tanks and may be eligible under this definition. The most important factor is the nature of the work performed.
(continued)			This category is not intended to cover personnel who may have entered F-111 fuel tanks to perform work other than maintenance or other directly related tasks.
2. Wing tank program	A person who spent at least 30 cumulative working days on the wing tank program during the period 1985–1992.	A person who spent between 10 and 29 cumulative working days on the wing tank program during the period 1985–1992.	Personnel who were employed on the wing tank program during the period 1985–1992.
	Additional Information Personnel employed full time on the formal wing tank program actively removing and replacing sealant for a period of not less than 30 cumulative working days between 1985 and 1992.	Additional Information Personnel employed full time on the formal wing tank program actively removing and replacing sealant for a cumulative period of between 10 and 29 cumulative working days between 1985 and 1992.	Additional information Personnel described in category 2 include those who worked as direct participants in the F-111 wing tank deseal/reseal program, known as the third deseal/reseal program. It has been retained as a separate category because in the strictest sense it did not necessarily involve fuel tank 'entry'. It did however involve exposure to deseal/reseal processes.
3. Sealant rework (pick and patch)	A person who spent at least 60 cumulative working days carrying out sealant rework (pick and patch) during the period 1973–2000 while attached to an F-111 deseal/reseal section.	A person who spent between 10 and 59 cumulative working days carrying out sealant rework (pick and patch) during the period 1973–2000 while attached to an F-111 deseal/reseal section.	As per Category 1
	Additional Information	Additional Information	
	Personnel working on sealant rework (pick and patch) inside fuselage fuel tanks of the F-111 aircraft for a cumulative period of not less than 60 working days while attached to a deseal/reseal section of 3AD/501WG, over the period 1973 to 2000, plus those six personnel posted to Sacramento who completed training in deseal/reseal procedures.	Personnel working on sealant rework (pick and patch) inside fuselage fuel tanks of the F-111 aircraft for a cumulative period of between 10 and 59 working days while attached to a deseal/reseal section of 3AD/501WG, over the period 1973 to 2000.	

(continued)

Category	Tier 1 definition (formal deseal/reseal programs only)	Tier 2 definition (formal deseal/reseal programs only)	Tier 3 definition
4. Boiler and plant attendants	Boiler and plant attendants whose usual place of duty was the Base incinerator as an incinerator operator, and who spent at least 30 cumulative working days undertaking these duties during the period 1976–1986.	Boiler and plant attendants whose usual place of duty was the Base incinerator as an incinerator operator, and who spent between 10 and 29 cumulative working days undertaking these duties during the period 1976–1986.	Boiler and plant attendants whose usual place of duty was the RAAF Base Amberley incinerator as an incinerator operator during the period 1976–1986.
	Additional Information	Additional Information	Additional information
	Boiler and plant attendants regularly disposing of deseal/reseal products by burning, in particular the sealant remover SR51 and SR51A, at the RAAF Base Amberley incinerator, for a cumulative period of not less than 30 working days between 1976 and 1986.	Boiler and plant attendants regularly disposing of deseal/reseal products by burning, in particular the sealant remover SR51 and SR51A, at the RAAF Base Amberley incinerator, for a cumulative period of between 10 and 29 cumulative working days between 1976 and 1986.	Boiler and plant attendants described in category 4 were regularly engaged in disposing of deseal/reseal products by burning, in particular the sealant remover SR51 and SR51A, at the RAAF Base Amberley incinerator between 1976 and 1986. This category also includes any Department of Construction workers who undertook these duties during the period.
5. Unable to continue in F-111 working environment	A person who can demonstrate that they would have met one of the above criteria except for the fact that they:	A person who can demonstrate that they would have met one of the above criteria except for the fact that they:	N/A
	 had an immediate physical reaction; and 	had an immediate physical reaction; and	
	• required medical treatment or intervention; and	required medical treatment or intervention; and	
	 were given a work restriction or medical fitness advice (PM 101) stating that they should not return to that working environment. 	 were given a work restriction or medical fitness advice (PM 101) stating that they should not return to that working environment. 	
6. Fire fighters	N/A	Fire fighters employed as instructors, whose usual place of duty was the Fire Training School fire pits and who spent at least 60 cumulative working days actively involved in the burning of by-products from the F-111 DSRS process during the period 1976–1990.	Fire fighters whose usual place of duty was a Unit at RAAF Base Amberley and who were actively involved in the burning of by-products from the F-111 deseal/reseal process during the period 1976–1994.

Category	Tier 1 definition (formal deseal/reseal programs only)	Tier 2 definition (formal deseal/reseal programs only)	Tier 3 definition
6. Fire fighters (continued)		Additional Information Fire fighters employed as instructors permanently posted to a Unit at RAAF Base Amberley, and who were actively involved in burning bi-products from the F-111 DS/RS process (including the sealant remover SR51 and SR51A) at the fire pits, for training and/or disposal purposes, for a cumulative period of not less than 60 working days during the period 1976 to 1990.	Additional information Personnel who were actively involved in burning by- products from the F-111 deseal/reseal process (including the sealant remover SR51 and SR51A) at the fire pits for training and/or disposal purposes between 1976 and 1994.
7. Rag Hangar personnel	N/A	Personnel who were not involved in tank entry and whose usual place of duty was the Rag Hangar for 60 cumulative working days during the period Dec 1977–Nov 1983.	Personnel who were not involved in tank entry and whose usual place of duty was the Rag Hangar at RAAF Base Amberley during the period Dec 1977–Nov 1983.
		Additional information Personnel are those for whom their normal place of work was the deseal/reseal air transportable ('Rag Hangar') hangar at RAAF Base Amberley, and who provided direct support to those staff entering F-111 fuel tanks for a period of 60 cumulative days. This does not include those personnel who may have regularly visited these hangars in the course of their duty.	Additional information Personnel are those for whom their normal place of work was the deseal/reseal air transportable ('Rag Hangar') hangar at RAAF Base Amberley, and who provided direct support to those staff entering F-111 fuel tanks. This does not include those personnel who may have regularly visited these hangars in the course of their duty.
8. Hangar 255, 260, 277 or 278 personnel	N/A	Personnel who were not involved in tank entry and whose usual place of duty was Hangar 255, 260, 277 or 278 for a period of 60 cumulative working days during the period 1977–1982, 1991–1993 and 1996–2000.	Personnel who were not involved in tank entry and whose usual place of duty was Hangar 255, 260, 277 or 278 at RAAF Base Amberley during the period 1977–1982, 1991–1993 and 1996–2000.

Category	Tier 1 definition (formal deseal/reseal programs only)	Tier 2 definition (formal deseal/reseal programs only)	Tier 3 definition
8. Hangar 255, 260,		Additional Information	Additional information
277 or 278 personnel (continued)		Personnel indirectly involved in DS/RS, for whom their normal place of work was Hangars 255, 260, 277 and 278, and who provided direct support to those staff entering F-111 fuel tanks for a period of 60 cumulative working days. This does not include those personnel who may have regularly visited these Hangars in the course of their duty.	Personnel described are those for whom their normal place of work was Hangars 255, 260, 277 and 278 at RAAF Base Amberley and who provided direct support to those staff entering F-111 fuel tanks. This does not include those personnel who may have regularly visited these hangars in the course of their duty.
9. Motor transport drivers	N/A	N/A	Motor transport drivers involved in the first deseal/reseal program, at RAAF Base Amberley, who came into contact with aviation fuel contaminated with deseal/reseal by-products during the period 1977–1982.
			Additional information
			Personnel described do not include motor transport drivers employed as fuel tank drivers who may have been responsible for de-fuelling F-111 aircraft prior to deseal/reseal activities being undertaken.
10. Canvas personnel and/or Rag Hangar dismantling workers	N/A	N/A	Maintenance personnel on the air transportable ('Rag') Hangar, at RAAF Base Amberley, who were involved in removing/replacing canvas or dismantling the Hangar during 1978, 1980 and 1984.
11. Engine Test Cell No 1 personnel	N/A	N/A	Personnel employed in Engine Test Cell No 1, at RAAF Base Amberley, during the period 1976–1986.
12. Warrill Creek Settling Pond— barrier maintenance personnel	N/A	N/A	Personnel who entered the Warrill Creek Settling Pond for the purpose of maintaining the physical barrier during the period 1977–2000.

(continued)

Category	Tier 1 definition (formal deseal/reseal programs only)	Tier 2 definition (formal deseal/reseal programs only)	Tier 3 definition
12. Warrill Creek			Additional information
Settling Pond— barrier maintenance personnel (continued)			Personnel described in this category include any Department of Construction workers who undertook these duties during the period. However, this category does not include Airfield Defence Guards, Ground Defence Officers or other personnel who may have entered Warrill Creek for any other purpose or reason.

Source: DVA 2010b.

Tier exposed

An F-111 DSRS or other F-111 fuel tank maintenance worker is someone who is, or can be, classified as being a Tier 1, 2 or 3 participant (Appendix Table A1).

Tier rejected

A person who is not accepted for Tier classification (Tier rejected) is considered 'not exposed' for the purpose of this study.

Evidence requirements

Applications for Tier classification were determined for the Study Population based on the following evidence (in order of weighting, from highest to lowest):

- 1. Primary evidence, sourced from official Air Force (or other employer) records, including:
 - individual service and personnel records
 - the Airman's Trade Progress Sheet
 - Air Force Record of Training and Employment
 - Defence pay records that show evidence of tank entry
 - Fuel Tank Entry Permits (from 1993–2000).
- 2. Secondary evidence, sourced from:
 - statements made to the RAAF BOI or in support of an individual's compensation claim
 - the individual's application for inclusion in the Interim or SHOAMP health-care schemes.
- 3. Tertiary evidence, including:
 - statutory declaration from claimant, corroborated by primary or secondary evidence (for example, work records, with that evidence sourced by DVA investigators, if necessary)
 - a second supporting statutory declaration made by an authorised/corroborating person (if possible)
 - personal photographs
 - personal copies of service records that are not available in official individual personnel records.

Where primary and/or secondary evidence was unavailable from a claimant, the DVA attempted to source such evidence. Where such evidence was unavailable, investigators would then attempt to identify and contact a third party (potential authorised person/s) to lend weight to a claim.

The provision of two statutory declarations did not automatically result in the end of the investigation process. The claim would still be investigated, including an attempt to source primary and secondary evidence to support eligibility. Every effort was made to verify information contained in statutory declarations. The content of the two statutory declarations would be subject to a test of plausibility in the same way that other evidence was assessed. As a result of this testing, contrary evidence that may have emerged would also be considered.

Exclusions

Data on female personnel and unmatched comparison records, made available through the 3rd MCIS or the Tier assessment process, were excluded from the 4th MCIS and the 3rd MCIS Update data sets and subsequent analysis.

Female personnel

The 3rd MCIS data set includes a total of 22 exposed female personnel records. The Tier assessment data included a total of 22 Tier-exposed female personnel records and 4 Tier-rejected female personnel records. These numbers are considered too small to produce reliable results. Therefore, all female personnel records have been excluded from analysis in the 4th MCIS and the 3rd MCIS Update. Although female personnel were included in the previous MCIS, they were similarly considered to be too few in number for meaningful comparative analysis.

Unmatched comparison data

The process of matching the Comparison populations was described in Section A2. The unmatched Comparison Population from the 3rd MCIS data set comprises 4,463 records. These data were not included in the analysis performed in the earlier studies. These data also cannot be included in the current study as the stratification variables required to construct the Comparison populations in the 2nd MCIS were not available.

A4 Constructing the analysis data sets

This section outlines the principles used to construct the 4th MCIS and 3rd MCIS Update data sets from the available data. It also describes the composition of the exposed Study Population and non-exposed Comparison populations.

Principles for constructing the 4th MCIS data set

Given the change in the scope and methodology of the 4th MCIS compared with the earlier studies, four principles were established to allow the previous study recommendations to be carried out while also using the additional Tier assessment data collected for the 4th MCIS. These four principles are described here:

- 1. The 4th MCIS will update and extend the 3rd MCIS, including additional personnel and reclassifying the exposure status of individuals from the 3rd MCIS using information available in the Tier assessment data, and linking to the most recent available mortality and cancer incidence data. The rules to determine and reclassify exposure status are as follows:
 - a. If a person was considered exposed in the 3rd MCIS or determined to be Tier exposed, they will be defined as exposed and included in the 4th MCIS Study Population.
 - b. A person will be removed from the 3rd MCIS Comparison populations and included in the 4th MCIS Study Population only if they were determined to have been Tier exposed.
 - c. A person will be excluded from the 4th MCIS data set if they were Tier rejected and not included in the 3rd MCIS Comparison populations.

2. The 3rd MCIS Update data set will update the 3rd MCIS, without reclassification of exposure status for individuals in that 3rd MCIS data set, and link to the most recent available mortality and cancer incidence data.

The reasons for these principles are detailed here.

Principle 1a – Although the definition of exposure for the 3rd MCIS was different from the definition of Tier exposure used in the Tier assessment process, the Scientific Advisory Committee determined that both definitions should be used to ensure maximum capture of exposed personnel.

Principle 1b – The Amberley and Richmond Comparison populations used in the 3rd MCIS should be preserved as far as possible. The Amberley and Richmond Comparison populations used in the earlier studies were matched by age, sex and rank and are comparable with the 3rd MCIS Study Population across all aspects, except exposure. However, if a person included in the 3rd MCIS Comparison populations is determined through the Tier assessment process as being exposed, they must be removed from the 4th MCIS Comparison populations and included in the 4th MCIS Study Population for the analysis.

Principle 1c – People who fall outside both Principle 1a and Principle 1b (for example, Tier-rejected personnel who were not in the 3rd MCIS data set) must be excluded from the 4th MCIS data set. They are ineligible for inclusion in the 4th MCIS Study Population and cannot be included in the 4th MCIS Comparison populations, as the Comparison populations have been selected to be representative of the Study Population.

Principle 2—Preserving and analysing the data used in the 3rd MCIS with a longer latency period meets the original purpose of this study.

There is a degree of overlap between the number of personnel in the 3rd MCIS (17,591 male personnel records) and the additional Tier assessment records provided for the 4th MCIS (1,744 male personnel records). This overlap occurs where personnel in the 3rd MCIS later apply to be Tier assessed. In order to determine the degree of overlap, the AIHW linked the two sets of records. This process identified that, from the total pool of 19,335 male records, there were 18,161 unique male personnel across both data sets.

These principles were applied to the available (pooled) data from the 3rd MCIS and the Tier assessment process to construct the 4th MCIS and the 3rd MCIS Update data set. This process, citing numbers of personnel included or excluded through each step, is described in the sections that follow and depicted in Figure A1. Further demographic information about the personnel in each of the 4th MCIS and 3rd MCIS Update data sets is shown in appendix tables A2 and A3

Fourth MCIS data set

The 4th MCIS data set uses the data from the 3rd MCIS and the additional Tier assessment data of personnel obtained through the Tier assessment process.

The 4th MCIS data set is made up of 18,033 male personnel. This data set comprises:

- 1,655 personnel in the 4th MCIS Study Population
- 16,378 personnel in the Amberley and Richmond Comparison populations (combined, noting that 259 personnel are in both Comparison populations) (Appendix Table A2).

Fourth MCIS Study Population

The 4th MCIS Study Population of 1,655 male personnel comprises:

- 705 personnel who were Tier exposed and were also exposed in the 3rd MCIS data (under Principle 1a)
- 444 personnel who were Tier exposed and were not captured in the 3rd MCIS data (under Principle 1a)
- 338 personnel who were Tier exposed and were identified as a Comparison Population member in the 3rd MCIS data (under Principle 1b)
- 168 personnel who were not Tier assessed and were previously identified in the 3rd MCIS Study Population (under Principle 1a).

There were 128 personnel who were Tier rejected in the 4th MCIS and were not captured in the Study Population or in either of the Comparison populations in the 3rd MCIS. These personnel were excluded from the 4th MCIS data set according to Principle 1c.



Fourth MCIS RAAF Comparison populations

The 4th MCIS Comparison Population of 16,378 male personnel comprises:

- 16,302 personnel who were Comparison Population members in the 3rd MCIS and were not Tier assessed
- 76 personnel who were Tier rejected but were included in the Comparison Population in the 3rd MCIS (under Principle 1c).

A total of 338 personnel were Tier exposed and moved from the Comparison Population to the Study Population under Principle 1a.

