MONASH University

2013 Health Watch

14th report

Australian Institute of Petroleum

HEALTH WATCH

The Australian Institute of Petroleum Health Surveillance Program

Fourteenth Report

November 2013

Monash University

Monash Centre for Occupational and Environmental Health (MonCOEH)
Department of Epidemiology and Preventive Medicine (DEPM)

This Fourteenth Report contains an analysis of deaths occurring up to 30th November 2010, and cancers registered up to 31st December 2008.

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Message from the Executive Director, Australian Institute of Petroleum

For over 33 years, the Australian Institute of Petroleum (AIP) has sponsored the independent *Health Watch* study to monitor the health of petroleum industry employees.

Health Watch follows the long term health of 20,000 past and current employees in the petroleum industry (during their industry employment and after they leave or retire), through a detailed analysis of job types, workplace practices, lifestyle influences, and illness and causes of death. The health of petroleum industry employees is then compared with data for the Australian community.

The study provides valuable insights into the influences on the health of employees, such as the relationship between the incidence of various cancers and working in the industry, and the measurable effects of lifestyle on the health of employees. The findings of the study assist the petroleum industry in developing policies and workplace programs that are providing safe and healthy working environments for employees. The study also provides a robust scientific basis for the community to understand the health impacts of exposure to petroleum products.

Since 2005, the *Health Watch* study has been conducted by Monash Centre for Occupational and Environmental Health (MonCOEH) at Monash University, to take advantage of other epidemiology programs and collaborative research at Monash University. The Study has been under the direction of Professor Malcolm Sim and his research team including Associate Professor Deborah Glass and Elisa Wood (Research Officer). AIP appreciates the dedication of the Monash team in delivering this new robust analysis of the health of petroleum industry workers.

Since the last report was published in 2007, all current worksite employees of the participating companies were provided the opportunity to join a new cohort of the *Health Watch* study. AIP congratulates the Monash team for their significant efforts in conducting the voluntary employee survey which recruited a significant number of new employees to *Health Watch*. This addition of a current, new cohort will help to maintain this important longitudinal health study of Australian petroleum industry employees into the future.

AIP therefore wishes to thank the thousands of employees who participated in the *Health Watch* survey over recent years to help enhance understanding of the health impacts of working in the petroleum industry. This demonstrates that this internationally respected study continues to be highly valued by the petroleum companies and their employees.

AIP is very pleased to receive the Fourteenth *Health Watch* Report from Monash University and is most encouraged by this latest study which continues to clearly show that petroleum industry employees in Australia have better health than the general community and are less likely to die from cancer and from heart, respiratory and digestive diseases.

Dr John Tilley

Executive Director

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AUSTRALIAN INSTITUTE OF PETROLEUM

COMPANIES WITH EMPLOYEES PARTICIPATING IN *HEALTH WATCH*

Caltex Oil Australia (incorporating Total, Ampol Australia and Australian Petroleum Pty Ltd)

BP Australia Pty Ltd (incorporating Amoco)

ExxonMobil Australia Ltd (formerly Esso Australia Ltd and Mobil Oil Australia Limited)

Santos Limited

The Shell Company of Australia Limited

Chevron Australia (formerly West Australian Petroleum Pty Limited (WAPET))

Woodside Energy Limited

Airport Fuel Services

Castrol Australia Pty Ltd (up to 30/06/1994)

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The *Health Watch* cohort study was designed by Professor David Christie.

We are indebted to the contact persons in each of the participating companies. *Health Watch* is dependent on them for follow-up information.

We thank the Australian Institute of Health and Welfare for its ongoing co-operation which has made it possible for *Health Watch* to report on the occurrence of cancer and mortality. We also thank the staff of State Death and Cancer Registries for confirmation of information, in particular the staff of the Victorian Cancer Registry for their co-operation in searching their registry.

Many thanks to Mr Steve Vander Hoorn and Professor Ian Gordon from the Statistical Consulting Centre, The University of Melbourne, for their professional conduct in delivering quality statistical analyses and consultation.

Finally we wish to thank the many employees who participated and assisted the team.

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PREFACE

Health Watch is an epidemiological health surveillance program established by the Australian Institute of Petroleum. Since 2005 the study has been run by researchers from Monash University.

Health Watch consists of a prospective cohort study of all-cause mortality and cancer incidence and a case-control study of leukaemia and benzene exposure. The cohort study was carried out by the University of Melbourne from 1980 to 1998 and by the University of Adelaide from 1999 to 2005, before being transferred to Monash University. Researchers from Monash and Deakin Universities took over responsibility for the nested case-control study in 1999.

Health Watch covers those petroleum industry employees from all major participating oil and gas companies who voluntarily joined the program at their work sites across Australia. About 95% of the industry's employees who were approached to participate from refineries, gas plants, distribution terminals, and production sites, onshore and offshore, have joined *Health Watch* during the major recruitment drives between 1981 and 2000.

Employees in the industry were enrolled in the study by participating in one or more of four industry surveys in the 1980s and 1990s, using a detailed job and health questionnaire. This process obtained information on job tasks, on lifestyle factors including smoking and alcohol, and on health status. An employee was eligible to be included in the cohort analysis following a survey interview or after having served five years in the industry, whichever is later, and remains in the *Health Watch* cohort for life. Employees who have left employment with participating companies are contacted periodically to obtain an update on employment and health status. A new cohort commenced in 2010 and current employees of participating companies were invited to participate via either a researcher assisted or online survey.

The employing companies maintain the flow of information on entrants, job changes, resignations and retirements and send regular employee updates to the *Health Watch* study. The study maintains contact with cohort members until death via regular Health Letter updates.

The main output of the study is this report and contains analyses of mortality and cancer incidence. These analyses are carried out by comparing the rates of deaths and cancers in the *Health Watch* cohort with the rates of the general Australian population.

Death and cancer registrations in the general population are obtained from the Australian Institute of Health and Welfare (AIHW), which compiles the National Death Index (NDI) and the Australian Cancer Database (ACD) on behalf of all State Death and Cancer Registries.