		Study Pop	ulation						
	Tier as (N=7	sessed ′82) ^(a)	To (N=1	tal ,655)	Ambe Comparison (N=7,4	rley Population 407)	Richr Comparison (N=9	nond Population 230)	
Strata variable	N	%	N	%	N	%	N	%	
Age group (years)									
20–24	1	0.13	2	0.12	154	2.08	75	0.81	
25–29	54	6.91	94	5.68	609	8.22	605	6.55	
30–34	105	13.43	216	13.05	806	10.88	1,407	15.24	
35–39	150	19.18	313	18.91	1,060	14.31	1,579	17.11	
40–44	119	15.22	302	18.25	1,234	16.66	1,800	19.50	
45–49	127	16.24	302	18.25	1,094	14.77	1,505	16.31	
50–54	117	14.96	216	13.05	991	13.38	1,114	12.07	
55–59	69	8.82	128	7.73	694	9.37	652	7.06	
60–64	28	3.58	51	3.08	484	6.53	270	2.93	
65–69	10	1.28	25	1.51	197	2.66	148	1.60	
70–74	2	0.26	6	0.36	84	1.13	75	0.81	
Exposure/posting category									
1975–79	168	21.48	453	27.37	1,813	24.48	2,224	24.10	
1980–84	154	19.69	353	21.33	1,686	22.76	2,098	22.73	
1985–89	210	26.85	414	25.02	1,686	22.76	2,167	23.48	
1990–94	168	21.48	286	17.28	1,127	15.22	1,581	17.13	
1995–99	82	10.49	149	9.00	1,095	14.78	1,160	12.57	
Rank									
Enlisted	433	55.37	1,008	60.91	4,389	59.25	5,788	62.71	
Non-commissioned Officer	330	42.2	599	36.19	2,056	27.76	2,962	32.09	
Officer	19	2.43	48	2.90	962	12.99	480	5.20	

Table A2: Characteristics of personnel in the 4th MCIS data set

(a) The 782 personnel in the Tier assessed group includes those personnel introduced to the 4th MCIS Study Population through the Tier assessment process, who were not included in the 3rd MCIS Study Population. This group includes 444 new personnel and 338 personnel previously included in the non-exposed Comparison populations.

Notes

1. A total of 72 individuals in the Study Population with missing rank were randomly allocated a rank (in the same distribution of ranks for the remainder of the group) for the purposes of matching and analysis.

2. A total of 3 individuals in the Study Population with missing exposure/posting category were randomly allocated an exposure/posting category (in the same distribution of ranks for the remainder of the group) for the purposes of matching and analysis.

3. A total of 2 individuals in the Study Population with missing date of birth were randomly allocated a date of birth based on the period of exposure/posting category for the purposes of matching and analysis.

Source: AIHW analysis of 4th MCIS data set.

Third MCIS Update data set

The 3rd MCIS Update uses data from the 3rd MCIS only. No additional personnel are included and the exposure status of personnel in that data set is unchanged.

The 3rd MCIS Update data set of 17,591 male personnel includes:

- 873 personnel in the Study Population
- 16,716 personnel in the Amberley and Richmond Comparison populations (combined, noting 267 personnel are in both Comparison populations) (Appendix Table A3).

	Study Pop (N=87	oulation 73)	Amberle Comparison Po (N=7,576	y pulation i)	Richmon Comparison Po (N=9,407	d pulation)
Strata variable	Ν	%	Ν	%	Ν	%
Age group (years)						
20–24	1	0.11	154	2.03	75	0.8
25–29	40	4.58	614	8.1	610	6.48
30–34	111	12.71	834	11.01	1,421	15.11
35–39	163	18.67	1,105	14.59	1,600	17.01
40–44	183	20.96	1,264	16.68	1,845	19.61
45–49	175	20.05	1,115	14.72	1,545	16.42
50–54	99	11.34	1,014	13.38	1,147	12.19
55–59	59	6.76	706	9.32	670	7.12
60–64	23	2.63	489	6.45	271	2.88
65–69	15	1.72	197	2.6	148	1.57
70–74	4	0.46	84	1.11	75	0.8
Exposure/posting categ	jory					
1975–79	285	32.65	1,835	24.22	2,267	24.1
1980–84	199	22.79	1,727	22.8	2,147	22.82
1985–89	204	23.37	1,758	23.2	2,217	23.57
1990–94	118	13.52	1,161	15.32	1,603	17.04
1995–99	67	7.67	1,095	14.45	1,173	12.47
Rank						
Enlisted	575	65.86	4,524	59.71	5,881	62.52
Non-commissioned Officer	269	30.81	2,089	27.57	3,042	32.34
Officer	29	3.32	963	12.71	484	5.15

Source: AIHW analysis of 4th MCIS data set.

A5 Data linkage

The 4th MCIS and 3rd MCIS Update data sets were linked to both the NDI (mortality) and the ACD (cancer incidence) using a probabilistic linkage process based on the Fellegi and Sunter methodology (Fellegi & Sunter 1969). This process uses full name, date of birth and

sex (males only). Linkage was carried out using the program 'ReMa', a system for probabilistic record linkage, which produces lists of likely matches, weighted according to the probability of the links being true. After the initial linkage, a full clerical review was used to identify valid links.

Data linkage for mortality and cancer incidence were performed separately as the linkage data sets (NDI and ACD) are stored separately.

Data linkage for mortality

The data sets were linked to the NDI for the period 1980 to 2012 (cause of death) or 1980 to 2013 (fact of death only). This linkage resulted in cause of death, fact of death, date of death and year of registration to be added to the data sets.

Data linkage for cancer incidence

The data sets were linked to the ACD for the period 1982–2010, with the exception of New South Wales and the Australian Capital Territory for which data are available only for 1982–2009. The result of this linkage is the addition of five variables to the data sets:

- state/territory of cancer diagnosis
- date of diagnosis
- ICD-O-3 topography code
- ICD-O-3 histology code
- ICD-O-3 disease code.

Data linkage protocol

All data matching and analysis were carried out by the AIHW Data Linkage Unit. Strict separation of identifiers and content data will be maintained within the Unit in accordance with the AIHW linkage protocols, so that no one person will ever have access to both. Both the NDI and ACD are held at the AIHW.

Summary results from the linked data set are presented in aggregate format. Personal identifiers are not released and no individual can be identified in any reporting, according to the AIHW privacy principles (Section A8).

A6 Data analysis methods

Analyses of the linked 4th MCIS and 3rd MCIS Update data sets was undertaken to determine if any differences can be detected between the Study Population and relevant Comparison populations.

Weighting

It is possible that the individual and environmental characteristics of the Study Population such as sex, age, rank (a proxy for socioeconomic status), location or posting/exposure category (a proxy for year cohort)—may be driving any observed increase (or decrease) in risk for mortality or cancer incidence. These characteristics are adjusted for in this study using weighting and standardisation. These adjustments effectively control for the influence of those characteristics in the comparison, so that the effect of the DSRS exposure can be more clearly examined.

For example, the Amberley and Richmond Comparison populations have age, rank, exposure/posting category in common. In order to adjust for any differences in those characteristics between the groups that may be influencing the comparison and the true effect of the DSRS exposure, the Comparison populations are weighted so those factors are statistically similar to those of the Study Population.

To adjust for differences in the distribution of characteristics expected to affect exposure, weights were calculated for each of the data sets.

Not all data were available to replicate exactly the methodology used by TUNRA in the 2nd MCIS, in order to generate new weights for the 4th MCIS data set (TUNRA 2004a). Instead, the AIHW generated altered weights using a similar methodology:

- Strata were generated for the Study Population, by each combination of age group, exposure/posting category and rank category.
- Counts in each of the strata were expressed as a percentage of the total number of observations for the exposure group.
- The weight for each stratum was obtained from the ratio of percentages in the exposed cohort relative to the Comparison Population.
- The exposed stratum each has a weight of 1.00.

The methodology used to generate the weights for the 3rd MCIS Update data set was the same as that used in the 2nd MCIS (TUNRA 2004a).

The weights applied to the 4th MCIS and 3rd MCIS Update data sets are shown in tables A4 and A5, respectively.

Strata variable		Weight			
Age category (years)	Exposure/ posting category	Rank category	4th MCIS Study Population	4th MCIS Amberley Comparison Population	4th MCIS Richmond Comparison Population
20–24	1995–1999	ENLISTED	1	0.058060972	0.14884995
25–29	1990–1994	ENLISTED	1	0.67060423	0.881348386
25–29	1995–1999	ENLISTED	1	0.302073977	0.457530583
25–29	1995–1999	NON-COMM OFFICER	1	58.11903323	2.113524771
25–29	1995–1999	OFFICER	1	0.100465053	0.223274925
30–34	1985–1989	ENLISTED	1	1.519168158	1.073437137
30–34	1990–1994	ENLISTED	1	0.90673248	0.685827413
30–34	1995–1999	ENLISTED	1	0.419127644	0.797410445
30–34	1990–1994	NON-COMM OFFICER	1	9.686505539	1.612541121
30–34	1995–1999	NON-COMM OFFICER	1	3.353021148	0.691967741
35–39	1980–1984	ENLISTED	1	2.0224572	1.38183178
35–39	1985–1989	ENLISTED	1	1.243572594	1.100010825
					(antinual)

Table A4: Weighting applied to the 4th MCIS data set

(continued)

Strata variable		Weight			
Age category (years)	Exposure/ posting category	Rank category	4th MCIS Study Population	4th MCIS Amberley Comparison Population	4th MCIS Richmond Comparison Population
35–39	1990–1994	ENLISTED	1	1.30775428	1.076325309
35–39	1995–1999	ENLISTED	1	0.362488773	0.587565591
35–39	1985–1989	NON-COMM OFFICER	1	3.808369699	3.469813015
35–39	1990–1994	NON-COMM OFFICER	1	2.835074792	1.451287009
35–39	1995–1999	NON-COMM OFFICER	1	0.770809459	0.469064967
35–39	1985–1989	OFFICER	1	0.438303418	0.300100705
35–39	1990–1994	OFFICER	1	0.227323468	0.558187311
40–44	1972–1979	ENLISTED	1	1.417537396	1.451287009
40–44	1980–1984	ENLISTED	1	0.854509545	0.646223565
40–44	1985–1989	ENLISTED	1	1.194932268	0.938401857
40–44	1990–1994	ENLISTED	1	1.371013092	1.510389195
40–44	1995–1999	ENLISTED	1	0.343899605	0.50744301
40–44	1980–1984	NON-COMM OFFICER	1	5.066787513	1.936568223
40–44	1985–1989	NON-COMM OFFICER	1	0.976358649	0.711782477
40–44	1990–1994	NON-COMM OFFICER	1	1.319221435	0.975472971
40–44	1990–1994	NON-COMM OFFICER	1	1.319221435	0.975472971
40–44	1995–1999	NON-COMM OFFICER	1	0.619019289	0.67887646
40–44	1980–1984	OFFICER	1	0.470599459	0.398705222
40–44	1985–1989	OFFICER	1	0.532225579	1.213450677
45–49	1972–1979	ENLISTED	1	1.533636426	1.027219705
45–49	1980–1984	ENLISTED	1	1.208295909	0.839379415
45–49	1985–1989	ENLISTED	1	1.13052054	1.306395835
45–49	1990–1994	ENLISTED	1	3.512688822	1.860624371
45–49	1995–1999	ENLISTED	1	0.812853612	2.232749245
45–49	1972–1979	NON-COMM OFFICER	1	4.470694864	4.806612957
45–49	1980–1984	NON-COMM OFFICER	1	1.454322426	0.891778545
45–49	1985–1989	NON-COMM OFFICER	1	1.617059844	1.24857688
45–49	1990–1994	NON-COMM OFFICER	1	1.635620072	1.443587874
45–49	1995–1999	NON-COMM OFFICER	1	0.397395099	0.85874971
45–49	1972–1979	OFFICER	1	0.231242838	0.418640483
45–49	1980–1984	OFFICER	1	0.219870239	1.116374622
45–49	1985–1989	OFFICER	1	0.133453578	0.429374855
45–49	1990–1994	OFFICER	1	0.203213403	1.116374622
50–54	1972–1979	ENLISTED	1	0.876943993	0.898030059
50–54	1980–1984	ENLISTED	1	0.923295678	1.093356589
50–54	1985–1989	ENLISTED	1	1.625707223	1.653888329
					(continued)

Table A4 (continued): Weighting applied to the 4th MCIS data set

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Strata variable		Weight			
Age category (years)	Exposure/ posting category	Rank category	4th MCIS Study Population	4th MCIS Amberley Comparison Population	4th MCIS Richmond Comparison Population
50–54	1990–1994	ENLISTED	1	2.235347432	2.325780463
50–54	1972–1979	NON-COMM OFFICER	1	1.588273175	1.282643183
50–54	1980–1984	NON-COMM OFFICER	1	1.254367624	1.077688373
50–54	1985–1989	NON-COMM OFFICER	1	0.917065613	1.030499651
50–54	1990–1994	NON-COMM OFFICER	1	1.009511744	1.028239784
50–54	1995–1999	NON-COMM OFFICER	1	1.37559842	1.860624371
50–54	1980–1984	OFFICER	1	0.219870239	0.728070406
50–54	1985–1989	OFFICER	1	0.068779921	0.34886707
50–54	1995–1999	OFFICER	1	0.159667674	0.930312185
55–59	1972–1979	ENLISTED	1	0.941198919	1.073437137
55–59	1980–1984	ENLISTED	1	1.294148513	1.70557234
55–59	1985–1989	ENLISTED	1	0.993487748	4.465498489
55–59	1972–1979	NON-COMM OFFICER	1	1.775128843	1.186697433
55–59	1980–1984	NON-COMM OFFICER	1	0.522888288	0.749244713
55–59	1985–1989	NON-COMM OFFICER	1	0.735683965	1.151815087
55–59	1972–1979	OFFICER	1	0.152410052	0.57743515
55–59	1980–1984	OFFICER	1	0.197236538	1.288124564
60–64	1972–1979	ENLISTED	1	0.731568251	1.25592145
60–64	1980–1984	ENLISTED	1	0.894138973	2.790936556
60–64	1972–1979	NON-COMM OFFICER	1	0.533814312	0.797410445
60–64	1980–1984	NON-COMM OFFICER	1	0.372557905	1.116374622
60–64	1985–1989	NON-COMM OFFICER	1	0.496743874	0.826944165
60–64	1990–1994	NON-COMM OFFICER	1	0.558836858	2.232749245
60–64	1972–1979	OFFICER	1	0.328727564	1.162890232
60–64	1985–1989	OFFICER	1	0.131491025	1.395468278
65–69	1972–1979	ENLISTED	1	0.515849407	0.930312185
65–69	1980–1984	ENLISTED	1	1.27734139	5.581873112
65–69	1972–1979	NON-COMM OFFICER	1	0.838255287	1.179268967
65–69	1980–1984	NON-COMM OFFICER	1	0.331162583	0.572499806
65–69	1972–1979	OFFICER	1	0.154161892	0.310104062
70–74	1972–1979	NON-COMM OFFICER	1	0.406426806	0.429374855
70–74	1980–1984	NON-COMM OFFICER	1	0.154161892	0.293782795
70–74	1980–1984	OFFICER	1	0.406426806	1.395468278

Table A4 (continued): Weighting applied to the 4th MCIS data set

Strata variable			Weight		
Age category (years)	Exposure/ posting category	Rank category	3rd MCIS Update Study Population	3rd MCIS Update Amberley Comparison Population	3rd MCIS Update Richmond Comparison Population
20–24	1995–1999	ENLISTED	1	0.056351438	0.143673158
25–29	1990–1994	ENLISTED	1	0.537582743	0.718365789
25–29	1995–1999	ENLISTED	1	0.381133711	0.571760526
25–29	1995–1999	NON-COMM OFFICER	1	31.81977854	1.128860525
25–29	1995–1999	OFFICER	1	0.195013965	0.431019473
30–34	1985–1989	ENLISTED	1	1.972300323	1.472061042
30–34	1990–1994	ENLISTED	1	0.729056271	0.563305382
30–34	1995–1999	ENLISTED	1	0.449643597	0.855197367
30–34	1990–1994	NON-COMM OFFICER	1	5.78541428	0.957821051
30–34	1995–1999	NON-COMM OFFICER	1	2.603436426	0.525633504
35–39	1980–1984	ENLISTED	1	3.074534446	2.155097365
35–39	1985–1989	ENLISTED	1	1.167122621	1.06722074
35–39	1990–1994	ENLISTED	1	0.76411132	0.673467927
35–39	1995–1999	ENLISTED	1	0.351815733	0.567130886
35–39	1985–1989	NON-COMM OFFICER	1	2.249883331	2.038605616
35–39	1990–1994	NON-COMM OFFICER	1	1.481630486	0.739494194
35–39	1995–1999	NON-COMM OFFICER	1	0.448868349	0.26716083
35–39	1985–1989	OFFICER	1	0.510477731	0.347596349
35–39	1990–1994	OFFICER	1	0.294173608	0.718365789
40–44	1972–1979	ENLISTED	1	2.300224955	2.316554171
40–44	1980–1984	ENLISTED	1	1.179092584	0.886142009
40–44	1985–1989	ENLISTED	1	0.964235713	0.795916641
40–44	1990–1994	ENLISTED	1	1.112579669	1.252963585
40–44	1995–1999	ENLISTED	1	0.667547802	0.979589712
40–44	1980–1984	NON-COMM OFFICER	1	4.049789996	1.450546304
40–44	1985–1989	NON-COMM OFFICER	1	0.887535145	0.633852166
40–44	1990–1994	NON-COMM OFFICER	1	0.995849999	0.698411183
40–44	1990–1994	NON-COMM OFFICER	1	1.319221435	0.975472971
40–44	1995–1999	NON-COMM OFFICER	1	0.534038241	0.567130886
40–44	1980–1984	OFFICER	1	0.228371616	0.189043629
40–44	1985–1989	OFFICER	1	0.206621939	0.448978618
45–49	1972–1979	ENLISTED	1	1.956021019	1.307794128
45–49	1980–1984	ENLISTED	1	0.939669198	0.675953048
45–49	1985–1989	ENLISTED	1	1.196982265	1.319447367
45–49	1990–1994	ENLISTED	1	4.958926526	2.612239231
45–49	1995–1999	ENLISTED	1	0.788920129	2.155097365

Table A5: Weighting applied to the 3rd MCIS Update data set

(continued)

Strata variable			Weight		
Age category (years)	Exposure/ posting category	Rank category	3rd MCIS Update Study Population	3rd MCIS Update Amberley Comparison Population	3rd MCIS Update Richmond Comparison Population
45–49	1972–1979	NON-COMM OFFICER	1	6.158666815	6.407046222
45–49	1980–1984	NON-COMM OFFICER	1	1.568335197	0.908046643
45–49	1985–1989	NON-COMM OFFICER	1	0.945141937	0.736213386
45–49	1990–1994	NON-COMM OFFICER	1	1.481630486	1.25714013
45–49	1995–1999	NON-COMM OFFICER	1	0.385694285	0.828883602
45–49	1972–1979	OFFICER	1	0.448868349	0.808161512
45–49	1980–1984	OFFICER	1	0.284528571	1.436731577
45–49	1985–1989	OFFICER	1	0.259048401	0.828883602
45–49	1990–1994	OFFICER	1	0.394460065	2.155097365
50–54	1972–1979	ENLISTED	1	0.720447816	0.7249563
50–54	1980–1984	ENLISTED	1	0.639440526	0.761903109
50–54	1985–1989	ENLISTED	1	0.754619254	0.798184209
50–54	1990–1994	ENLISTED	1	1.735624284	1.795914471
50–54	1972–1979	NON-COMM OFFICER	1	1.746894572	1.391833715
50–54	1980–1984	NON-COMM OFFICER	1	1.010466193	0.880688827
50–54	1985–1989	NON-COMM OFFICER	1	0.640189285	0.718365789
50–54	1990–1994	NON-COMM OFFICER	1	1.119757603	1.077548683
50–54	1995–1999	NON-COMM OFFICER	1	1.335095603	1.657767204
50–54	1980–1984	OFFICER	1	0.1399697	0.448978618
50–54	1985–1989	OFFICER	1	0.13350956	0.673467927
50–54	1995–1999	OFFICER	1	0.309932908	1.795914471
55–59	1972–1979	ENLISTED	1	0.788920129	0.923613157
55–59	1980–1984	ENLISTED	1	0.445031868	0.567130886
55–59	1985–1989	ENLISTED	1	0.482117857	1.795914471
55–59	1972–1979	NON-COMM OFFICER	1	2.027006463	1.321132485
55–59	1980–1984	NON-COMM OFFICER	1	0.345152557	0.496239525
55–59	1985–1989	NON-COMM OFFICER	1	0.428549206	0.653059808
55–59	1972–1979	OFFICER	1	0.295845048	1.114705534
55–59	1980–1984	OFFICER	1	0.127619433	0.828883602
60–64	1972–1979	ENLISTED	1	0.464899362	0.808161512
60–64	1980–1984	ENLISTED	1	0.867812142	2.693871707
60–64	1972–1979	NON-COMM OFFICER	1	0.514259047	0.769677631
60–64	1980–1984	NON-COMM OFFICER	1	0.213396428	0.64652921
60–64	1985–1989	NON-COMM OFFICER	1	0.703631467	1.197276314
60–64	1990–1994	NON-COMM OFFICER	1	1.084765178	4.310194731
60–64	1972–1979	OFFICER	1	0.125769876	0.431019473
					(continued)

Table A5 (continued): Weighting applied to the 3rd MCIS Update data set
	Strata	variable	Weight						
Age category (years)	Exposure/ posting category	Rank category	3rd MCIS Update Study Population	3rd MCIS Update Amberley Comparison Population	3rd MCIS Update Richmond Comparison Population				
60–64	1985–1989	OFFICER	1	0.255238865	2.693871707				
65–69	1972–1979	ENLISTED	1	0.333773901	0.598638157				
65–69	1980–1984	ENLISTED	1	1.239731632	5.387743414				
65–69	1972–1979	NON-COMM OFFICER	1	1.084765178	1.517674201				
65–69	1980–1984	NON-COMM OFFICER	1	0.315568052	0.552589068				
65–69	1972–1979	OFFICER	1	0.299245566	0.598638157				
70–74	1972–1979	NON-COMM OFFICER	1	0.394460065	0.414441801				
70–74	1980–1984	NON-COMM OFFICER	1	0.299245566	0.567130886				
70–74	1980–1984	OFFICER	1	0.788920129	2.693871707				

Table A5 (continued): Weighting applied to the 3rd MCIS Update data set

Production of mortality and cancer statistics

Two methods of comparative analysis were used in this study:

- *the weighted comparative method*, comparing the Study Population with the Amberley and Richmond Comparison populations
- *the standardised method,* comparing the Study Population with the Australian male population.

Weighted comparative method: calculating the weighted relative risk for incidence and mortality

Weighted incidence relative risk (IRR) and mortality relative risk (MRR) were calculated for each combination of Study Population and Comparison populations, using the following method:

- 1. calculating the weighted number of cancers or deaths in each group
- 2. calculating the weighted number of person years in each group
- 3. dividing the weighted number of cancers or deaths by the weighted number of person years in each group
- 4. calculating the ratio of these rates to compare the Study Population with each Comparison Population.

Standardised method: calculating the standardised incidence/mortality ratios

The standardised cancer incidence ratios (SIRs) and standardised mortality ratios (SMRs) were derived by calculating the:

- 1. observed number of deaths/cancers in the group
- 2. number of person years at risk in 5-year age groups for each year between 1980 and 2012
- 3. expected number of deaths/cancers, by applying Australian age-specific incidence rates to the study group's person years at risk for each year
- 4. ratio of observed to expected number of deaths/cancers.

Confidence intervals and statistical significance

Ninety-five per cent (95%) confidence intervals (CIs) for the relative risks (IRR, MRR) and standardised ratios (SIR, SMR) were calculated, based on using the Normal Distribution to approximate the distributions of the event counts. This analysis was conducted in SAS using PROC STDRATE. For details of that method, see

<http://support.sas.com/documentation/onlinedoc/stat/121/stdrate.pdf>.

In this study, statistical significance was indicated when the 95% CI around an estimate did not include 1.0.

Study periods for mortality

The results of the 3rd MCIS showed that the observed differences between the 3rd MCIS Study Population and the Comparison populations in the years before 1999 were likely affected by survivor bias (AIHW 2009).

In the context of this study, the health concerns in relation to DSRS work were not raised as an issue until 1999, and the programs were ceased in early 2000. The survivor bias results from excluding personnel from the Study Population who died before 1999 and who were not identified as ever working in the DSRS programs. The presence of survivor bias in this study is shown in Figure A2, where the cumulative number of deaths among the Study Population is shown to increase more rapidly from 1999–2012, compared with 1980–1998.



Therefore, although data were available for linkage from 1980 to 2012, the key findings of the 4th MCIS are *based on mortality data for 1999–2012* only, to minimise the effect of the survivor bias on the results.

For completeness, the results of the analysis on the 1980–2012 data set are presented in appendixes C and D (appendix tables C5, C6, D5 and D6).

Power analysis

The purpose of the power analysis used in the 4th MCIS was to estimate the year in which a sufficient number of cases of specific cancer types/sites will be observed in the Study Population to produce a statistically significant result, should the current best estimate of the cancer incidence rates derived from this analysis reflect the true population rates (real-world effect). This analysis was based on the comparison of the Study Population with the Amberley Comparison Population.

This analysis used a modified power analysis method, and:

- assumed that the most recent relative risk did not change and that the rate of cancer incidence used to derive that relative risk is the best available estimate of the true underlying rate of cancer incidence (given known and unknown bias in the study method) that can be used for the purpose of sensitivity and projection analysis
- inflated the underlying numbers of cancers driving this estimate by the expected percentage increase in cancers, by age group and sex, in the Australian population.

The theory behind the power analysis is that, as the estimated underlying numbers of cancers increase, the 95% CI around the estimate decreases until it becomes statistically significant.

Given the small number of observed cases for some cancer types/sites, a minor change in the observed cancer rate from the estimated rate used in this extrapolation would lead to a substantial change in the estimates. As a result, this power analysis should be seen as a guide only to planning future research, if the purpose of that research is to identify a true difference by using statistical significance.

Assuming a lack of statistical power was the reason for the non-statistically significant results, power analysis was also done on all remaining specific cancer types that met the following conditions:

- at least 10 observed cancers between 1982 and 2010
- the lower bound of the 95% confidence interval on the relative risk was greater than 0.7 and less than 1.0
- *a priori* link to solvent/sealant exposure (benzene, hexavalent chromium, silica).

This process ensures that the estimates are based upon a suitably large number of cancers, which provides a greater degree of confidence in the reliability of the results feeding into the power analysis. A total of 3 cancer types met the conditions stated above and these estimates are presented in Table A6.

Table A6: Power analysis: cand	cer incidence data, by	selected cancer t	ype/site, comparison
of the 4th MCIS Study Popula	tion and the Amberle	y Comparison Po	opulation, 1982–2010

Cancer type/site ^{(a)(b)}	Observed ^(c)	IRR ^(d)	95% Cl ^(e)	Estimated incident year for significance ^(f)
Colorectal	20	1.64	0.92–2.36	2013
Prostate	31	1.40	0.91–1.90	2020
Lung	13	1.65	0.75–2.55	2023

95%Cl 95% confidence interval

IRR incidence relative risk

(a) All cancers defined by ICD-O-3 codes C00–C99, D45, D46, D47.1 and D47.3, excluding those codes for basal cell carcinoma and squamous cell carcinoma of the skin. For a complete list of codes, see Appendix Table B2.

(b) Lung and prostate cancers are associated with benzene exposure, lung and colorectal cancers are associated with hexavalent chromium exposure, and lung cancer is associated with silica exposure (Bowling 2014; JSCFADT 2009; TUNRA 2003a). Other cancers associated with these compounds include multiple myeloma and non-Hodgkin lymphoma (benzene), and pulmonary, nasal, pharyngeal and sinus cancers (hexavalent chromium). Benzene, hexavalent chromium and silica are recognised human carcinogens (IARC 1987).

(c) The observed (actual) incidence among the Study Population.

(d) The IRR of the Study Population compared with the Amberley Comparison Population. The IRR is the ratio of the observed mortality rate in the Study Population to the estimated (weighted) rate in the Comparison Population(s). If those rates are the same, the MRR is 1.0. If the rate in the Study Population is higher than in the Comparison Population(s), the MRR is greater than 1.0. If the rate in the Study Population is lower than in the Comparison Population(s), the MRR is less than 1.0.

- (e) The 95% CI indicates the range of values around the IRR in which there is 95% certainty that the true value of the difference lies. If the CI includes 1.0, it is considered there is insufficient evidence of a difference in the rates of the Study and Comparison Populations. If the confidence interval excludes 1.0, it is considered that there is sufficient evidence of a difference in rates between the Study and Comparison Populations (a statistically significant finding).
- (f) This 'estimated incident year for significance' refers to the year in which the cancers are diagnosed, and not the year in which the ACD would be available for analysis. Based on current practices, the ACD would be available for analysis approximately 3 years after the incident year. For example, the 2013 data would be expected to be available for analysis from 2016.

Note: All predicted power calculations are based on the comparison of the Study Population and the Amberley Comparison Population.

Source: Appendix Table C2.

A7 Data storage and record retention

Data provided and created for this study are stored as per AIHW information security protocols. No third parties (including the DVA) have access to any identified data. Any data provided to the DVA by the AIHW are in aggregated and de-identified form and stored in accordance with the DVA's security processes and procedures.

Data stored and analysed at the AIHW are protected under the *Privacy Act 1988* and the *Australian Institute of Health and Welfare Act 1987*. The AIHW is subject to the *Public Service Act 1999* and the APS Code of Conduct. In addition, the AIHW has issued formal Guidelines for the Custody of Institute Data as a further measure to ensure data protection.

The AIHW performs data linkage projects on a separate secure private network and only Data Integration Services Centre (DISC) staff and the Systems Manager have access to this network. Dedicated DISC infrastructure capabilities replicate the hardware that has already been used with success on other large data integration projects across the AIHW. This environment is completely separate from any other AIHW systems.

The AIHW connects, via the Intra Government Communications Network, to an internet gateway provider accredited by the Australian Signals Directorate. As such, the AIHW's internet gateway is certified to the PROTECTED level. Further, DISC projects are undertaken on a separate secure network, which is not connected to the internet.

The AIHW uses best practice technology, procedures and policies to protect its information and communication technology assets. A layered system of security is in place with different technologies and techniques used at different levels. In line with the Australian Government Protective Security Policy Framework:

- passwords are changed regularly
- accounts are locked out after three failed attempts
- Operating System patching of desktops, networking equipment and servers is done in line with Australian Signals Directorate guidelines
- application software updates are tested and applied as soon as practical after release
- access to the data centre is controlled by swipe card
- the network is protected by a state-of-the art firewall to protect against external intrusion, beyond which the accredited gateway has their firewalls
- anti-virus software is constantly updated
- regular backups are taken, including rotation to a secure off-site storage facility
- desktops have been hardened to prevent users from installing software or tampering with the system.

These security measures are backed up by an auditing regime, based around tightly controlled separate information domains (staging, linking, and consolidation domains) that exist for each stage of creating the project data. Each project in each information domain is in a separate storage location, with access limited by user (different users in different information domains for separation requirements).

This architecture determines who can access what data at any time and access is therefore predetermined and logged. Work logs of basic user and time/date information are generated when code is run against these data and are stored as part of the audit trail.

In summary, access is provided to individuals for each stage of a project. This allows the AIHW to determine and log all access rights to the data throughout the process. At the completion of the project, and in line with the data retention date, the AIHW uses sdelete (Microsoft) to remove all files relating to a project from the hard disk. In line with DISC data retention/backup cycle procedures, data are overwritten on a 4-weekly cycle. Data are encrypted as part of the archival process using Commvault.

The 4th MCIS and 3rd MCIS Update data sets will be stored for at least 7 years. When required, these data will be destroyed as per the *Archives Act 1983*.

A8 Privacy principles

The *Privacy Act 1988* sets out 13 Australian Privacy Principles that govern agencies of the Australian Government in their collection, storage, use, disclosure and management of data containing personal information. The Privacy Act permits the handling of health information for health and medical research purposes in certain circumstances, where researchers are unable to seek individuals' consent. This recognises:

- the need to protect health information from unexpected uses beyond individual health care
- the important role of health and medical research in advancing public health.

To promote these ends, the Privacy Commissioner has approved two sets of legally binding guidelines, issued by the National Health and Medical Research Council. Researchers must follow these guidelines when handling health information for research purposes without individuals' consent. The guidelines also assist Human Research Ethics Committees (HRECs) in deciding whether to approve research applications. The guidelines are produced under sections 95 and 95A of the Privacy Act:

- Guidelines under Section 95 of the Privacy Act set out procedures that HRECs and researchers must follow when personal information is disclosed from an Australian Government agency for medical research purposes.
- Guidelines under Section 95A of the Privacy Act provide a framework for HRECs to assess proposals to handle health information for health and medical research (without individuals' consent). They ensure that the public interest in the research activities substantially outweighs the public interest in the protection of privacy.

Individuals were not approached for consent to participate in this study, as it was considered that seeking consent from all possible study participants may impact on study results. Specifically, seeking consent may have resulted in a statistically less significant study as healthy individuals are less likely to respond than sick individuals. Further, as the study may also include deceased individuals it would not be possible to seek consent in these circumstances and may distress the families of these individuals.