Deaths and cancers in the *Health Watch* cohort are obtained by linking the *Health Watch* data with State and National Death and Cancer Registries.

Results have been published in periodic *Health Watch* reports of which this report is the fourteenth, and in scientific medical journals.(1-9) This Report is published on the Australian Institute of Petroleum website (www.aip.com.au) and on the MonCOEH website (www.coeh.monash.org/healthwatch.html). Summary reports are distributed to all members of the *Health Watch* cohort.

SUMMARY OF LATEST *HEALTH WATCH* RESULTS

Overview

Overall, the Study clearly shows that petroleum industry employees have better health than the general Australian community and are less likely to die of the diseases commonly causing death – including cancer, heart disease and respiratory conditions.

For men, death rates in all major disease categories are significantly lower than for the corresponding Australian population. A significant reduction in all-cause mortality is seen among men in each workplace type e.g. refinery, terminal.

For men and women in this industry, the chance of contracting cancer is similar to that for all Australians. However, mortality from cancer is reduced for *Health Watch* members.

There is no evidence of increasing mortality, cancer incidence or increasing cancer mortality with increasing duration of employment. Generally, the chances of dying at any age, or of getting cancer or heart disease are very similar no matter where *Health Watch* people work/ed and compare favourably with the rates in all Australian men.

Status of the cohort

This update of the *Health Watch* cohort is based on national mortality data to 30th November 2010 and cancer incidence data to 31st December 2008. 16,639 men and 1,374 women are included in this analysis. 2,265 men and 64 women in the cohort had died by the end of 2010. *Health Watch* has now accumulated 376,601 person-years of observation in men and 26,852 person-years in women.

Healthy worker effect continues for men and women

The age-adjusted death rate in male and female *Health Watch* members remains significantly lower than that of the general Australian population. The strong *healthy worker effect* identified in previous studies continues to be observed. The chance of contracting cancer is similar for men and women in this industry as for all Australians. However, the mortality from cancer is reduced for *Health Watch* members, significantly so for men.

Results in women

Of the 64 female cohort members who have died, 38 deaths were from cancer. The standardised mortality rate from cancer in women is significantly lower than that of the Australian female population. Ninety four cancers have occurred in women. The chance of getting most types of cancer is similar for women working in this industry as for the general female population.

The proportion of women in the *Health Watch* program remains very small and this precludes more detailed analysis of the data.

Results in men

For men, death rates in all major disease categories – heart disease, cancer, respiratory disease, diseases of the digestive system, and external causes (accidents, violence etc) are significantly lower than for the corresponding Australian population. A significant reduction in all-cause mortality is seen among men in all workplace types e.g. refinery, terminal.

There is no trend of increasing mortality with increasing duration of employment. There is evidence of a trend of increasing overall mortality by period of first employment within the cohort and time since first employment within the cohort. This may be because the most recently employed men have particularly low absolute mortality, or the healthy worker effect may be dissipating over time.

There is no evidence of increasing cancer incidence with period of first employment, increasing duration of employment or increasing time since first employment within the cohort.

Lifestyle factors

Smoking related diseases i.e. lung cancer incidence, incidence of cancer of the lip, oral cavity and pharynx, ischaemic heart disease mortality and chronic obstructive pulmonary disease mortality, are lower in *Health Watch* members, than in the general population. However, within the cohort, there is a clear pattern that increasing smoking category is associated with increasing risk of all-cause mortality, specifically of ischaemic heart disease mortality, of overall cancer incidence and cancer mortality and especially increased incidence of lung cancer and bladder cancer. Furthermore it is clear that rates of mortality and cancer incidence are greatly reduced for ex-smokers compared with those who continue to smoke, however, the risk is still higher than for those who have never smoked.

Moderate drinkers have lower death rates than total abstainers. Heavy drinking (more than 7 drinks per day), however, remains associated with increased overall mortality.

Specific cancers

Two cancers, mesothelioma and melanoma, have been and are still occurring at statistically significantly higher rates than in the general population. Prostate cancer is also in statistically significant excess.

Thirty nine incident mesotheliomas have occurred in the cohort (SIR 1.70 C.I. 1.21 – 2.32), of which 18 were in refinery maintenance workers and operators. Five cohort members have died from asbestosis (SMR 1.80 95% C.I. 0.59 – 4.21) and 99 members of the cohort have reported asbestos related illnesses. This is probably an underestimate of the true number because not all members self-report their illnesses.

Refinery workers have a slightly higher lung cancer rate compared to all other workers; however, this increase was not statistically significant (RIR 1.05, 95% C.I. 0.79 – 1.40).

There is a statistically significant increase in the incidence of melanoma in men compared to the general population. The rates are higher in the sunnier states, and the increase remains when compared with state-based rates. The rate does not increase with increasing duration of employment, time since first employment or period of first employment. In fact, there is a reduction in melanoma rates for those employed for more than nine years, statistically significantly so for those employed for 16 – 24 years. This suggests that a causal association with any exposure in the workplace is less likely, but this finding will continue to be monitored.

Although an increased incidence of bladder cancer in the overall cohort was reported in previous *Health Watch* reports, this updated analysis now shows an almost identical risk of bladder cancer compared to the general population. This analysis also confirms the known association between bladder cancer and smoking. Bladder cancer in drivers however, remains elevated with borderline statistical significance compared to the general population (SIR 1.60, 95% C.I. 0.96 – 2.49). When compared to office only workers in the cohort, the risk is 2.4 times greater in drivers (RIR 2.42, 95% C.I. 1.09 – 5.37). This comparison has not been made in previous *Health Watch* reports.

As identified in the 12th and 13th Reports (5,9) and contrary to findings in previous *Health Watch* reports (6, 8, 10, 11) there is now no statistically significant excess of leukaemia in the cohort (SIR 0.80, 95% C.I. 0.60-1.04). There were three new cases of acute non-lymphocytic leukaemia (ANLL), which is the leukaemia most strongly associated with benzene exposure, since the last report, but there was no statistically significant excess in the cohort compared with the general population (SIR 0.69, 95% C.I. 0.38-1.16).