The F-111 Tier cohort was identified through the Defence 2005 Tier classification and ex gratia scheme, which is administered by the DVA. Tier classification allows the DVA to identify individuals for inclusion in Tier-specific compensation and in health-care schemes implemented in response to the health concerns of the F-111 group which surrounded the F-111 DSRS programs.

Final results of the study are presented in aggregate format and do not identify individuals.

A9 Ethics approval

The AIHW Ethics Committee accepted that the public interest in the research activities of this project substantially outweighs the public interest in the protection of privacy and approved the study pursuant to Section 95 of the Privacy Act.

Appendix B: Data sources and classifications

Data sources

Study Population

Information on DSRS exposure was sourced from the Tier classification program, provided by the DVA, and from the 3rd MCIS, originally provided by TUNRA and currently held by the AIHW.

Cancer incidence: the Australian Cancer Database

The ACD contains information on Australians who were diagnosed with cancer (excluding basal cell and squamous cell carcinomas of the skin) between 1982 and 2011. Data are collected by state and territory cancer registries from a number of sources and are supplied annually to the AIHW. The AIHW compiles and maintains the ACD, in partnership with the Australasian Association of Cancer Registries.

In Australia, cancer is a notifiable disease. This means that reporting all cancers (excluding basal cell and squamous cell carcinomas of the skin) is mandatory under legislation in each Australian state and territory.

Cancer reporting and registration is a dynamic process, and records in the state and territory cancer registries may be modified if new information is received. As a result, the number of cancer cases reported by the AIHW for any particular year may change slightly over time and may not always align with state and territory reporting for that same year (AIHW 2014).

Although, at the time of publication, national cancer incidence data are available in the ACD from 1982–2011, at the time of the linkage analysis for this study, data were available only to 2010.

The Data Quality Statement for the ACD 2010 is available on the AIHW website at http://meteor.aihw.gov.au/content/index.phtml/itemId/565218>.

National Death Index

The NDI is maintained by the AIHW and contains information on all deaths in Australia since 1980. This database exists solely for linkage purposes for health and medical research, such as to gain epidemiological mortality information on individuals in a particular cohort, or with a known disease state. Ethics approval is required to use the NDI for any particular research project.

The Data Quality Statement for the NDI can be found on the AIHW website at http://meteor.aihw.gov.au/content/index.phtml/itemId/480010>.

Australian male population

Population data sourced from the Australian Bureau of Statistics and referred to as 'estimated resident populations' are used to derive the age-standardised summary statistics

presented in this report. The populations used in this report were derived from the 2011 Census of Population and Housing, and the standard population is the 2001 Australian Standard Population (at 30 June 2001). These populations are updated over time, and those used in this report are from *Australian demographic statistics, June 2013* (ABS cat. no. 3101.0, released 17 December 2013) and available from the following ABS website:

<http://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/3101.0Main+Features1Jun%20201 3?OpenDocument> (ABS 2013).

Classifications

International Classification of Diseases

The International Statistical Classification of Diseases and Related Health Conditions (ICD) is used to classify diseases and other health problems (including symptoms and injuries) in clinical and administrative records. In Australia, mortality cause of death data are coded according to the ICD. Data for 1977–1996 are based on the ninth revision (ICD-9) and data from 1997 are based on the tenth revision (ICD-10).

For information on the codes used to define the mortality groups presented in this report, see Table B1.

Cause of death	ICD-10 codes (1997–2012)	ICD-9 codes (1977–1996)
All deaths	All (A00–Y98)	All (001–999)
Certain infectious and parasitic diseases	A00–B99	001–139
Neoplasms (cancers)	C00–D48	140–239
Colorectal cancer	C18–C20	153–154
Prostate cancer	C61	185
Head and neck cancers	C01–C14, C30–C32	141–149, 160–161
Lung cancer	C33–C34	162
Leukaemia	C91–C95	204–208
Non-Hodgkin lymphoma	C82–C85	200, 202
Melanoma of the skin	C43	172
Diseases of the blood and blood-forming organs, and certain disorders involving the immune mechanism	D50–D89	280–289
Endocrine, nutritional and metabolic diseases	E00–E90	240–278
Mental and behavioural disorders	F00–F99	290–319
Diseases of the nervous system	G00–G99	320–359
Diseases of the circulatory system	100–199	390–459
Ischaemic heart diseases	120–125	410–414
Cerebrovascular diseases (stroke)	160–169	430–438
Diseases of the respiratory system	J00–J99	460–519
Chronic obstructive pulmonary disease	J41–J44	491–492, 496
Diseases of the digestive system	K00–K93	520–579
Diseases of the liver, gallbladder and bile ducts	K70–K83	570–576
Alcoholic liver disease	K70	5710–5713
Diseases of the genitourinary system	N00-N99	580–629
External causes of morbidity and mortality	V01–Y98	800–999
Assault	X85–Y09	960–969
Transport accidents	V020–V040, V070–V090, V120–V140, V190-V790, V803–V806, V810–V811, V820–V821, V830–V880, V890, V892, V899	810–825
Intentional self-harm (suicide)	X60–X84	950–959

Table B1: ICD-9 and ICD-10 codes used to define mortality groups, 1982-2010

International Classification of Diseases for Oncology

The International Classification of Diseases for Oncology (ICD-O) is used to classify cancer by both morphology (histology type and behaviour) and topography (site). The first edition was released in 1976 and has since been updated to include lymphomas and leukaemias. In Australia, cancer morphology and topography are coded according to the ICD-O third edition in most state and territory cancer registries and the AIHW ACD (Fritz et al. 2000).

For information on the codes used to define the cancer types presented in this report, see Table B2.

Cancer type	ICD-O-3 codes
All cancers ^(a)	C00–C97, D45–D46, D47.1, D47.3
Brain	C71
Breast	C50
Connective soft tissue	C47–C49
Eye	C69
Gastrointestinal	C16–C21
Colorectal	C18–C20
Stomach	C16
Genitourinary	C60–C68
Bladder	C67
Kidney	C64
Prostate	C61
Head and neck	C01–C14, C30–C32
Larynx	C32
Lip	C00
Liver	C22
Lung	C33–C34
Lymphoid and haematopoietic	C81–C96, D45–D46, D47.1, D47.3
Leukaemia	C91–C95
Lymphoid leukaemia	C91
Myeloid leukaemia	C92–C94
Lymphoma	C81–C85
Hodgkin lymphoma	C81
Non-Hodgkin lymphoma	C82–C85
Multiple myeloma	C90
Melanoma	C43
Pancreas	C25
Cancer of unknown primary site (Unknown)	C26, C39, C76–C80

Table B2: ICD-0-3 codes used to define cancer groups, 1982–2010

(a) 'All cancers' excludes basal cell and squamous cell carcinomas (common non-melanoma skin cancers). These are not notifiable cancers in Australia and data are incomplete.

Appendix C: Detailed results of the 4th MCIS

		Study Population v Amberley ^(b)		Study Po	Study Population v Richmond ^{(b}		
Cancer type/site ^(a)	Observed cases (Study Population)	IRR ^(c)	95% Cl ^(d)	IRR ^(c)	95% Cl ^(d)		
All cancers	149	*1.23	1.03–1.48	*1.30	1.09–1.56		
Brain	0	—	_	—	—		
Male breast	1	—	—	—	—		
Connective soft tissue	1	0.46	0.06–3.61	0.89	0.11–7.34		
Eye	4	*19.17	1.99–184.45	*6.10	1.47–25.27		
Gastrointestinal	25	1.21	0.78–1.88	1.27	0.82–1.97		
Colorectal	20	1.57	0.94–2.62	1.31	0.80–2.13		
Stomach	1	0.42	0.05–3.24	0.81	0.10–6.64		
Genitourinary	42	1.27	0.90–1.79	1.15	0.83–1.60		
Bladder	3	1.28	0.35–4.63	1.75	0.48-6.42		
Kidney	5	1.35	0.50–3.67	1.47	0.55–3.95		
Prostate	31	1.27	0.85–1.89	1.16	0.78–1.70		
Head and neck	6	1.09	0.44–2.65	1.77	0.71–4.44		
Larynx	0	—	—	—	—		
Lip	4	2.45	0.72-8.32	2.50	0.77–8.13		
Liver	0	—	_	—	—		
Lung	13	1.38	0.74–2.56	*1.96	1.04–3.68		

Table C1: Weighted incidence relative risk: 4th MCIS Study Population and Comparison populations, by selected cancer type/site, 1982-2010

Table C1 (continued): Weighted incidence relative risk : 4th MCIS Study Population and Comparison populations, by selected cancer type/site, 1982-2010

		Study P	opulation v Amberley ^(b)	Study P	Study Population v Richmond ^(b)		
Cancer type/site ^(a)	Observed cases (Study Population)	IRR ^(c)	95% Cl ^(d)	IRR ^(c)	95% Cl ^(d)		
Lymphoid and haematopoietic	16	*1.82	1.02–3.26	1.54	0.89–2.68		
Leukaemia	4	1.31	0.43-4.00	1.86	0.60–5.76		
Lymphoid leukaemia	2	1.71	0.33-8.73	3.39	0.58–19.72		
Myeloid leukaemia	2	1.07	0.23–4.99	1.28	0.27–5.94		
Lymphoma	11	*2.33	1.12-4.83	1.46	0.75–2.84		
Hodgkin lymphoma	0	_	—	_	—		
Non-Hodgkin Lymphoma	11	*2.94	1.37–6.30	1.81	0.92–3.59		
Multiple myeloma	0	_	—	_	—		
Melanoma of the skin	26	1.10	0.71–1.69	1.28	0.83–1.96		
Pancreas	1	0.40	0.05–3.14	0.53	0.07–4.09		
Unknown	4	3.14	0.87–11.34	1.40	0.47-4.20		

* statistically significant difference at the 95% confidence level

nil or rounded to zero

IRR (weighted) incidence relative risk

95% CI 95% confidence interval

(a) All cancers defined by ICD-0-3 codes C00–C99, D45, D46, D47.1 and D47.3, excluding those codes for basal cell carcinoma and squamous cell carcinoma of the skin. For a complete list of codes, see Appendix Table B2.

(b) IRR and 95% CI of the 4th MCIS Study Population compared with the Amberley Comparison Population or the Richmond Comparison Population.

(c) The IRR of the Study Population compared with the Amberley or Richmond Comparison Population. The IRR is the ratio of the observed mortality rate in the Study Population to the estimated (weighted) rate in the Comparison Population(s). If those rates are the same, the MRR is 1.0. If the rate in the Study Population is higher than in the Comparison Population(s), the MRR is greater than 1.0. If the rate in the Study Population is lower than in the Comparison Population(s), the MRR is greater than 1.0. If the rate in the Study Population is lower than in the Comparison Population(s), the MRR is less than 1.0.

(d) The 95% CI indicates the range of values around the IRR in which there is 95% certainty that the true value of the difference lies. If the CI includes 1.0, it is considered there is insufficient evidence of a difference in the rates of the Study and Comparison populations. If the CI excludes 1.0, it is considered that there is sufficient evidence of a difference in rates between the Study and Comparison populations (a statistically significant finding).

Note: Data are weighted according to the method defined in the 2nd MCIS (TUNRA 2004a). See Appendix A for details.

Source: AIHW linkage analysis of the ACD 2010.

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		Study Population v Amberley ^(b)		Study Population v Richmond ^(b)		
Cause of death ^(a)	Observed cases (Study Population)	MRR ^(c)	95% CI ^(d)	MRR ^(c)	95% CI ^(d)	
All deaths	52	*0.73	0.54-0.97	0.94	0.70–1.26	
Certain infectious and parasitic diseases	1	0.62	0.08–5.00	2.40	0.23–25.14	
Neoplasms (cancers)	29	0.94	0.63–1.40	1.34	0.89–2.01	
Colorectal cancer	3	0.67	0.20-2.26	1.34	0.38–4.72	
Head and neck cancers	0	_	_	_	_	
Leukaemia	3	1.84	0.48-7.08	3.38	0.80–14.22	
Lung cancer	7	1.10	0.48–2.51	1.45	0.63–3.33	
Melanoma of the skin	1	0.47	0.06–3.67	0.70	0.09–5.63	
Non-Hodgkin lymphoma	3	*5.55	1.01–30.47	3.09	0.75–12.71	
Prostate cancer	0	_	_	_	_	
Diseases of the blood and blood-forming organs, and certain disorders involving the immune mechanism	0	_	_	_	_	
Endocrine, nutritional and metabolic diseases	0	_	_	_	_	
Mental and behavioural disorders	1	1.29	0.14–11.95	4.03	0.31–53.34	
Diseases of the nervous system	1	0.48	0.06–3.79	1.30	0.15–11.49	
Diseases of the circulatory system	8	0.53	0.25–1.10	0.60	0.29–1.24	
Ischaemic heart diseases	4	0.50	0.18–1.42	0.50	0.18–1.40	
Cerebrovascular diseases (stroke)	0	_	—	_	—	
Diseases of the respiratory system	2	0.66	0.15–2.94	0.91	0.20-4.05	
Chronic obstructive pulmonary disease (COPD)	0	_	_	_	_	
Diseases of the digestive system	2	0.67	0.15–2.96	0.85	0.19–3.78	
Diseases of the liver, gallbladder and bile ducts	1	0.45	0.06–3.53	0.74	0.09–5.97	
Alcoholic liver disease	1	0.99	0.11–8.67	2.31	0.22–23.87	

Table C2: Weighted mortality relative risk: 4th MCIS Study Population and Comparison populations, by selected causes of death, 1999-2012

Table C2 (continued): Weighted mortality relative risk: 4th MCIS Study Population and Comparison populations, by selected causes of death, 1999–2012

		Study Population v Amberley ^(b)		Study Population v Richmond ^(b)		
Cause of death ^(a)	Observed cases (Study Population)	MRR ^(c)	95% CI ^(d)	MRR ^(c)	95% CI ^(d)	
Diseases of the genitourinary system	0	_	_	_	_	
External causes of morbidity and mortality	5	0.45	0.18–1.14	0.46	0.19–1.15	
Assault	0	—	—	—	—	
Transport accidents	0	_	—	—	—	
Intentional self-harm (suicide)	4	1.02	0.34–3.04	0.83	0.29–2.36	

* statistically significant difference at the 95% confidence level

nil or rounded to zero

MRR (weighted) mortality relative risk

95% CI 95% confidence interval

(a) A complete list of ICD-9 and ICD-10 codes used to define the mortality groupings is presented in Appendix Table B1.

(b) MRR and 95% CI of the Study Population compared with the Amberley Comparison Population or the Richmond Comparison Population.

(c) The MRRof the Study Population compared with the Amberley or Richmond Comparison Population. The MRR is the ratio of the observed mortality rate in the Study Population to the estimated (weighted) rate in the Comparison Population(s). If those rates are the same, the MRR is 1.0. If the rate in the Study Population is higher than in the Comparison Population(s), the MRR is greater than 1.0. If the rate in the Study Population is lower than in the Comparison Population(s), the MRR is greater than 1.0. If the rate in the Study Population is lower than in the Comparison Population(s), the MRR is less than 1.0.

(d) The 95% CI indicates the range of values around the MRR in which there is 95% certainty that the true value of the difference lies. If the CI includes 1.0, it is considered there is insufficient evidence of a difference in the rates of the Study and Comparison populations. If the CI excludes 1.0, it is considered that there is sufficient evidence of a difference in rates between the Study and Comparison Populations (a statistically significant finding).

Note: Data are weighted according to the method defined in the 2nd MCIS (TUNRA 2004a). See Appendix A for details.

		Study	Populatio	n	Amberley Comparison Population				Richmond Comparison Population			
Cancer type/site ^(a)	Obs ^(b)	Exp ^(c)	$\boldsymbol{SIR}^{(d)}$	95% Cl ^(e)	Obs ^(b)	Exp ^(c)	$\boldsymbol{SIR}^{(d)}$	95% CI ^(e)	Obs ^(b)	Exp ^(c)	SIR ^(d)	95% CI ^(e)
All cancers	149	107	*1.39	1.16–1.61	660	572	*1.15	1.07–1.24	612	588	1.04	0.96–1.12
Brain	0	3	_	_	9	12	0.74	0.26–1.22	22	14	1.59	0.93–2.26
Male breast	1	0	5.28	0.00–15.64	0	1	_	_	0	1	—	_
Connective soft tissue	1	1	1.03	0.00-3.06	10	5	2.19	0.83–3.55	6	5	1.14	0.23–2.05
Eye	4	0	9.84	0.20–19.48	2	2	1.01	0.00-2.40	3	2	1.37	0.00–2.91
Gastrointestinal	25	20	1.24	0.75–1.72	123	113	1.09	0.90–1.29	98	111	0.88	0.71–1.06
Colorectal	20	12	1.64	0.92–2.36	86	69	1.24	0.98–1.51	73	67	1.09	0.84–1.33
Stomach	1	2	0.47	0.00–1.38	11	12	0.92	0.38–1.47	8	12	0.68	0.21–1.15
Genitourinary	42	32	1.32	0.92–1.72	212	177	*1.20	1.04–1.36	197	174	1.13	0.97–1.29
Bladder	3	2	1.50	0.00–3.19	13	12	1.09	0.50–1.69	11	11	0.98	0.40–1.55
Kidney	5	4	1.42	0.18–2.67	18	18	1.01	0.54–1.47	16	19	0.84	0.43–1.25
Prostate	31	22	1.40	0.91–1.90	169	129	*1.31	1.11–1.50	146	121	*1.21	1.01–1.40
Head and neck	6	5	1.12	0.22–2.02	24	28	0.86	0.51–1.20	19	29	0.65	0.36–0.95
Larynx	0	1	_	_	11	6	1.72	0.70–2.74	4	6	0.66	0.01–1.31
Lip	4	3	1.54	0.03–3.05	8	12	0.65	0.20-1.10	10	14	0.71	0.27–1.15
Liver	0	2	_	_	3	8	0.39	0.00-0.82	1	8	0.12	0.00–0.36
Lung	13	8	1.65	0.75–2.55	48	48	1.01	0.72–1.29	39	44	0.88	0.61–1.16
Lymphoid and haematopoietic	16	12	1.37	0.70–2.03	50	59	0.85	0.61–1.08	56	64	0.88	0.65–1.10
Leukaemia	4	3	1.29	0.03–2.55	14	16	0.88	0.42–1.34	13	17	0.76	0.35–1.18
Lymphoid leukaemia	2	2	1.32	0.00–3.14	6	8	0.75	0.15–1.35	4	8	0.48	0.01–0.96
Myeloid leukaemia	2	2	1.30	0.00–3.10	8	8	1.05	0.32–1.77	9	8	1.06	0.37–1.76

Table C3: Standardised incidence ratio: 4th MCIS Study Population and Comparison populations, by selected cancer type/site, 1982-2010

Table C3 (continued): Standardised incidence ratio: 4th MCIS Study Population and Comparison populations, by selected cancer type/site, 1982–2010

	Study Population					rley Comp	parison Po	opulation	Richmond Comparison Population			
Cancer type/site ^(a)	Obs ^(b)	Exp ^(c)	SIR ^(d)	95% Cl ^(e)	Obs ^(b)	Exp ^(c)	$\boldsymbol{SIR}^{(d)}$	95% Cl ^(e)	Obs ^(b)	Exp ^(c)	SIR ^(d)	95% CI ^(e)
Lymphoma	11	6	1.73	0.71–2.75	27	31	0.88	0.55–1.21	40	35	1.16	0.80–1.51
Hodgkin lymphoma	0	1	—	—	6	4	1.34	0.27–2.42	9	6	1.58	0.55–2.62
Non-Hodgkin lymphoma	11	5	2.06	0.84–3.28	21	26	0.80	0.46–1.14	32	29	1.11	0.72–1.49
Multiple myeloma	0	1	—	—	7	6	1.09	0.28–1.90	8	6	1.25	0.38–2.11
Melanoma of the skin	26	17	1.49	0.92–2.07	112	83	*1.35	1.10–1.60	110	94	1.17	0.95–1.39
Pancreas	1	2	0.57	0.00–1.69	11	10	1.12	0.46–1.79	10	10	1.04	0.39–1.68
Unknown	4	2	1.77	0.04–3.50	8	13	0.63	0.19–1.07	15	13	1.19	0.59–1.80

* statistically significant difference at the 95% confidence level

nil or rounded to zero

Exp expected

Obs observed

95% CI 95% confidence interval

SIR standardised incidence ratio

(a) All cancers defined by ICD-O-3 codes C00–C99, D45, D46, D47.1 and D47.3, excluding those codes for basal cell carcinoma and squamous cell carcinoma of the skin. For a complete list of codes, see Appendix Table B2.

(b) The observed (actual) incidence in the 4th MCIS Study and Comparison populations.

(c) The expected incidence is calculated by applying the year- and age-specific incidence rate of the Australian male population to the Study or Comparison Population to determine the number of new cases of cancer that would be expected if those groups had the same age and exposure profile as the Australian male population. For more detail on this method, see Appendix A.

- (d) The SIR is the ratio of the estimated incidence rate in the Study Population (or Comparison populations) compared with the Australian male population, adjusting for any difference in age structure between the two populations, and calculated by dividing the observed number of new cases by the expected number of new cases. If those rates are the same, the SIR is 1.0.If the rate in the Study or Comparison Population(s) is higher than in the Australian male population, the SIR is greater than 1.00. If the rate in the Study or Comparison Population(s) is lower than in the Australian male population, the SIR is greater than 1.00.
- (e) The 95% CI indicates the range of values around the SIR in which there is 95% certainty that the true value of the difference lies. If the confidence interval includes 1.0, it is considered there is insufficient evidence of a difference in the rates of the Study or Comparison populations and the Australian male population. If the confidence interval excludes 1.0, it is considered that there is sufficient evidence of a difference in rates between the Study or Comparison Populations and the Australian male population (a statistically significant finding).

Source: AIHW linkage analysis of the ACD 2010.

	Study Population			Ambe	Amberley Comparison Population				Richmond Comparison Population			
Cause of death ^(a)	$\mathbf{Obs}^{(\mathrm{b})}$	Exp ^(c)	SMR ^(d)	95% Cl ^(e)	Obs ^(b)	Exp ^(c)	SMR ^(d)	95% Cl ^(e)	Obs ^(b)	Exp ^(c)	$\boldsymbol{SMR}^{(d)}$	95% CI ^(e)
All deaths	52	82	*0.64	0.46–0.81	385	418	0.92	0.83–1.01	308	433	*0.71	0.63–0.79
Certain infectious and parasitic diseases	1	2	0.62	0.00–1.85	7	7	0.96	0.25–1.66	2	8	*0.24	0.00–0.56
Neoplasms (cancers)	29	30	0.97	0.62–1.32	162	161	1.00	0.85–1.16	127	157	*0.81	0.67–0.95
Colorectal cancer	3	3	0.93	0.00–1.99	22	18	1.25	0.73–1.78	13	17	0.77	0.35–1.19
Head and neck cancers	0	1	_	_	4	5	0.77	0.02–1.53	1	5	*0.19	0.00–0.55
Leukaemia	3	1	2.98	0.00–6.36	6	6	1.09	0.22–1.96	5	5	0.93	0.12–1.75
Lung cancer	7	6	1.10	0.28–1.91	35	36	0.98	0.65–1.30	29	34	0.87	0.55–1.18
Melanoma of the skin	1	2	0.65	0.00–1.91	11	8	1.43	0.59–2.28	7	8	0.86	0.22–1.50
Non-Hodgkin lymphoma	3	1	2.77	0.00–5.91	4	6	0.69	0.01–1.38	6	6	1.05	0.21–1.89
Prostate cancer	0	2	_	_	14	10	1.42	0.67–2.16	5	8	0.60	0.07–1.13
Diseases of the blood and blood-forming organs, and certain disorders involving the immune mechanism	0	0	_	_	1	1	0.80	0.00–2.37	2	1	1.49	0.00–3.57
Endocrine, nutritional and metabolic diseases	0	3		_	13	15	0.88	0.40–1.36	6	15	*0.41	0.08–0.74
Mental and behavioural disorders	1	1	0.73	0.00–2.16	6	7	0.90	0.18–1.62	2	7	*0.28	0.00-0.66
Diseases of the nervous system	1	2	0.44	0.00–1.29	12	12	1.02	0.44–1.60	5	12	*0.41	0.05–0.77
Diseases of the circulatory system	8	20	*0.40	0.12–0.69	93	104	0.90	0.72–1.08	73	104	*0.70	0.54–0.86
Ischaemic heart diseases	4	13	*0.32	0.01–0.63	51	66	*0.78	0.56–0.99	42	66	*0.64	0.44–0.83
Cerebrovascular diseases (stroke)	0	4	_	_	20	21	0.93	0.52–1.34	20	21	0.97	0.54–1.39
Diseases of the respiratory system	2	4	0.54	0.00–1.29	18	21	0.84	0.45–1.23	12	20	*0.61	0.26–0.95
Chronic obstructive pulmonary disease	0	2	_	_	10	11	0.88	0.34–1.43	2	10	*0.20	0.00–0.49
Diseases of the digestive system	2	4	0.51	0.00–1.21	17	19	0.90	0.47–1.33	14	21	0.68	0.32–1.03
Diseases of the liver, gallbladder and bile ducts	1	3	0.34	0.00–1.00	13	14	0.96	0.44–1.48	7	15	*0.45	0.12–0.79
Alcoholic liver disease	1	2	0.54	0.00–1.60	7	8	0.84	0.22–1.47	2	10	*0.21	0.00–0.50

Table C4: Standardised mortality ratio: 4th MCIS Study Population and Comparison populations, by selected cause of death, 1999–2012

Table C4 (continued): Standardised mortality ratio: 4th MCIS Study Population and Comparison populations, by selected cause of death, 1999-2012

	Study Population				Amber	Amberley Comparison Population					Richmond Comparison Population			
Cause of death ^(a)	$\boldsymbol{Obs}^{(b)}$	Exp ^(c)	$\boldsymbol{SMR}^{(d)}$	95% Cl ^(e)	Obs ^(b)	Exp ^(c)	SMR ^(d)	95% CI ^(e)	Obs ^(b)	Exp ^(c)	SMR ^(d)	95% CI ^(e)		
Diseases of the genitourinary system	0	1	_	_	4	4	1.03	0.02–2.05	3	4	0.81	0.00–1.73		
External causes of morbidity and mortality	5	14	*0.37	0.05–0.69	45	59	*0.77	0.54–0.99	55	75	*0.74	0.54–0.93		
Assault	0	0	_	—	2	2	0.98	0.00–2.34	0	3	—	—		
Transport accidents	0	2	_	—	10	11	0.92	0.35–1.49	12	14	0.87	0.38–1.36		
Intentional self-harm (suicide)	4	6	0.73	0.01–1.44	17	23	0.73	0.38–1.07	28	30	0.92	0.58–1.26		

* statistically significant difference at the 95% confidence level

nil or rounded to zero

Exp expected

Obs observed

95% CI 95% confidence interval

SMR standardised mortality ratio

(a) A complete list of ICD-9 and ICD-10 codes used to define the mortality groupings is presented in Appendix Table B1.

(b) The observed (actual) mortality in the 4th MCIS Study and Comparison populations.

(c) The expected mortality is calculated by applying the age-specific mortality rate of the Australian male population to the Study or Comparison Population, to determine the number of new cases of cancer that would be expected if those groups had the same age and exposure profile as the Australian male population. For more detail on this method, see Appendix A.

(d) The SMR is the ratio of the estimated mortality rate in the Study Population (or Comparison populations) compared with the Australian male population, adjusting for any difference in age structure between the two populations, and calculated by dividing the observed number of deaths by the expected number of deaths. If those rates are the same, the SMR is 1.0. If the rate in the Study or Comparison Population(s) is higher than in the Australian male population, the SMR is greater than 1.00. If the rate in the Study or Comparison Population(s) is lower than in the Australian male population, the SMR is less than 1.00.

(e) The 95% CI indicates the range of values around the SMR in which there is 95% certainty that the true value of the difference lies. If the CI includes 1.0, it is considered there is insufficient evidence of a difference in the rates of the Study or Comparison populations and the Australian male population. If the confidence interval excludes 1.0, it is considered that there is sufficient evidence of a difference in rates between the Study or Comparison populations and the Australian male population (a statistically significant finding).

		Stud	y Population v Amberley ^(b)	Stud	ly Population v Richmond ^(b)
Cause of death ^(a)	Observed cases (Study Population)	MRR ^(c)	95% Cl ^(d)	MRR ^(c)	95% Cl ^(d)
All deaths	58	*0.54	0.41-0.72	*0.62	0.47–0.81
Certain infectious and parasitic diseases	1	0.50	0.06-3.99	1.62	0.17–15.07
Neoplasms (cancers)	32	0.81	0.56–1.18	0.99	0.68–1.44
Colorectal cancer	4	0.67	0.23–1.92	1.09	0.37–3.19
Head and neck cancers	0	_	—	_	—
Leukaemia	3	0.99	0.28–3.46	2.12	0.56-8.05
Lung cancer	8	0.96	0.45-2.06	1.23	0.57–2.66
Melanoma of the skin	1	0.44	0.06–3.45	0.47	0.06–3.61
Non-Hodgkin lymphoma	3	5.08	0.96–26.77	2.15	0.56–8.15
Prostate cancer	0	_	—	_	—
Diseases of the blood and blood-forming organs, and certain disorders involving the immune mechanism	0	_	_	_	_
Endocrine, nutritional and metabolic diseases	0	—	—	_	_
Mental and behavioural disorders	1	0.84	0.10–7.13	0.70	0.09–5.58
Diseases of the nervous system	1	0.32	0.04–2.43	0.94	0.11–7.80
Diseases of the circulatory system	10	*0.44	0.23–0.85	*0.49	0.26-0.94
Ischaemic heart diseases	6	0.46	0.20-1.06	0.50	0.22–1.15
Cerebrovascular diseases (stroke)	0	_	—	_	—
Diseases of the respiratory system	2	0.49	0.11–2.13	0.81	0.18–3.55
Chronic obstructive pulmonary disease	0	—	—	—	_
Diseases of the digestive system	2	0.49	0.11–2.12	0.59	0.14–2.55
Diseases of the liver, gallbladder and bile ducts	1	0.33	0.04–2.53	0.48	0.06–3.74
Alcoholic liver disease	1	0.67	0.08–5.54	1.20	0.14–10.41

Table C5: Weighted mortality relative risk (MRR): 4th MCIS Study Population and Comparison populations, by selected causes of death, 1980–2012

Table C5 (continued): Weighted mortality relative risk (MRR): 4th MCIS Study Population and Comparison populations, by selected causes of death, 1980–2012

		Stu	dy Population v Amberley ^(b)	Stu	dy Population v Richmond ^(b)
Cause of death ^(a)	Observed cases (Study Population)	MRR ^(c)	95% CI ^(d)	MRR ^(c)	95% Cl ^(d)
Diseases of the genitourinary system	0	_	_	_	_
External causes of morbidity and mortality	6	*0.26	0.11–0.58	*0.22	0.10-0.49
Assault	0	_	—	_	—
Transport accidents	1	0.21	0.03–1.54	*0.13	0.02-0.97
Intentional self-harm (suicide)	4	0.38	0.14–1.05	0.36	0.13–0.99

* statistically significant difference at the 95% confidence level

nil or rounded to zero

95% CI 95% confidence interval

SMR standardised mortality ratio

(a) A complete list of ICD-9 and ICD-10 codes used to define the mortality groupings is presented in Appendix Table B1.

(b) MRR and 95% CI of the Study Population compared with the Amberley Comparison Population or the Richmond Comparison Population.

(c) The MRR of the Study Population compared with the Amberley or Richmond Comparison Population. The MRR is the ratio of the observed mortality rate in the Study Population to the estimated (weighted) rate in the Comparison Population(s). If those rates are the same, the MRR is 1.0. If the rate in the Study Population is higher than in the Comparison Population(s), the MRR is greater than 1.0. If the rate in the Study Population is lower than in the Comparison Population(s), the MRR is greater than 1.0. If the rate in the Study Population is lower than in the Comparison Population(s), the MRR is less than 1.0.

(d) The 95% CI indicates the range of values around the MRR in which there is 95% certainty that the true value of the difference lies. If the CI includes 1.0, it is considered there is insufficient evidence of a difference in the rates of the Study and Comparison populations. If the CI excludes 1.0, it is considered that there is sufficient evidence of a difference in rates between the Study and Comparison populations (a statistically significant finding).

Note: Data are weighted according to the method defined in the 2nd MCIS (TUNRA 2004a). See Appendix A for details.