Job group analyses

Health Watch carries out analyses of members in some particular occupational groups, and a small but statistically significant overall excess in cancer incidence was found in tanker drivers. A similar excess was observed in the 13th report but it was not statistically significant at that time.(5) The breakdown of major cancer categories among drivers showed that melanoma is the only specific cancer type that was statistically significantly elevated compared to the general population. Mesothelioma, cancer of the testis, bladder, kidney brain and nervous system were all elevated in drivers but not statistically significantly so. The excess risk of bladder cancer among drivers, however, was approaching statistical significance (SIR 1.60, 95% C.I. 0.96 – 2.29) and warrants close monitoring.

Cancer mortality rates, however, were lower than the general population for most occupational groups, including drivers in the current analyses. Terminal operators had a slightly elevated risk of cancer mortality, although not statically significant, while refinery operators had a slightly lower risk of cancer mortality compared with the general population (SMR 0.86, 95% C.I. 0.74-0.99).

1. INTRODUCTION

1.1. Industry Background

The petroleum industry became established in Australia in the first decade of the twentieth century when international companies began importing fuels and lubricants. Refineries were built from 1910 onwards and nationwide distribution networks were set up. The distances involved led to considerable cooperation between the competing companies, which were servicing a relatively small, scattered population. World War II was followed by a period of rapid population expansion. Refinery and associated petrochemical plant development took place with major refineries in three States coming on-stream during the 1950s. Technological development has continued to date in line with the worldwide oil and gas industry. Australian refineries and terminals are technologically advanced although relatively small in capacity. Environmental legislation and emission controls are amongst the most stringent in the world, and this has resulted in changes in technology, e.g. introduction of bottom loading of road and rail tankers and hydrocarbon vapour recovery systems.

Local production of both oil and gas has grown, and from the 1970s, the production of light crude oil and of natural gas made Australia a net energy exporter. Although development of new and existing fields continues around the continent and overall production continues to grow, Australian petroleum requirements are now partly met from imports. Moreover, in the 1990s, the industry underwent considerable reorganisation leading to refinery operations becoming less labour-intensive, with a significant proportion of work now being undertaken by contractors. Consequently fewer people are employed by the petroleum companies than when *Health Watch* was established, especially in the refining sector.

The downstream petroleum industry is represented by the Australian Institute of Petroleum (AIP) which was founded in 1975. AIP established a Health Committee in the same year.

1.2. Development and Design of the Health Watch Surveillance Program

In 1980, the AIP contracted the (then) Department of Community Medicine at the University of Melbourne to establish an epidemiological health surveillance program to monitor major health outcomes of employees in the industry. The program, called *Health Watch*, has been running continuously since that time, monitoring deaths and cancer incidence in the cohort of people who work(ed) in the industry. As Australia's oil and gas development has expanded, new companies and projects entered the program. Entry to the existing cohort was closed in 2000, however, a new cohort comprising existing and new employees was established in 2010. Recruitment to the new cohort spanned 18 months but is also currently closed to further recruitment.

What is a cohort?

> *A cohort was originally a group of Roman soldiers who marched together. The Health Watch cohort is made up of people who are or have been working in the industry who are marching together through time.*

In 1987, an overall excess of lympho-haematopoietic (LH) cancers (all leukaemias, multiple myeloma and all lymphomas except Hodgkin disease) was observed in the cohort. To evaluate the relationship between workplace exposures (specifically benzene) and the excess of these cancers, a nested case-control study was commenced within the cohort in 1988.

In 1999, the University of Melbourne relinquished responsibility for *Health Watch*, and the AIP contracted the University of Adelaide to continue the cohort study. Responsibility for the case-control study was passed to a consortium at Monash University and Deakin University. With the approval of the University of Adelaide's Ethics Committee, information for conduct of the case-control study was provided to the consortium.

In 2005 the AIP transferred custodianship of the *Health Watch* cohort to Monash University's Centre for Occupational and Environmental Health (MonCOEH) in the Department of Epidemiology and Preventive Medicine (DEPM). With the consent of the University of Adelaide's Ethics Committee, Monash University's Ethics Committee and of the State and Territory Cancer Registries and the Australian Institute of Health and Welfare (AIHW), the cohort data were transferred to Monash University.

Figure 1 is a representation of the *Health Watch* cohort structure as at 30/11/2010.