	Study Population				Ambe	rley Com	parison P	opulation	Richmond Comparison Population			
Cause of death ^(a)	Obs ^(b)	Exp ^(c)	SMR ^(d)	95% Cl ^(e)	Obs ^(b)	Exp ^(c)	SMR ^(d)	95% CI ^(e)	Obs ^(b)	Exp ^(c)	SMR ^(d)	95% Cl ^(e)
All deaths	58	123	*0.47	0.35-0.59	547	629	*0.87	0.80-0.94	515	660	*0.78	0.71–0.85
Certain infectious and parasitic diseases	1	2	0.43	0.00–1.27	8	11	0.76	0.23–1.29	3	12	*0.24	0.00–0.52
Neoplasms (cancers)	32	38	0.83	0.54–1.12	207	214	0.97	0.83–1.10	184	206	0.89	0.76–1.02
Colorectal cancer	4	4	0.95	0.02–1.87	31	24	1.27	0.82–1.71	19	23	0.83	0.46–1.21
Head and neck cancers	0	1	_	_	5	7	0.69	0.09–1.29	3	7	*0.42	0.00-0.89
Leukaemia	3	2	1.96	0.00–4.17	11	8	1.35	0.55–2.15	8	8	0.97	0.30–1.65
Lung cancer	8	8	1.02	0.31–1.72	43	47	0.92	0.64–1.19	39	43	0.92	0.63–1.20
Melanoma of the skin	1	2	0.45	0.00–1.32	12	11	1.07	0.47–1.68	11	12	0.93	0.38–1.47
Non-Hodgkin lymphoma	3	2	1.80	0.00–3.84	5	9	0.57	0.07–1.06	9	9	1.01	0.35–1.68
Prostate cancer	0	2	_	_	15	11	1.34	0.66–2.02	8	9	0.86	0.26–1.45
Diseases of the blood and blood-forming organs, and certain disorders involving the immune mechanism	0	0	—	_	2	2	1.19	0.00–2.84	2	2	1.11	0.00–2.64
Endocrine, nutritional and metabolic diseases	0	3	_	_	17	19	0.90	0.47–1.32	8	19	*0.43	0.13–0.72
Mental and behavioural disorders	1	3	*0.33	0.00–0.99	8	13	0.61	0.19–1.03	7	16	*0.44	0.11–0.76
Diseases of the nervous system	1	3	*0.32	0.00–0.94	16	16	1.01	0.52–1.51	7	17	*0.42	0.11–0.72
Diseases of the circulatory system	10	28	*0.36	0.14–0.58	139	154	0.90	0.75–1.06	109	149	*0.73	0.59–0.87
Ischaemic heart diseases	6	18	*0.34	0.07–0.61	84	100	0.84	0.66–1.02	68	96	*0.71	0.54–0.88
Cerebrovascular diseases (stroke)	0	4	_	_	20	21	0.93	0.52–1.34	20	21	0.97	0.54–1.39
Diseases of the respiratory system	2	5	*0.42	0.00–0.99	24	28	0.85	0.51–1.19	14	26	*0.54	0.26–0.82
Chronic obstructive pulmonary disease	0	2	_	_	12	14	0.86	0.37–1.35	3	12	*0.25	0.00–0.54
Diseases of the digestive system	2	5	*0.36	0.00–0.87	21	28	0.76	0.44-1.09	19	29	*0.65	0.36–0.94
Diseases of the liver, gallbladder and bile ducts	1	4	*0.24	0.00–0.71	16	20	0.79	0.40–1.17	10	22	*0.45	0.17–0.74
Alcoholic liver disease	1	3	0.37	0.00–1.10	9	13	0.69	0.24–1.14	4	14	*0.28	0.01–0.56

Table C6: Standardised mortality ratio: 4th MCIS Study Population and Comparison populations, by selected cause of death, 1980-2012

Table C6 (continued): Standardised mortality ratio: 4th MCIS Study Population and Comparison populations, by selected cause of death, 1980-2012

	Study Population				Amber	rley Com	parison P	opulation	Richm	Richmond Comparison Population			
Cause of death ^(a)	$\boldsymbol{Obs}^{(b)}$	Exp ^(c)	$\boldsymbol{SMR}^{(d)}$	95% Cl ^(e)	Obs ^(b)	Exp ^(c)	$\boldsymbol{SMR}^{(d)}$	95% Cl ^(e)	Obs ^(b)	Exp ^(c)	$\boldsymbol{SMR}^{(d)}$	95% Cl ^(e)	
Diseases of the genitourinary system	0	1	_	_	4	5	0.85	0.02–1.67	4	5	0.88	0.02–1.74	
External causes of morbidity and mortality	6	30	*0.20	0.04–0.36	90	125	*0.72	0.57–0.87	146	161	0.91	0.76–1.05	
Assault	0	1	_	—	3	5	0.59	0.00–1.26	0	7	_	—	
Transport accidents	1	8	*0.13	0.00–0.38	22	32	*0.69	0.40-0.98	42	42	1	0.70–1.31	
Intentional self-harm (suicide)	4	12	*0.35	0.01–0.69	36	48	0.75	0.51–1.00	62	62	1	0.75–1.24	

* statistically significant difference at the 95% confidence level

nil or rounded to zero

Exp expected

Obs observed

95% CI 95% confidence interval

SMR standardised mortality ratio

(a) A complete list of ICD-9 and ICD-10 codes used to define the mortality groupings is presented in Appendix Table B1.

(b) The observed (actual) mortality in the 4th MCIS Study and Comparison populations.

(c) The expected mortality is calculated by applying the year- and age-specific mortality rate of the Australian male population to the Study or Comparison Population, to determine the number of new cases of cancer that would be expected if those groups had the same age and exposure profile as the Australian male population. For more detail on this method, see Appendix A.

(d) The SMR is the ratio of the estimated mortality rate in the Study Population (or Comparison populations) compared with the Australian male population, adjusting for any difference in age structure between the two populations, and calculated by dividing the observed number of deaths by the expected number of deaths. If those rates are the same, the SMR is 1.0. If the rate in the Study or Comparison Population(s) is higher than in the Australian male population, the SMR is greater than 1.00. If the rate in the Study or Comparison Population(s) is lower than in the Australian male population, the SMR is less than 1.00.

(e) The 95% CI indicates the range of values around the SMR in which there is 95% certainty that the true value of the difference lies. If the CI includes 1.0, it is considered there is insufficient evidence of a difference in the rates of the Study or Comparison populations and the Australian male population. If the CI excludes 1.0, it is considered that there is sufficient evidence of a difference in rates between the Study or Comparison populations and the Australian male population. If the CI excludes 1.0, it is considered that there is sufficient evidence of a difference in rates between the Study or Comparison populations and the Australian male population.

Appendix D: Detailed results of the 3rd MCIS Update

		Study Population	on v Amberley ^(b)	Study Population v Richmond ^(b)			
Cancer type/site ^(a)	Observed cases (Study Population)	IRR ^(c)	95% Cl ^(d)	IRR ^(c)	95% Cl ^(d)		
All cancers	75	1.20	0.94–1.53	1.22	0.96–1.55		
Brain	0	_	_	_	_		
Male breast	0	—	_	—	_		
Connective soft tissue	0	—	—	—	—		
Eye	1	7.60	0.51–112.51	2.24	0.26–19.38		
Gastrointestinal	12	1.10	0.60-2.00	1.10	0.61–1.99		
Colorectal	11	1.64	0.86–3.12	1.31	0.70–2.46		
Stomach	0	—	—	—	_		
Genitourinary	21	1.24	0.79–1.97	1.10	0.70–1.73		
Bladder	0	—	—	—	_		
Kidney	2	1.09	0.25-4.77	1.18	0.27–5.09		
Prostate	17	1.36	0.81–2.27	1.21	0.73–1.99		
Head and neck	1	0.37	0.05–2.73	0.53	0.07–3.96		
Larynx	0	—	_	—	_		
Lip	4	*5.44	1.55–19.08	*5.41	1.62–18.05		
Liver	0	—	—	—	_		
Lung	7	1.40	0.63–3.11	2.14	0.95–4.81		

Table D1: Weighted incidence relative risk: 3rd MCIS Update Study Population and Comparison populations, by selected cancer type/site, 1982-2010

Table D1 (continued): Weighted incidence relative risk: 3rd MCIS Update Study Population and Comparison populations, by selected cancer type/site, 1982–2010

		Study Pop	Study Pop	ulation v Richmond ^(b)	
Cancer type/site ^(a)	Observed cases (Study Population)	IRR ^(c)	95% Cl ^(d)	IRR ^(c)	95% Cl ^(d)
Lymphoid and haematopoietic	5	0.97	0.39–2.46	0.84	0.34–2.10
Leukaemia	2	1.33	0.30–5.90	1.67	0.38–7.41
Lymphoid leukaemia	0	_	—	_	—
Myeloid leukaemia	2	2.05	0.44–9.62	2.23	0.49–10.26
Lymphoma	3	1.01	0.30–3.34	0.66	0.21–2.12
Hodgkin lymphoma	0	_	—	—	—
Non-Hodgkin lymphoma	3	1.29	0.38–4.35	0.83	0.26–2.68
Multiple myeloma	0	_	_	_	_
Melanoma of the skin	18	1.55	0.94–2.57	1.60	0.97–2.63
Pancreas	0	_	—	_	—
Unknown	3	*5.79	1.34–25.09	1.98	0.58–6.81

* statistically significant difference at the 95% confidence level

nil or rounded to zero

95% CI 95% confidence interval

IRR (weighted) incidence relative risk

(a) All cancers defined by ICD-O-3 codes C00–C99, D45, D46, D47.1 and D47.3, excluding those codes for basal cell carcinoma and squamous cell carcinoma of the skin. For a complete list of codes, see Appendix Table B2.

(b) IRR and 95% CI of the Study Population compared with the Amberley Comparison Population or the Richmond Comparison Population.

(c) The IRR of the Study Population compared with the Amberley or Richmond Comparison Population. The IRR is the ratio of the observed mortality rate in the Study Population to the estimated (weighted) rate in the Comparison Population(s). If those rates are the same, the MRR is 1.0. If the rate in the Study Population is higher than in the Comparison Population(s), the MRR is greater than 1.0. If the rate in the Study Population is lower than in the Comparison Population(s), the MRR is greater than 1.0. If the rate in the Study Population is lower than in the Comparison Population(s), the MRR is less than 1.0.

(d) The 95%CI indicates the range of values around the IRR in which there is 95% certainty that the true value of the difference lies. If the CI includes 1.0, it is considered there is insufficient evidence of a difference in the rates of the Study and Comparison populations. If the confidence interval excludes 1.0, it is considered that there is sufficient evidence of a difference in rates between the Study and Comparison populations (a statistically significant finding).

Note: Data are weighted according to the method defined in the 2nd MCIS (TUNRA 2004a). See Appendix A for details.

Source: AIHW linkage analysis of the ACD 2010.

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		Study Population v Amberley ^(b)		Study Popula	on v Richmond ^(c)	
Cause of death ^(a)	Observed cases (Study Population)	MRR ^(c)	95% CI ^(d)	MRR ^(c)	95% Cl ^(d)	
All deaths	27	0.72	0.48-1.06	0.93	0.63–1.38	
Certain infectious and parasitic diseases	1	1.37	0.17–11.30	4.41	0.43-45.50	
Neoplasms (cancers)	12	0.74	0.41–1.33	1.06	0.59–1.93	
Colorectal cancer	1	0.41	0.06–3.09	0.91	0.12-7.01	
Prostate cancer	0	_	_	_	_	
Head and neck cancers	1	1.19	0.15–9.63	2.28	0.26–19.86	
Lung cancer	3	0.88	0.27–2.90	1.25	0.38–4.15	
Leukaemia	0	_	_	_	_	
Non-Hodgkin lymphoma	2	3.24	0.64–16.54	3.61	0.73–18.02	
Melanoma of the skin	0	_	_	_	_	
Diseases of the blood and blood-forming organs, and certain disorders involving the immune mechanism	0	_	_	_	_	
Endocrine, nutritional and metabolic diseases	0	—	—	—	_	
Mental and behavioural disorders	1	3.01	0.31–29.52	10.39	0.66–164.64	
Diseases of the nervous system	1	0.98	0.12-7.73	2.12	0.25–18.14	
Diseases of the circulatory system	4	0.50	0.18–1.37	0.56	0.20–1.53	
Ischaemic heart diseases	2	0.47	0.11–1.97	0.49	0.12–2.04	
Cerebrovascular diseases (stroke)	0	—	—	—	_	
Diseases of the respiratory system	2	1.40	0.31–6.25	1.90	0.42-8.55	
Chronic obstructive pulmonary disease	0	—	—	—	_	
Diseases of the digestive system	2	1.30	0.29–5.74	1.67	0.38–7.43	
Diseases of the liver, gallbladder and bile ducts	1	0.86	0.11–6.72	1.46	0.18–11.84	
Alcoholic liver disease	1	2.10	0.24–18.79	4.89	0.46–52.38	

Table D2: Weighted mortality relative risk: 3rd MCIS Update Study Population and Comparison populations, by selected causes of death, 1999–2012

Table D2 (continued): Weighted mortality relative risk: 3rd MCIS Update Study Population and Comparison populations, by selected causes of death, 1999-2012

		Study Popula	ation v Amberley ^(b)	Study Population v Richmond		
Cause of death ^(a)	Observed cases (Study Population)	MRR ^(c)	95% Cl ^(d)	MRR ^(c)	95% Cl ^(d)	
Diseases of the genitourinary system	0	—	_	_	—	
External causes of morbidity and mortality	2	0.32	0.08–1.31	0.35	0.08–1.41	
Assault	0	—	—	_	—	
Transport accidents	0	—	_	_	—	
Intentional self-harm (suicide)	2	0.92	0.21–3.94	0.76	0.18–3.20	

* statistically significant difference at the 95% confidence level

nil or rounded to zero

95% CI 95% confidence interval

MMR mortality relative risk

(a) A complete list of codes used to define the mortality groupings is presented in Appendix Table B2.

(b) MRR and 95% CI of the Study Population compared with the Amberley Comparison Population or the Richmond Comparison Population.

(c) The MRR of the Study Population compared with the Amberley or Richmond Comparison Population. The MRR is the ratio of the observed mortality rate in the Study Population to the estimated (weighted) rate in the Comparison Population(s). If those rates are the same, the MRR is 1.0. If the rate in the Study Population is higher than in the Comparison Population(s), the MRR is greater than 1.0. If the rate in the Study Population is lower than in the Comparison Population(s), the MRR is less than 1.0.

(d) The 95% CI indicates the range of values around the MRR in which there is 95% certainty that the true value of the difference lies. If the CI includes 1.0, it is considered there is insufficient evidence of a difference in the rates of the Study and Comparison populations. If the confidence interval excludes 1.0, it is considered that there is sufficient evidence of a difference in rates between the Study and Comparison populations (a statistically significant finding).

Note: Data are weighted according to the method defined in the 2nd MCIS (TUNRA 2004a). See Appendix A for details.

		n	Ambe	rley Com	parison Po	opulation	Richmond Comparison Population					
Cancer type/site ^(a)	Obs ^(b)	Exp ^(c)	SIR ^(d)	95% Cl ^(e)	Obs ^(b)	Exp ^(c)	SIR ^(d)	95% Cl ^(e)	Obs ^(b)	Exp ^(c)	SIR ^(d)	95% CI ^(e)
All cancers	75	56	*1.35	1.04–1.65	672	583	*1.15	1.06–1.24	626	599	1.04	0.96–1.13
Brain	0	1	_	_	9	12	0.72	0.25–1.19	22	14	1.56	0.91–2.22
Male breast	0	0	—	—	0	1	—	—	0	1	—	—
Connective soft tissue	0	1	—	—	10	5	2.14	0.82–3.47	6	5	1.12	0.22–2.01
Eye	1	0	4.69	0.00–13.88	2	2	0.99	0.00–2.35	4	2	1.78	0.04–3.53
Gastrointestinal	12	10	1.15	0.50-1.80	125	115	1.09	0.90–1.28	100	113	0.88	0.71–1.06
Colorectal	11	6	1.75	0.72–2.79	87	70	1.23	0.98–1.49	74	68	1.08	0.83–1.33
Stomach	0	1	—	—	12	12	0.99	0.43–1.55	8	12	0.66	0.20–1.12
Genitourinary	21	16	1.29	0.74–1.85	214	180	*1.19	1.03–1.35	200	177	1.13	0.97–1.28
Bladder	0	1	—	—	13	12	1.07	0.49–1.66	11	11	0.96	0.39–1.53
Kidney	2	2	1.10	0.00–2.62	18	18	0.99	0.53–1.44	17	19	0.88	0.46–1.29
Prostate	17	11	1.53	0.80–2.26	171	132	*1.30	1.10–1.49	148	123	*1.20	1.01–1.40
Head and neck	1	3	0.36	0.00-1.07	26	29	0.91	0.56–1.26	20	30	0.67	0.38–0.97
Larynx	0	1	—	—	11	6	1.69	0.69–2.69	4	6	0.65	0.01–1.29
Lip	4	1	2.91	0.06–5.76	8	13	0.64	0.20-1.08	10	14	0.70	0.27–1.13
Liver	0	1	—	—	3	8	0.38	0.00-0.80	1	8	*0.12	0.00-0.35
Lung	7	4	1.73	0.45–3.01	51	48	1.05	0.76–1.34	39	45	0.87	0.60–1.14
Lymphoid and haematopoietic	5	6	0.81	0.10–1.52	52	60	0.86	0.63–1.10	56	65	0.86	0.63–1.08
Leukaemia	2	2	1.23	0.00–2.93	14	16	0.86	0.41–1.31	13	17	0.75	0.34–1.16
Lymphoid leukaemia	0	1	—	_	6	8	0.73	0.15–1.32	4	8	*0.47	0.01–0.94
Myeloid leukaemia	2	1	2.46	0.00-5.86	8	8	1.03	0.32–1.74	9	9	1.04	0.36–1.73

Table D3: Standardised incidence ratio: 3rd MCIS Update Study Population and Comparison populations, by selected cancer type/site, 1982-2012

Table D3 (continued): Standardised incidence ratio: 3rd MCIS Update Study Population and Comparison populations, by selected cancer type/site, 1982-2012

	Study Population				Ambe	pulation	Richm	Richmond Comparison Population				
Cancer type/site ^(a)	Obs ^(b)	Exp ^(c)	SIR ^(d)	95% Cl ^(e)	Obs ^(b)	Exp ^(c)	SIR ^(d)	95% CI ^(e)	Obs ^(b)	Exp ^(c)	SIR ^(d)	95% CI ^(e)
Lymphoma	3	3	0.89	0.00–1.90	29	32	0.92	0.59–1.26	40	35	1.13	0.78–1.49
Hodgkin lymphoma	0	1	—	_	6	5	1.31	0.26–2.36	9	6	1.55	0.54–2.57
Non-Hodgkin lymphoma	3	3	1.07	0.00–2.29	23	27	0.85	0.51–1.20	32	29	1.09	0.71–1.46
Multiple myeloma	0	1	—	_	7	7	1.07	0.28–1.86	8	7	1.22	0.38–2.07
Melanoma of the skin	18	9	*1.96	1.06–2.87	112	85	*1.32	1.07–1.56	115	96	1.20	0.98–1.41
Pancreas	0	1	—	—	11	10	1.10	0.45–1.75	11	10	1.12	0.46–1.78
Unknown	3	1	2.54	0.00–5.42	8	13	0.62	0.19–1.05	15	13	1.17	0.58–1.77

* statistically significant difference at the 95% confidence level

nil or rounded to zero

Exp expected

Obs observed

95% CI 95% confidence interval

SIR standardised incidence ratio

- (a) All cancers defined by ICD-O-3 codes C00–C99, D45, D46, D47.1 and D47.3, excluding those codes for basal cell carcinoma and squamous cell carcinoma of the skin. For a complete list of codes, see Appendix Table B2.
- (b) The observed (actual) incidence in the 3rd MCIS Update Study and Comparison populations.
- (c) The expected incidence is calculated by applying the age-specific incidence rate of the Australian male population to the Study or Comparison Population, to determine the number of new cases of cancer that would be expected if those groups had the same age and exposure profile as the Australian male population. For more detail on this method, see Appendix A.
- (d) The SIR is the ratio of the estimated incidence rate in the Study Population (or Comparison populations) compared with the Australian male population, adjusting for any difference in age structure between the two populations, and calculated by dividing the observed number of new cases by the expected number of new cases. If those rates are the same, the SIR is 1.0. If the rate in the Study or Comparison Population(s) is higher than in the Australian male population, the SIR is greater than 1.00. If the rate in the Study or Comparison Population(s) is lower than in the Australian male population, the SIR is greater than 1.00.
- (e) The 95% CI indicates the range of values around the SIR in which there is 95% certainty that the true value of the difference lies. If the CI includes 1.0, it is considered there is insufficient evidence of a difference in the rates of the Study or Comparison populations and the Australian male population. If the confidence interval excludes 1.0, it is considered that there is sufficient evidence of a difference in rates between the Study or Comparison populations and the Australian male population (a statistically significant finding).

Source: AIHW linkage analysis of the ACD 2010.

	Study Population				Ambe	rley Com	parison P	opulation	Richm	Richmond Comparison Population			
Cause of death ^(a)	Obs ^(b)	Exp ^(c)	SMR ^(d)	95% Cl ^(e)	Obs ^(b)	Exp ^(c)	SMR ^(d)	95% CI ^(e)	Obs ^(b)	Exp ^(c)	SMR ^(d)	95% CI ^(e)	
All deaths	27	42	*0.64	0.40-0.89	390	426	0.92	0.82–1.01	313	441	*0.71	0.63-0.79	
Certain infectious and parasitic diseases	1	1	1.18	0.00–3.49	7	7	0.94	0.24–1.63	2	9	*0.23	0.00–0.55	
Neoplasms (cancers)	12	15	0.78	0.34–1.23	166	164	1.01	0.86–1.16	131	160	*0.82	0.68–0.96	
Colorectal cancer	1	2	0.61	0.00–1.81	23	18	1.29	0.76–1.81	13	17	0.75	0.34–1.17	
Head and neck cancers	0	1	_	_	4	5	0.76	0.02–1.50	1	5	*0.18	0.00–0.54	
Leukaemia	1	1	1.96	0.00–5.79	6	6	1.07	0.21–1.92	5	5	0.92	0.11–1.72	
Lung cancer	3	3	0.93	0.00–1.97	37	36	1.02	0.69–1.34	29	34	0.85	0.54–1.16	
Melanoma of the skin	0	1	_	_	11	8	1.40	0.57–2.23	8	8	0.96	0.30–1.63	
Non-Hodgkin lymphoma	2	1	3.61	0.00–8.61	5	6	0.85	0.11–1.60	6	6	1.03	0.21–1.86	
Prostate cancer	0	1	_	_	14	10	1.40	0.66–2.13	5	8	0.59	0.07–1.11	
Diseases of the blood and blood-forming organs, and certain disorders involving the immune mechanism	0	0	_	_	1	1	0.79	0.00–2.33	2	1	1.47	0.00–3.50	
Endocrine, nutritional and metabolic diseases	0	1	_	_	13	15	0.86	0.39–1.33	6	15	*0.40	0.08–0.73	
Mental and behavioural disorders	1	1	1.42	0.00-4.22	6	7	0.88	0.18–1.59	2	7	*0.27	0.00-0.65	
Diseases of the nervous system	1	1	0.84	0.00–2.50	12	12	1.00	0.43–1.57	5	12	*0.40	0.05–0.75	
Diseases of the circulatory system	4	10	*0.40	0.01–0.79	93	105	0.88	0.70–1.06	73	106	*0.69	0.53–0.85	
Ischaemic heart diseases	2	6	*0.31	0.00–0.74	51	67	*0.76	0.55–0.97	42	67	*0.63	0.44–0.81	
Cerebrovascular diseases (stroke)	0	2	_	_	20	22	0.92	0.52–1.32	20	21	0.95	0.53–1.37	
Diseases of the respiratory system	2	2	1.07	0.00–2.56	18	22	0.83	0.45–1.21	12	20	*0.60	0.26-0.94	
Chronic obstructive pulmonary disease	0	1	_	_	10	12	0.87	0.33–1.41	2	10	*0.20	0.00-0.48	
Diseases of the digestive system	2	2	0.97	0.00–2.31	17	19	0.89	0.46–1.31	14	21	0.66	0.32–1.01	
Diseases of the liver, gallbladder and bile ducts	1	2	0.64	0.00–1.90	13	14	0.94	0.43–1.44	7	16	*0.44	0.12–0.77	
Alcoholic liver disease	1	1	1.03	0.00–3.05	7	8	0.83	0.21–1.44	2	10	*0.20	0.00-0.49	

Table D4: Standardised mortality ratio: 3rd MCIS Update Study Population and Comparison populations, by selected cause of death, 1999-2012

Table D4 (continued): Standardised mortality ratio: 3rd MCIS Update Study Population and Comparison populations, by selected cause of death, 1999–2012

	Study Population			Amberley Comparison Population				Richmond Comparison Population				
Cause of death ^(a)	$\boldsymbol{Obs}^{(b)}$	Exp ^(c)	$\boldsymbol{SMR}^{(d)}$	95% Cl ^(e)	Obs ^(b)	Exp ^(c)	$\boldsymbol{SMR}^{(d)}$	95% Cl ^(e)	Obs ^(b)	Exp ^(c)	$\boldsymbol{SMR}^{(d)}$	95% Cl ^(e)
Diseases of the genitourinary system	0	0	_	_	4	4	1.02	0.02–2.01	3	4	0.80	0.00–1.70
External causes of morbidity and mortality	2	7	*0.28	0.00–0.67	45	60	*0.75	0.53–0.97	56	76	*0.74	0.54–0.93
Assault	0	0	—	—	2	2	0.95	0.00–2.28	0	3	—	—
Transport accidents	0	1	_	—	10	11	0.90	0.34–1.45	12	14	0.86	0.37–1.34
Intentional self-harm (suicide)	2	3	0.69	0.00–1.64	17	24	0.71	0.37–1.05	29	31	0.94	0.60–1.28

* statistically significant difference at the 95% confidence level

nil or rounded to zero

Exp expected

Obs observed

95% CI 95% confidence interval

SMR standardised mortality ratio

(a) A complete list of codes used to define the mortality groupings is presented in Appendix Table B2.

(b) The observed (actual) mortality in the 3rd MCIS Update Study and Comparison populations.

(c) The expected mortality is calculated by applying the year- and age-specific mortality rate of the Australian male population to the Study or Comparison Population, to determine the number of new cases of cancer that would be expected if those groups had the same age and exposure profile as the Australian male population. For more detail on this method, see Appendix A.

- (d) The SMR is the ratio of the estimated mortality rate in the Study Population (or Comparison populations) compared with the Australian male population, adjusting for any difference in age structure between the two populations, and calculated by dividing the observed number of deaths by the expected number of deaths. If those rates are the same, the SMR is 1.0. If the rate in the Study or Comparison Population(s) is higher than in the Australian male population, the SMR is greater than 1.00. If the rate in the Study or Comparison Population(s) is lower than in the Australian male population, the SMR is less than 1.00.
- (e) The 95% CI indicates the range of values around the SMR in which there is 95% certainty that the true value of the difference lies. If the CI includes 1.0, it is considered there is insufficient evidence of a difference in the rates of the Study or Comparison populations and the Australian male population. If the confidence interval excludes 1.0, it is considered that there is sufficient evidence of a difference in rates between the Study or Comparison populations and the Australian male population (a statistically significant finding).

		Stud	Study Population v Amberley ^(b)		y Population v Richmond ^(c)
Cause of death ^(a)	Observed cases (Study Population)	MRR ^(c)	95% CI ^(d)	MRR ^(c)	95% CI ^(d)
All deaths	31	*0.55	0.38-0.79	*0.63	0.44–0.91
Certain infectious and parasitic diseases	1	1.07	0.13–8.53	3.05	0.33–28.20
Neoplasms (cancers)	14	0.66	0.38–1.13	0.85	0.49–1.47
Colorectal cancer	2	0.63	0.15–2.66	1.10	0.26-4.71
Prostate cancer	0	_	—	—	_
Head and neck cancers	1	0.59	0.08-4.45	1.48	0.18–11.98
Lung cancer	4	0.88	0.31–2.46	1.30	0.46-3.66
Leukaemia	0	_	_	_	_
Non-Hodgkin lymphoma	2	3.07	0.61–15.50	2.75	0.58–13.05
Melanoma of the skin	0	_	—	—	_
Diseases of the blood and blood-forming organs, and certain disorders involving the immune mechanism	0	_	_	—	—
Endocrine, nutritional and metabolic diseases	0	_	—	—	_
Mental and behavioural disorders	1	1.96	0.22-17.25	1.51	0.19–12.25
Diseases of the nervous system	1	0.63	0.08-4.81	1.70	0.21–14.02
Diseases of the circulatory system	5	0.42	0.17–1.04	0.47	0.19–1.14
Ischaemic heart diseases	3	0.44	0.14–1.42	0.47	0.15–1.51
Cerebrovascular diseases (stroke)	0	_	—	—	_
Diseases of the respiratory system	2	1.01	0.23-4.38	1.67	0.38–7.44
Chronic obstructive pulmonary disease	0	_	—	_	_
Diseases of the digestive system	2	0.90	0.21–3.88	1.18	0.27–5.10
Diseases of the liver, gallbladder and bile ducts	1	0.58	0.08–4.39	0.99	0.13–7.72
Alcoholic liver disease	1	1.30	0.16–10.70	2.11	0.25–18.11

Table D5: Weighted mortality relative risk: 3rd MCIS Update Study Population and Comparison Populations, by selected causes of death, 1980–2012

Table D5 (continued): Weighted mortality relative risk: 3rd MCIS Update Study Population and Comparison Populations, by selected causes of death, 1980–2012

		Stu	Study Population v Amberley ^(b)		Study Population v Richmond ^(c)		
Cause of death ^(a)	Observed cases (Study Population)	MRR ^(c)	95% Cl ^(d)	MRR ^(c)	95% CI ^(d)		
Diseases of the genitourinary system	0	_	_	_	_		
External causes of morbidity and mortality	3	0.24	0.07-0.74	*0.20	0.06–0.62		
Assault	0	—	—	_	—		
Transport accidents	1	0.35	0.05–2.62	0.23	0.03–1.70		
Intentional self-harm (suicide)	2	0.37	0.09–1.52	0.36	0.09–1.46		

* statistically significant difference at the 95% confidence level

nil or rounded to zero

95% CI 95% confidence interval

MRR (weighted) mortality relative risk

(a) A complete list of ICD-9 and ICD-10codes used to define the mortality groupings is presented in Appendix Table B1.

(b) MRR and 95% CI of the Study Population compared with the Amberley Comparison Population or the Richmond Comparison Population.

(c) The (weighted) MRR of the Study Population compared with the Amberley or Richmond Comparison Population. The MRR is the ratio of the observed mortality rate in the Study Population to the estimated (weighted) rate in the Comparison Population(s). If those rates are the same, the MRR is 1.0. If the rate in the Study Population is higher than in the Comparison Population(s), the MRR is greater than 1.0. If the rate in the Study Population is lower than in the Comparison Population(s), the MRR is less than 1.0.

(d) The 95% CI indicates the range of values around the MRR in which there is 95% certainty that the true value of the difference lies. If the CI includes 1.0, it is considered there is insufficient evidence of a difference in the rates of the Study and Comparison populations. If the confidence interval excludes 1.0, it is considered that there is sufficient evidence of a difference in rates between the Study and Comparison populations (a statistically significant finding).

Note: Data are weighted according to the method defined in the 2nd MCIS (TUNRA 2004a). See Appendix A for details.