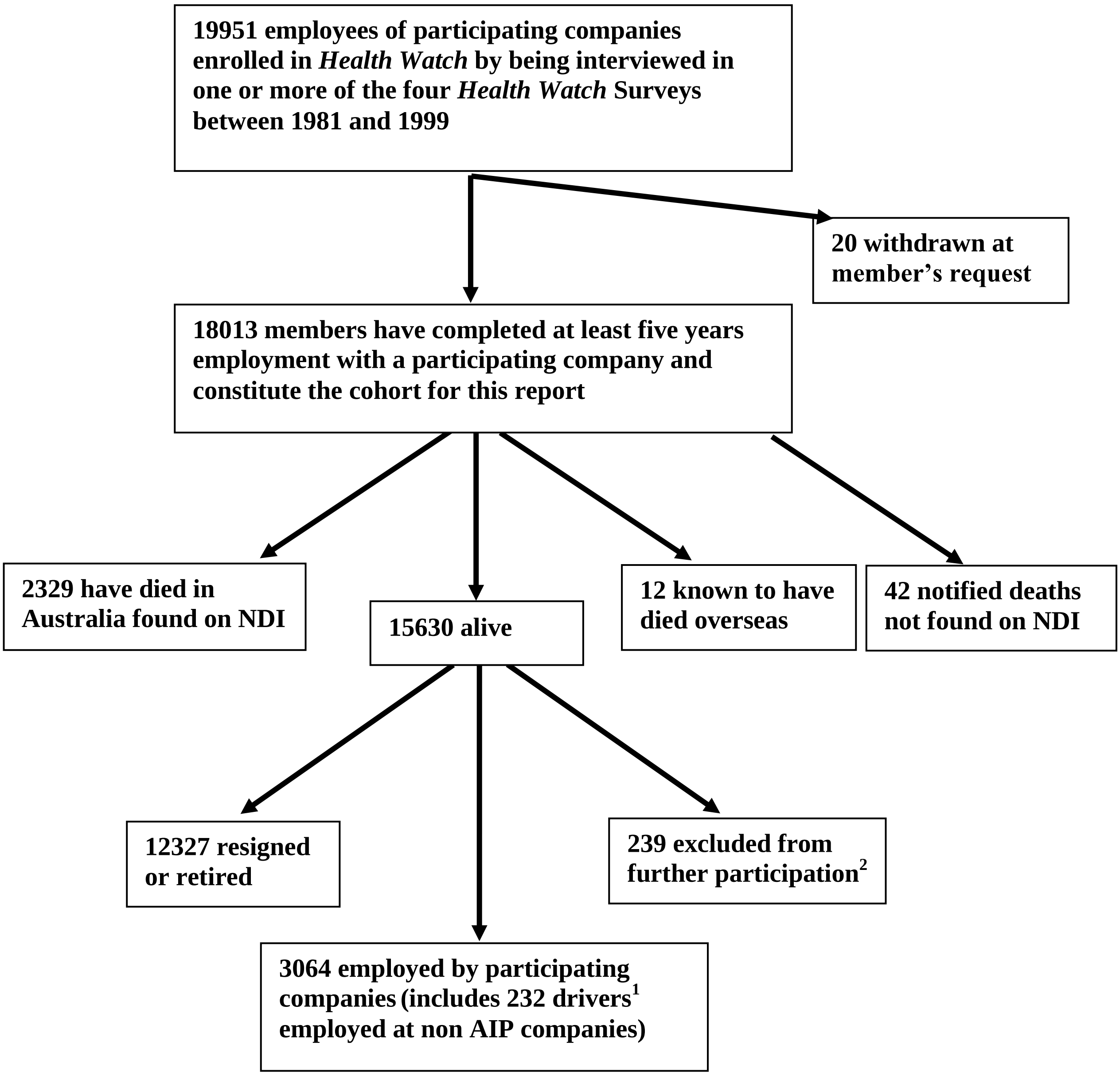


Figure 1: *Health Watch* cohort structure

1. Section 2.2.8, page 23
2. Excluded Castrol employees from 1994

Although all the major petroleum companies of the AIP joined the *Health Watch* program, participation by individual employees is voluntary. The health outcomes monitored are deaths from any cause and the incidence of cancer. These measures have provided a broad view of the health experience of people working in the participating companies over recent decades. Death and Cancer Registry data available since about 1982 has allowed mortality and cancer incidence to be recorded and analysed.

1.3. Reporting Results

Results are reported to the *Health Watch* Advisory Committee comprising:

- representatives of the Executive Director of AIP
- representatives of member companies of the petroleum industry
- representatives of trade unions in the industry
- representatives from the research team at Monash University.

Results are published in this report and will be summarised in leaflets provided to all *Health Watch* sites for distribution to employees. These leaflets will also be posted to all individuals who have resigned or retired for whom a current address is available. The leaflets have been prepared by the *Health Watch* project team and set out the current findings of the study in simple to understand language.

Results of this research program have also been published in medical and scientific journals. (1-3,4)

1.4. Consent and Confidentiality

All information is kept at Monash University and results are published in such a way that no individual member of the cohort is identifiable. The guidelines for research set out in the DEPM's A Guide to Good Research Practice (12) are followed and only members of the *Health Watch* study team have access to identifiable data. Under the terms of the contract between the AIP and Monash University, all members of the team are bound by formal confidentiality agreements.

All *Health Watch* approaches to cohort members are assessed and approved by the Advisory Committee. Project team members are aware of the need to avoid distress in their dealings with individuals and their families. Medically confidential matters relating to individual members of the cohort are handled within the project by the Study Director who is a medical practitioner.

Health Watch obtains information from members of the cohort, their next-of-kin, families, relatives, employers, and the AIHW, which maintains the National Death Index (NDI) and the Australian Cancer Database (ACD) on behalf of State Cancer Registries, and the Victorian Cancer Registry (VCR).

Signed consent was obtained from members of the cohort at interview to obtain relevant information, and specifically to search the Cancer Registries and to approach employers for job histories. Continuity of consent was obtained at each subsequent survey. Information regarding the consent and its implications was provided to potential entrants at briefing sessions on site, in writing, and at the time of interview. A small number of employees declined to give consent: these employees are still members of the cohort but are not included in Cancer Registry searches (unless deceased).

There are about 900 pilot study members in Victoria who did not complete second or subsequent surveys and were never asked for consent for their names to be searched against the Cancer Registries. Almost all *Health Watch* participants who were asked for consent have agreed to the match. With the agreement of the *Health Watch* Advisory Committee, and the relevant Ethics Committees, the Victorian Cancer Registry (VCR) has agreed to continue to match these cohort members.

1.5. Ethics Committee Approval

The *Health Watch* program deals with matters relating to medical and human research ethics, informed consent, and confidentiality. The work of the *Health Watch* cohort study has been approved by the Monash University Human Research Ethics Committee (MUHREC).

To obtain identifiable cancer records it has also been necessary to obtain approval from the Human Research Ethics Committee (HREC) of the AIHW, and from each of the individual State and Territory Cancer Registry HRECs and for some States and Territories, the Chief Health Officers, Data Custodians or Health Department Privacy Committees. Cause of Death (COD) data for deaths after 2006 that went before a Coroner required separate ethics approvals from the National Coronial Information System (NCIS) at the Department of Justice and independently from the Victorian and Western Australian Coroners. Fortunately, written consent was obtained from members of the cohort at the time of recruitment into *Health Watch* and although the ethics approval process is becoming increasingly complex, ethics approvals from all departments have been approved. Nevertheless privacy laws currently present several obstacles to the efficient conduct of research, including lengthy procedures applying, reapplying, providing annual updates and responding to Ethics and Privacy Committees of State and National data repositories as each of these have their own forms and processes. The entire application process to obtain all relevant data for this report took over 30 months even though all Ethics approvals were current and valid, mostly due to changes in the application processes at various agencies.