	Study Population			Ambe	rley Corr	parison P	opulation	Richmond Comparison Population				
Cause of death ^(a)	Obs ^(b)	Exp ^(c)	SMR ^(d)	95% Cl ^(e)	Obs ^(b)	Exp ^(c)	SMR ^(d)	95% Cl ^(e)	Obs ^(b)	Exp ^(c)	SMR ^(d)	95% CI ^(e)
All deaths	31	65	*0.48	0.31-0.65	552	641	*0.86	0.79–0.93	520	672	*0.77	0.71–0.84
Certain infectious and parasitic diseases	1	1	0.8	0.00–2.37	8	11	0.74	0.23–1.26	3	13	*0.24	0.00–0.51
Neoplasms (cancers)	14	20	0.71	0.34–1.08	211	218	0.97	0.84–1.10	188	210	0.90	0.77–1.02
Colorectal cancer	2	2	0.92	0.00–2.21	32	25	1.29	0.84–1.73	19	23	0.82	0.45–1.19
Head and neck cancers	0	1	_	_	5	7	0.68	0.08–1.27	3	7	*0.41	0.00–0.87
Leukaemia	1	1	1.25	0.00–3.69	11	8	1.33	0.54–2.11	8	8	0.96	0.29–1.62
Lung cancer	4	4	1.00	0.02–1.98	45	48	0.95	0.67–1.22	39	43	0.90	0.62–1.18
Melanoma of the skin	0	1	_	_	12	11	1.05	0.46–1.65	12	12	0.99	0.43–1.55
Non-Hodgkin lymphoma	2	1	2.31	0.00–5.52	6	9	0.67	0.13–1.20	9	9	0.99	0.34–1.64
Prostate cancer	0	1	_	_	15	11	1.33	0.65–2.00	8	9	0.85	0.26–1.43
Diseases of the blood and blood-forming organs, and certain disorders involving the immune mechanism	0	0	_	_	2	2	1.17	0.00–2.79	2	2	1.09	0.00–2.59
Endocrine, nutritional and metabolic diseases	0	2	_	—	17	19	0.88	0.46–1.30	8	19	*0.42	0.13–0.71
Mental and behavioural disorders	1	2	0.61	0.00–1.82	8	13	0.6	0.18–1.01	7	16	*0.43	0.11–0.75
Diseases of the nervous system	1	2	0.60	0.00–1.78	16	16	0.99	0.51–1.48	7	17	*0.41	0.11–0.71
Diseases of the circulatory system	5	14	*0.35	0.04–0.66	139	156	0.89	0.74–1.04	109	152	*0.72	0.58–0.85
Ischaemic heart diseases	3	9	*0.33	0.00-0.70	84	102	0.83	0.65–1.00	68	98	*0.70	0.53–0.86
Cerebrovascular diseases (stroke)	0	2	_	—	20	22	0.92	0.52–1.32	20	21	0.95	0.53–1.37
Diseases of the respiratory system	2	2	0.81	0.00–1.94	24	29	0.84	0.50–1.18	14	27	*0.53	0.25–0.80
Chronic obstructive pulmonary disease	0	1	_	—	12	14	0.85	0.37–1.33	3	12	*0.25	0.00–0.53
Diseases of the digestive system	2	3	0.70	0.00–1.66	21	28	0.75	0.43–1.07	19	30	*0.64	0.35–0.92
Diseases of the liver, gallbladder and bile ducts	1	2	0.46	0.00-1.36	16	21	0.77	0.39–1.15	10	22	*0.45	0.17–0.72
Alcoholic liver disease	1	1	0.71	0.00–2.09	9	13	0.67	0.23–1.11	4	15	*0.27	0.01–0.54

Table D6: Standardised mortality ratio: 3rd MCIS Update Study Population and Comparison populations, by selected cause of death, 1980–2012

Table D6 (continued): Standardised mortality ratio: 3rd MCIS Update Study Population and Comparison populations, by selected cause of death, 1980–2012

	Study Population			Ambe	Amberley Comparison Population				Richmond Comparison Population			
Cause of death ^(a)	$\boldsymbol{Obs}^{(b)}$	Exp ^(c)	$\boldsymbol{SMR}^{(d)}$	95% CI ^(e)	Obs ^(b)	Exp ^(c)	$\boldsymbol{SMR}^{(d)}$	95% Cl ^(e)	Obs ^(b)	Exp ^(c)	$\boldsymbol{SMR}^{(d)}$	95% Cl ^(e)
Diseases of the genitourinary system	0	0	_	_	4	5	0.83	0.02–1.65	4	5	0.86	0.02–1.71
External causes of morbidity and mortality	3	17	*0.18	0.00–0.38	90	128	*0.70	0.56–0.85	147	164	0.90	0.75–1.04
Assault	0	1	—	—	3	5	0.58	0.00–1.23	0	7	—	—
Transport accidents	1	5	*0.22	0.00–0.65	22	33	*0.68	0.39–0.96	42	43	0.98	0.69–1.28
Intentional self-harm (suicide)	2	6	*0.32	0.00–0.75	36	49	*0.73	0.49–0.97	63	63	0.99	0.75–1.24

* statistically significant difference at the 95% confidence level

nil or rounded to zero

Exp expected

Obs observed

95% CI 95% confidence interval

SMR standardised mortality ratio

(a) A complete list of ICD-9 and ICD-10 codes used to define the mortality groupings is presented in Appendix Table B1.

(b) The observed (actual) mortality in the 3rd MCIS Update Study and Comparison populations.

(c) The expected mortality is calculated by applying the year- and age-specific mortality rate of the Australian male population to the Study or Comparison Population, to determine the number of new cases of cancer that would be expected if those groups had the same age and exposure profile as the Australian male population. For more detail on this method, see Appendix A.

(d) The SMR is the ratio of the estimated mortality rate in the Study Population (or Comparison populations) compared with the Australian male population, adjusting for any difference in age structure between the two populations, and calculated by dividing the observed number of deaths by the expected number of deaths. If those rates are the same, the SMR is 1.0. If the rate in the Study or Comparison Population(s) is higher than in the Australian male population, the SMR is greater than 1.00. If the rate in the Study or Comparison Population(s) is lower than in the Australian male population, the SMR is less than 1.00.

(e) The 95% CI indicates the range of values around the SMR in which there is 95% certainty that the true value of the difference lies. If the CI includes 1.0, it is considered there is insufficient evidence of a difference in the rates of the Study or Comparison populations and the Australian male population. If the CI excludes 1.0, it is considered that there is sufficient evidence of a difference in rates between the Study or Comparison populations and the Australian male population. If the CI excludes 1.0, it is considered that there is sufficient evidence of a difference in rates between the Study or Comparison populations and the Australian male population (a statistically significant finding).

Appendix E: Comparison between Mortality and Cancer Incidence Studies

The 2nd, 3rd and 4th MCISs used different methods and/or analysis data sets, and are therefore not strictly comparable. The most important differences are:

- the 4th MCIS data set includes an additional 444 personnel, introduced through the Tier classification process
- the 4th MCIS Study Population incorporates those additional 444 personnel along with 338 personnel previously counted in the 3rd MCIS Comparison populations
- the method used to calculate the relative risks in the 3rd MCIS was based on unweighted data.

These differences are summarised in Table E1, and described more fully at Appendix A.

			Current study				
	2nd MCIS	3rd MCIS	3rd MCIS Update ^(a)	4th MCIS ^(b)			
Cohort size							
Study Population	873	873	873	1,655			
Amberley Comparison Population	7,577	7,577	7,576	7,407			
Richmond Comparison Population	9,408	9,408	9,407	9,230			
Methodology							
Comparative analysis: exposed Study Population versus non-exposed Comparison populations (IRR, MRR)	Weighted Incidence and mortality rates are derived from the weighted number of cases or deaths divided by the weighted person years at risk.	Unweighted Incidence and mortality rates are standardised to the unweighted expected number of cases or deaths in a pooled sample of exposed and Comparison Population.	As per 2nd MCIS: Weighted	As per 2nd MCIS: Weighted (<i>modified</i> weights)			
Years of follow-up							
Cancer incidence	1982–2000	1982–2003	1982–2010	1982–2010			
Mortality	1980–2001	1999–2004	1999–2012	1999–2012			
Key findings							
Cancer incidence	Non-significant increase (Amberley and Richmond)	Non-significant increase (Amberley); Statistically significant increase (Richmond)	Non-significant increase (Amberley and Richmond)	Statistically significant increase (Amberley and Richmond)			
Mortality	StatisticallyNon-significantsignificantincrease(Amberley andand Richmond)Richmond)		Non-significant decrease (Amberley and Richmond)	Statistically significant decrease (Amberley); Non-significant decrease (Richmond)			

Table E1: Summary of data sets and methodology used in the 2nd MCIS, 3rd MCIS, 3rd MCIS Update and 4th MCIS

IRR (weighted) incidence relative risk

MRR (weighted) mortality relative risk

(a) The 3rd MCIS Update was conducted in parallel with the 4th MCIS, using personnel and exposure data collected for the 3rd MCIS.

(b) The 4th MCIS was conducted in parallel with the 3rd MCIS Update, using personnel and exposure data collected for the 3rd MCIS and through the Tier classification process.

Note: The first MCIS report presented interim results (TUNRA 2003b). The methodology was revised ahead of the 2nd MCIS (TUNRA 2004a). The interim results are not presented here.

Sources: AIHW 2009; Appendix A; TUNRA 2004a.

Although these differences mean that the studies are not strictly comparable over time, it is possible to show that the key findings are consistent, taking into account the size of the data sets and the power of the study (years of follow-up). This is demonstrated here for cancer incidence and shows that the comparison of the Study Populations with the Amberley and Richmond Comparison populations moved toward significance, indicated by the narrowing


confidence intervals over time, due to the greater number of cases that have occurred over time (Figure E1).

Weighted comparison of the Study Population with the Amberley and Richmond Comparison populations produced similar point estimates in the 4th MCIS and 3rd MCIS Update, but the number of observed cases for each cancer type was higher in the 4th MCIS. This is the main reason why statistical significance was more common. That is, the 4th MCIS has greater statistical power to detect a real effect compared with the previous studies (Figure E2).

Some key differences between the analyses were:

- higher relative incidence rates for head and neck cancer and non-Hodgkin lymphoma, and higher relative mortality rates for cancers and external causes of morbidity and mortality, in the 4th MCIS compared with the 3rd MCIS Update
- lower relative incidence rates for lip cancer and melanoma of the skin, and lower relative mortality rates for diseases of the respiratory system, in the 4th MCIS compared with the 3rd MCIS Update (Figure E2).



Statistical power, and the nature of small sample sizes — either being unable to detect a true difference (if it exists) or detecting and exaggerating a difference that does not truly exist (false-positive) — plays a role in relation to the 4th MCIS study findings for eye cancer in particular. Figure E3 depicts the relative progression of cancer incidence in the Study

Population compared with the Amberley Comparison Population, for all cancers and selected cancers with smaller (eye and lip cancers) and larger (prostate and colorectal cancers) relative sample size. This figure demonstrates that the stability of the point estimates and finding of statistical significance in relation to sample size is relevant to the findings of the 4th MCIS, and gives additional support to the note of caution in relation to the statistically significant finding for the incidence of eye cancer.

Of the 1,655 personnel in the 4th MCIS data set, just under half (47%) were introduced to the study through the Tier classification process. The characteristics of the Tier-classified personnel (N=782) and the personnel in the 3rd MCIS Update data set (N=873) were generally similar. Some key differences between the cohorts were:

- a higher proportion of personnel aged 50–59 (25%) and fewer aged 40–49 (31%) in the Tier classification cohort compared with the 3rd MCIS Update cohort (18% and 41%, respectively)
- a higher proportion from the 1990–94 posting category (21%) and fewer from the 1975–79 category (21%) in the Tier classification cohort compared with the 3rd MCIS Update cohort (14% and 33%, respectively)
- a higher proportion of non-commissioned officers (42%) and fewer enlisted personnel in the Tier classification cohort (55%) compared with the 3rd MCIS Update cohort (31% and 66%, respectively).

More detail on these data is available in appendix tables A2 and A3.



Comparison Population

Appendix F: Firefighters

Firefighters comprise a subpopulation of the 4th MCIS Study Population that is of particular interest, given the findings of recent studies of occupational exposures and health outcomes among civilian firefighters (MonCOEH 2014, 2015). The following analysis of the 4th MCIS data set presents the standardised comparison of Tier-classified personnel in the 4th MCIS Study Population with the work category 'Firefighter' (Tier 2 or 3, Category 6), with the Australian male population. See Appendix A, for information on this Tier group (Table A1).

Due to small numbers, results are available only at the broadest level (incidence of all cancers and all-cause mortality).

There were 193 firefighters identified in the 4th MCIS Study Population in the 4th MCIS data set. When compared with the Australian male population, the firefighters of the 4th MCIS Study Population were observed to have:

- lower than expected incidence from all cancers combined, with 10 cases diagnosed in 1982–2010 (SIR=0.86, CI=0.33–1.39)
- lower than expected mortality from all causes of death, with 5 deaths in 1999–2012 (SMR=0.59, CI=0.07–1.11) (Table F1).

These differences were not found to be statistically significant. These findings need to be interpreted with great caution, not only because of very small numbers (10 cases of cancer and 5 deaths), but also for the following reasons:

- a lack of information available on type or duration of firefighting
- a lack of information available on potential confounders (see Chapter 5.3)
- a lack of comparable working reference population for use in the analyses (such as civilian firefighters).

Table F1: Mortality and cancer incidence among firefighters of the 4th MCIS Study Population compared with the Australian male population, 1982–2010 and 1999–2012

	Observed ^(a)	Expected ^(b)	Standardised Ratio ^(c)	95% Cl ^(d)
Cancer incidence ^(e)	10	12	0.86	0.33–1.39
All-cause mortality ^(f)	5	8	0.59	0.07–1.11

95% Cl 95% confidence interval

(f) Mortality (deaths) from all causes in 1999–2012.

Note: A firefighter is defined as a person that was Tier 2 or 3 and category 6 in the 4th MCIS. This study has a total of 193 firefighters.

Source: AIHW linkage analysis of the ACD and the NDI.

⁽a) The observed (actual) number of deaths or new cases of cancer in the firefighters of the 4th MCIS Study Population.

⁽b) The expected number of deaths or new cases of cancer if the Study Population had the same age and exposure profile as the Australian male population. For more detail on this method, see Appendix A.

⁽c) The standardised incidence ratio (SIR) or standardised mortality ratio (SMR) is the ratio of the estimated mortality rate in the Study Population compared with the Australian male population, adjusting for any difference in age structure between the two populations, and calculated by dividing the observed number of deaths or new cases of cancer by the expected number. If those rates are the same, the SIR or SMR is 1.0. If the rate in the Study Population is higher than in the Australian male population, the SIR or SMR is greater than 1.00. If the rate in the Study Population is lower than in the Australian male population, the SIR or SMR is less than 1.00.

⁽d) The 95% CI indicates the range of values around the SIR or SMR in which there is 95% certainty that the true value of the difference lies. If the CI includes 1.0, it is considered there is insufficient evidence of a difference in the rates of the Study Population and the Australian male population. If the CI excludes 1.0, it is considered that there is sufficient evidence of a difference in rates between the Study Population and the Australian male the Australian male population (a statistically significant finding).

⁽e) Incidence (new cases) of all cancers, defined as ICD-10 C00–C97, and diagnosed in the period 1982–2010.

Glossary

These glossary terms are defined according to their use in the context of the 4th MCIS and 3rd MCIS Update.

95% confidence interval: A range of values around the point estimate in which there is 95% certainty that the true value of the difference lies.

cancer incidence: The number or rate of new cases of cancer diagnosed in a population during a given time period (1982–2010).

Comparison Population(s): Personnel not exposed to the Deseal/Reseal (DSRS) programs or related activities (either directly or indirectly) and used as a control group for comparative analyses with the DSRS-exposed Study Population.

data linkage: A process that brings together information relating to an individual, from more than one source. Also known as data integration

Deseal/Reseal (DSRS): Formal F-111 aircraft fuel tank repair and maintenance programs requiring the removal of degraded tank sealant (deseal) and application of a new sealant (reseal). In addition to the formal programs, *ad hoc* maintenance was undertaken as part of routine tank repairs and maintenance, in order to keep the aircraft operational.

exposure: Involvement in any of the four formal DSRS programs or associated duties, including *ad hoc* and 'pick and patch' maintenance, between 1977 and January 2000.

incidence relative risk: The ratio of the observed cancer incidence rate in the Study Population to the estimated (weighted) rate in the Comparison Population(s).

mortality: Number or rate of deaths in a population during a given time period (1999-2012).

mortality relative risk: The ratio of the observed mortality rate in the Study Population to the estimated (weighted) rate in the Comparison Population(s).

mustering: A functional employment category to which an airman or airwoman is enlisted and which provides the employment basis on which their Air Force career is managed.

standardised incidence ratio: The ratio of the cancer incidence rate in the Study Population or Comparison Population(s) to the rate in the Australian male population, adjusting for differences in age structure between the two populations.

standardised mortality ratio: The ratio of the mortality rate in the Study Population or Comparison Population(s) to the rate in the Australian male population adjusting for differences in age structure between the two populations.

statistical power: The likelihood that a study will detect a true difference, where one exists.

statistical significance: A measure of the strength of statistical evidence that a true difference exists between the Study and Comparison Population(s), given the underlying assumptions of the statistical test used.

Study Population: Personnel who participated in the Deseal/Reseal (DSRS) programs and associated activities.

Tier classification: The rating system that reflects a worker's level of involvement in F-111 aircraft maintenance activities. Classification ratings are determined using a set of Tier

definitions developed by the Department of Defence and the Department of Veterans' Affairs. Personnel are classified as a Tier 1-, 2- or 3-participant by application of the Tier definitions.

weighting: A process of adjusting the characteristics of one group (Comparison populations) so they are statistically similar to the characteristics of another group (Study Population) so that comparisons of the effect under study (DSRS exposure) can be more certain.

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Between 1974 and 2000, the Royal Australian Air Force undertook a series of formal Deseal/Reseal (DSRS) programs, alongside informal repair activities, to correct fuel leaks inside the fuel tanks of F-111 aircraft. A number of concerns were raised about health outcomes in personnel who worked on these programs and associated activities. The repair work was suspended in 2000, and a series of inquiries and health studies followed. This report presents the findings of the fourth iteration of a series of studies on mortality and cancer incidence of F-111 DSRS personnel. The report will be a valuable resource for policy makers, program managers and health professionals interested in health outcomes of Australian Defence Force personnel.