1.6. Present Work

This report is based on the work carried out in the *Health Watch* program in the period 2007-2012. The deaths occurring in the cohort prior to the cut-off date of 30th November 2010 have been ascertained as far as possible, and mortality rates compared with national rates. This is the latest date for which complete enumeration is available from the AIHW. Registration of all cancers takes longer than death registrations, so that at the time of analysis national cancer rates were only available for comparison up to 31st December 2008. Accordingly, the analysis of cancer rates in the *Health Watch* cohort covers the period up to that date.

This extends the previous study by six years in respect of mortality and cancer incidence data.

Mortality data are provided to the AIHW by the Registries of Births, Deaths and Marriages (BDM), the Australian Bureau of Statistics (ABS) and the NCIS. These data are maintained at the AIHW in the NDI.

2. METHODS

2.1. Study Design

The overall design of the *Health Watch* program is that of a prospective cohort study. Members of the cohort were recruited in successive surveys and are followed up by periodic searches of the death and cancer registries. Vital status (whether members of the cohort are living or dead) is checked using information obtained from cohort members, their next of kin and employing companies. Death rates by cause of death and cancer rates by site (e.g. lung cancer) are periodically compared with national death rates and cancer rates.

Within the cohort, a case-control study was conducted examining the association between benzene exposure and certain cancers of the blood, bone marrow and lymphatic systems known as lymphohaematopoietic cancers (LH cancers). In the past, the benzene exposure of cohort members with these cancers was estimated, and was compared with the estimated exposure of a sample of cohort members who do not have these cancers. The comparison enabled an estimation to be made of any association between these cancers and exposure to benzene. This aspect of the study was carried out by a consortium from Monash and Deakin Universities, and was concluded in 2001. The outcome of the study and the methodology were reported to the AIP in 2001(13), and in peer reviewed literature.(13-20) The complete report can be accessed on the AIP website (www.aip.com.au). The case-control study was updated in a collaborative study with cases from two similar overseas petroleum industry cohorts in 2012. These are the UK Institute of Petroleum study and the Canadian Imperial Oil study.(21, 22) The combined case-control study was funded by the Conservation of Clean Air and Water in Europe (CONCAWE) (The Health, Safety and Environment Office of the European Petroleum Industry). The methodology and findings are being published. (23, 24)

2.2. Formation and Maintenance of the Cohort

2.2.1.Recruitment

Recruitment to the cohort has been by participation in one or more interviews carried out in four successive surveys, with the last survey ending in 2000. A recruitment drive for a new cohort was also carried out in 2010-2012. Although 1,985 existing cohort members were identified in this new cohort, this cohort will be treated as a separate entity and is discussed in detail in Section 9. The following describes the recruitment to the existing *Health Watch* cohort.

All employees of participating petroleum companies operating in Australia, who worked in refineries, storage and distribution terminals, offshore and onshore production facilities and airports were eligible to become members of the *Health Watch* cohort. Employees working in capital city offices and sites with fewer than ten employees were excluded.

Altogether, four surveys were carried out before the cohort was closed to further entry in 2000. The First *Health Watch* Survey was carried out in 1981-83. The Second *Health Watch* Survey was in 1986-87, the Third *Health Watch* Survey was conducted during 1991-93 and the Fourth *Health Watch* Survey was undertaken between 1996-2000. The repeated surveys allowed updating of information for each member of the cohort population still employed, and the recruitment into the cohort of any new employees in the industry since the last survey.

Site rolls were provided by the participating companies, and these were used to make contact with each employee to offer them the opportunity to participate in the survey interview.

During the periodic surveys, entry to the *Health Watch* cohort register was gained through voluntary attendance on site for personal interview with a project team interviewer. Full and informed consent procedures were undertaken for each employee during pre-interview briefings to employees in groups and individually at the time of interview. The major purpose of these briefings was to explain the nature of the study, the implications of entry and the consent procedures, and to provide feedback to existing and prospective cohort participants.

For each survey, interviewers were trained in the application of the questionnaire. Surveys have used almost identical questionnaires and the methodologies have remained comparable, although some changes in technology have occurred. Most of the Fourth Survey was conducted by the University of Melbourne using direct input to portable notebook computers. The interviewer had access to all the previous job history of current members and could accept potential corrections to previous data.

Not all sites were visited for the Fourth Survey, and further questionnaire responses were obtained by mail and by telephone.

2.2.2.Entry to the Cohort

Petroleum industry employees were admitted to the cohort after completing a survey interview or upon completion of five years of employment with a participating company, whichever was later. Thus members of the cohort who had already completed five years of employment at the time of their first interview were admitted to the cohort immediately.

2.2.3.Information Collected at Survey Interviews

Demographic information collected at interview included name, gender, date of birth and country of birth.

Employment information was obtained in some detail, in particular, members of the cohort were asked their occupation, the area they worked in, the tasks they performed and the proportion of the working week spent in each area.

During the first two surveys, details were collected by interview on the current job held by each participant. Participants were also asked to identify jobs held for up to five years prior to their first interview. By 1990 it was apparent that more complete job histories were required for the purpose of a nested case-control study of LH cancers within the cohort. Accordingly in 1991-93, during the Third Survey, all participants were asked at interview about all jobs held during their employment in the petroleum industry. The complete job histories were collected from nearly all current employees who participated. In a few cases, where complete employment histories were not obtained, or later proved to be incomplete, the computerisation of the Fourth Survey allowed gaps in the information to be more easily identified and corrections to be made at the time of re-interview. By this time about 4,000 men and 250 women had retired or resigned from the industry after having worked for at least five years. Their complete job histories had to be collected by including questions relating to this in the periodic Health Letter sent to all retirees, which was undertaken in 1994-95. Retirees were generally longer serving employees than those still employed, and therefore had longer gaps in their previously collected job histories. For many reasons, their complete job histories are likely to be less accurate than those still employed and interviewed in the Third Survey. The response rate from retirees to requests for complete job histories was about 80%. Some job history information for deceased members was completed by surviving partners or family. These more complete job histories were used to assess benzene exposures in the case-control study rather than the more limited information from the survey.

Lifestyle information was also obtained at interview. Standard questions on present and past smoking habits were asked of each participant, and a lifetime smoking history obtained.

Information on alcohol consumption was also collected during the survey interview. Each cohort member interviewed was asked: "In an average week, on how many days would you have a drink?" and "How many drinks would you usually have on those days?" A drink is defined as a standard measure as served in a hotel or bar. The average number of drinks taken weekly can then be estimated.

Health information, related to current or significant past health problems, was also collected.

2.2.4. Information from Participating Companies

Participating companies have periodically provided lists of new employees, transfers, resignations and retirements. Following the decision to close the cohort to further entry in 2000, companies have continued to provide lists of transfers, resignations and retirements on request. This information from companies is used to compute the date of termination of employment of all members of the cohort and vital status for all current employees. In some cases addresses can be provided to update the contact address used for the periodic Health Letter (Section 2.2.7, page 23).

2.2.5. Coding of Employment Data for Assigning Estimates of Hydrocarbon

Direct measurements of exposure to hydrocarbons for particular jobs, e.g., in "parts per million in air, time weighted average" are generally unavailable for the several decades of interest to *Health Watch*. In the absence of such information from companies, estimates of exposure have previously been derived from the job details provided at the survey interviews. More details of the coding were included as Appendix 1 to the 9th Health Watch report.(6)

A precise job description code was used as the principal exposure index for the cohort analyses, based on collection of a job history from each participant. The job classification developed for the American Petroleum Institute was used, with modifications on the advice of local occupational hygienists in the Australian industry (25, 26).

This ranking for exposure to hydrocarbons was used in the first case-control analysis. Distribution of *Health Watch* person-years across these categories was unequal, with many jobs being placed in the default category in the middle of the range. A more rigorous, quantitative methodology for assessing benzene exposure was developed for the *Health Watch* case-control study. However the assessment was applied to only the cases and controls in the case-control study and was not applied to the cohort as a whole.

The hydrocarbon ranking methodology was established in the early 1980s. During 1994-96 the rankings were revised to take account of changes to workplaces and exposures. The categorisation and groupings are however, now out of date, for example there has been a significant move towards bottom loading of tankers in recent years. Hydrocarbon exposure during bottom loading is measurably reduced, perhaps a third of that experienced during top loading.(17)

Therefore, as agreed in a meeting of the HWAC in 2007, the overall hydrocarbon ranking has not been revised nor used in this analysis as it is considered to be out of date.

Monash has now developed a list of generic job classifications or titles, which meets the current job descriptions, as a more suitable replacement for the previous hydrocarbon ranking scheme. This classification is used in the new *Health Watch* cohort.

2.2.6. Participation Rates in *Health Watch* Surveys

For the first two surveys, a record was kept of the proportion of employees interviewed. In both surveys, approximately 93% of employees on the site rolls agreed to participate.

It is estimated that 84% of eligible employees were interviewed in the Third Survey.(9)

In the Fourth Survey not all worksites were visited. Further contact was made by mailing out questionnaires and by telephone, but the response rate was not as high as that obtained by on-site interview. Seventy three percent of *Health Watch* members still employed were re-interviewed in the Fourth Survey, and an additional 1,479 new employees were interviewed. A previous report identified that the incompleteness of the Fourth Survey affected recruitment mainly from offshore production.(9)

In 2003, a Fifth Survey was carried out by the University of Adelaide. This was a questionnaire that was sent to all members of *Health Watch* still employed by participating companies. There was a 40% response rate and more details are provided in the 12th Report.(9) In addition, members of *Health Watch* who were no longer employed by participating companies were sent a reply-paid questionnaire with their 2002 letter. There was a 62% response rate from these cohort members.(9)

2.2.7. Follow-up

Efforts are made to maintain contact with all *Health Watch* cohort members. Retired members are sent periodic Health Letters where they are asked to report changes of address, illnesses and changes in smoking or drinking habits. This is important when updating personal information; in particular it is one of the main means of determining the vital status of cohort members.

A member is considered *Lost to Contact* for whom reliable contact data is not available. If the periodic Health Letter to a *Health Watch* member is unanswered or is 'returned to sender', contact with the employing company does not provide a recent address and a search of the White Pages fails to find a telephone number on which the person can be contacted, the person is considered "lost to contact".

Following an extensive search, Adelaide University located most individuals in the cohort who had been previously classified as lost to contact. Adelaide University estimated in 2003, that 4% of the cohort has been lost to contact and the percentage loss of observation time from loss of contact was only 1.3% in men and 4.9% in women.(9) The DIMIA records identified an individual's last departure or arrival in Australia. For this report, the DIMIA records provided to Adelaide University were reviewed and those who left before 2000 and had not returned by 2003 were assumed to have emigrated. Monash University has not attempted any further traces for members of the cohort.

Monash University sent a brief summary of the findings in the 13th *Health Watch* report to all members of the cohort with a Health Letter in 2007. This was sent to the entire cohort, either to their place of employment or to a home/postal address if the employee was retired/resigned or was ever a tanker driver.

2.2.8. The Special Case of Drivers

In recent years, most participating companies have outsourced tanker drivers' duties to transport contractors. Many tanker drivers who formerly worked for participating companies now work for contractors but perform identical duties to those previously performed. Although the contractors are not members of the AIP, it has been possible to identify many such tanker drivers from their responses to the Health Questionnaires and Health Letters. In such cases, the drivers have been classified as still "employed" and are included in the analyses.

Numerous other *Health Watch* members have continued to work in the petroleum industry for non-member companies of the AIP. However, they perform a variety of tasks not readily assigned to the API job coding system, so their non-AIP jobs have not been included in the duration of employment.

2.3. Withdrawal of Members of the Cohort

Twenty cohort members have indicated that they wish to withdraw from the study and do not wish to participate further in *Health Watch*. Their follow-up time has been excluded retrospectively (i.e. back to their enrolment), and they have been excluded from the analyses presented here. With the permission of MUHREC, if a person asks to be withdrawn from the cohort, they are sent the necessary formal notice of withdrawal to sign and also a letter explaining that withdrawal means that past contributions are deleted. They are also offered the option of remaining in the cohort, but with no further communication from *Health Watch*.

2.4. Health Outcomes

Health Watch cohort members have provided information on their health in the successive *Health Watch* surveys and in questionnaires sent to members of the cohort no longer employed by participating companies. The only health outcomes that have been statistically analysed are cause-specific death rates and cancer incidence rates. These analyses are not based on information supplied by members of the cohort, but from the national mortality and cancer records. However, health information supplied by members of the cohort has proved useful when verifying matches with official records. For example, if there is uncertainty as to whether a name appearing in a Death Registry is the same individual as a person with the same name in the *Health Watch* cohort, identification is assisted if the person has notified *Health Watch* of a corresponding illness. Cancer matches are now completed by the AIHW and are returned de-identified so unless there is an exact name and date of birth match, a record will not be returned. This has the potential to underestimate the cancer incidence of this cohort.

2.4.1. Mortality Records

Consideration of all causes of death can provide a broad picture of major health patterns, as these are directly linked to death outcomes. Some medical conditions, where death is not a consequence, e.g., osteoarthritis, cannot be analysed by *Health Watch*, because there is no population registry of diseases other than cancer. Others, where there is a link between number of deaths and overall morbidity (ill-health), such as ischaemic heart disease (i.e. coronary artery disease) and accidents, can be reliably explored using *Health Watch* information.

For the purpose of mortality analyses, death records are obtained from the NDI, maintained by the AIHW. The NDI is compiled from death records from State Registries of Births, Deaths and Marriages, and causes of death, coded by The Australian Bureau of Statistics (ABS). ICD-9 coding was used for deaths occurring up to and including 1996.(27) Deaths occurring from 1997 onwards are coded in ICD-10.(28) The coded deaths by cause are used to compile national annual cause of death statistics (mortality rates).

Periodic searches are made of the NDI by submitting the list of *Health Watch* members, with dates of birth, to the AIHW, which uses a matching algorithm to identify likely and possible matches. These are supplied to *Health Watch* for clerical review and decisions are made on which names on the list are to be accepted as true matches. Matching is sometimes made difficult because many older State death certificates gave only the age (in years) of the person at death, rather than the date of birth. Final decisions on doubtful matches are based on information already held by *Health Watch*, such as notification of death from next of kin or from companies. Previously, it was sometimes necessary to obtain a copy of the death certificate, where certain items of information (e.g. occupation or place of birth) can be compared with information held by *Health Watch*. Changes to the privacy landscape have made it very difficult for anyone other than the next of kin to obtain a copy of the death certificate. In addition registration data is now usually more precise so this confirmatory step is no longer needed.

The coded deaths identified as true matches are used for comparison with Australian mortality data statistics resulting in the calculation of a comparative index called the Standardised Mortality Ratio (SMR) (Section 2.5.2, page 28). These analyses are undertaken to the time when the NDI is considered to be complete. At the time of this analysis the NDI is considered to have a complete record of all deaths with the cause of death coded up to 30th November 2010, which has therefore been determined as the cut-off date for the mortality analyses included in this report.

2.4.2. Validation of Mortality Records

As discussed in the previous section, mortality analysis is carried out by comparing death rates in the *Health Watch* cohort with national rates. For such an analysis to be valid, the data sets must be comparable. This means that all deaths in *Health Watch* members of the cohort must be included in the data set from which national mortality tables are computed. To ensure that this is so, it is necessary to ensure that all deaths known to *Health Watch* are located on the NDI.

Health Watch does not rely solely on NDI linkages to learn of deaths. Notification of deaths in currently employed members of the *Health Watch* cohort may be supplied by the employer. Deaths of members who have left the industry may be notified by next of kin in response to a mail contact or voluntarily via the *Health Watch* freecall number or email address. There are 959 deaths among eligible *Health Watch* members which have been notified in this manner. Most of them have been subsequently identified through the NDI search, but some have not. *Health Watch* has been notified of thirty four members who died before 30th November 2010, but who could not be found on the NDI. A further 12 members have died overseas. These deaths have not been included in the analyses because they do not appear on the NDI, but follow up ceases as of the notified death date.

Deaths identified from the NDI occurring after the cut-off date have not been included. The NDI currently records complete cause of death data up until November 2010.

It is not possible to be certain that all deceased members of the cohort are identified in the matching process. For example, when members of the cohort have changed their name (e.g. women after marriage or divorce) it is possible that their deaths may not be detected. In addition, members who die overseas e.g. after emigration, will not appear on the NDI. Therefore absence of a person's name from the NDI does not necessarily mean that he/she is alive. As discussed in Section 2.5.1 (page 27), the follow-up time of such members cease from the date of emigration for those who died overseas or the cut-off date of 30th November 2010.

In previous linkages, all matches from preceding NDI searches were accepted and added to the new matches from the additional years that were searched. The current linkage covers the entire time span of the cohort, not just the additional years of follow up since the last report. Therefore, for this report, only matches found on the cancer and death registries in this linkage are counted in this analysis.

In previous analyses, deaths were re-coded by Adelaide or Melbourne Universities based on individual death certificates. Some data was also coded from ICD10 back to ICD9. In some cases these manually re-coded deaths did not match what was recorded on the NDI. For this report, only data obtained from the current NDI linkage has been used to ensure it is consistent with the national population data in these analyses.

2.4.3. Cancer Incidence

A distinguishing feature of the *Health Watch* study, from most cohort studies in the petroleum industry around the world (or indeed any industry), is its ability to consider the occurrence or incidence of cancer which is not necessarily fatal. This is made possible by the existence of population-based Cancer Registries in all Australian States. Cancer is a notifiable disease in all States and Territories and all cancers, except non-melanoma skin cancer, and all deaths are legally notifiable in Australia. Cancer registration has been universal in Australia and represents a complete registry of all cancers since 1982. Written consent has been obtained from most members of the cohort to search for their names on the Cancer Registry.

Until the mid-1990s, *Health Watch* obtained information on cancer incidence by submitting the names and dates of birth of all members of the cohort to each individual State Cancer Registry. Since then, matching has been achieved by matching with the ACD, a compilation of data from all State and Territory Registries from which national cancer incidence data is generated. Additional information from Victoria is obtained directly from the VCR. Only confirmed matches are supplied to *Health Watch* from the ACD and VCR due to privacy restrictions. The uncertain but possible matches are reviewed at the individual State Registry level and only highly certain matches are released to *Health Watch*.

The analysis is undertaken to the latest time at which the ACD is considered to be complete. In this report the cut-off date is 31st December 2008, which is two years prior to the available death data, because complete enumeration of cancers takes longer than enumeration of deaths.

Cancer cases are grouped into various categories based on the ICD-10 coding system.(28) These categories range from malignancies which include all types of cancers, to broad organ system groupings which contain a range of cancer codes, such as respiratory (C30-C38), or digestive system (C15-C25). Cancers are also categorised into more specific single site categories such as stomach (C16) or bladder (C67). Non-melanoma skin cancers are not generally recorded by the State Cancer Registries, so for the analyses comparing skin cancer rates in the *Health Watch* cohort with national rates, only melanomas are included.

Data on cancer deaths have been available for many years and is obtained from information on medical certificates of cause of death. However, the major question for studies of the effects of occupational (or other) exposure is how many people actually develop cancer, which is not the same as how many people die from cancer. Cancer death rates relate not just to cancer occurrence, but also to other factors such as the presence of effective treatments, access to health care and presence of co-morbid conditions, which are not directly relevant to the aims of the *Health Watch* study. Since the death rate from cancer is so strongly related to the effectiveness of treatment and other factors and cure rates are now high for many types of cancer, cancer incidence (i.e. the occurrence of cancer) is a more reliable measure of the cancer rate than deaths from cancer and this is used in most analyses in this report, rather than cancer deaths. Some cancer mortality figures are also quoted where appropriate.

2.4.4. Validation of Cancer Incidence

Only cancer matches found in the current linkage were used in this analysis. Previous matches that were not matched this time were not included. Cancers can be re-coded by the Registry to other sites over time (especially those initially coded as “unknown”) and can also change between being malignant and non-malignant and vice-versa. Therefore, it is preferable to refresh the entire list of matched cancers in each linkage as has been done for this report.

Another source of cancer notification is death registrations where cancer is given as the cause of death. ICD-10 coding used since 1997 also includes underlying causes of deaths, which can also be checked for cancer occurrence. All but 38 members identified with cancer in this way were found in the 2008 or earlier searches of the ACD and VCR. Some of these missing cancers can be explained in earlier years as they might have been diagnosed before the commencement of the cancer registries with the resultant death occurring several years later.

Current Cancer and Death Linkage and revised Job Groups

This report analyses deaths occurring up to 30th November 2010, and cancers registered up to 31st December 2008. The current linkage covers the entire time span of the cohort, not just the additional years of follow up since the last report. This provides a more accurate account of the status of the cohort.

The job groups that appear in this report have been revised, mainly to remove overlaps and ships’ personnel. The job groups in this report are Drivers, Refinery operators (not including ship personnel), Terminal operators and Maintenance (refinery or terminal based not upstream), Office workers and Shift workers. Shift work was a self-assessed category and employees in this group also belong in other job groups including operators and maintenance workers. Apart from the drivers group which did not change, the cancer and mortality analyses assessing these revised job groups cannot be compared to previous Health Watch report.

2.5. *Analyses*

The analyses undertaken for this report was completed in conjunction with MonCOEH and the Statistical Consulting Centre, University of Melbourne using an updated version of the SAS program developed at Adelaide University.

The basic analyses in *Health Watch* are to compare the death and cancer incidence rates of the *Health Watch* cohort with the corresponding rates in the general population by sex and by five year age groups. The rates are expressed as the number of deaths or new cancers as a proportion of the person-time of follow-up.

The total person-time is the total of the follow-up time of each individual. For example, if 20 people are each followed up for 10 years, the total person-time would be 200 person-years. If two cancers occurred in these 10 people over that time, the cancer rate would be 2 per 200 person-years.

2.5.1. Follow-up Time

The definition of cohort members' follow-up time (usually expressed in person-years) is critical. Follow-up time commences on admission to the cohort (Section 2.2.2, page 20), which is the date of initial Survey interview, or on completion of five years of employment in the industry, whichever is the later.

Follow-up time stops on the date of death or the cut-off date (30/11/2010 for mortality, 31/12/2008 for cancer) or the date of emigration, whichever occurs sooner. Members of the cohort who have emigrated cease to be followed up after leaving Australia. This is because if they die or develop cancer whilst outside Australia, their death or cancer would not appear in the data on which national death and cancer tables are based. Since such deaths or cancers will not be included in the analyses, the person's corresponding follow-up time is excluded from the denominator.

The vital status of some members of the cohort is unknown and the subject is therefore deemed to be lost to contact. There are a number of possible explanations:

- Emigration
- The subject may have died in Australia but the name was not detected on the NDI. This is particularly likely if the person has had a name change that *Health Watch* is not aware of
- The subject may be alive and living in Australia but not identified through the various searches carried out by the University of Adelaide (Section 2.2.7, page 23).

It will be seen that there are two categories of members of the cohort lost to contact:

(i) Those who will be found on the NDI when they die

(ii) Those who will not be found on the NDI when they die.

For example, a person with whom *Health Watch* has lost contact may be living in Australia and be found in the NDI when he or she dies. On the other hand, a person who has emigrated and remains overseas will never appear in the NDI, and a person who has changed his or her name may be on the NDI under the changed name, and a match with the NDI may never be found.

In most previous *Health Watch* reports, members of the cohort not found to be deceased or not known to have emigrated were treated as living, and all had their follow-up time extended to the cut-off date for the analyses. The inclusion of these people in this way could result in slight over-enumeration of person years, leading to a slight underestimate of the mortality (or cancer incidence) rate relative to the national rate. As discussed in previous *Health Watch* reports, individual cohort participants who were considered to be lost to follow up have been identified in matches with the NDI and ACD. It was not therefore considered appropriate to remove these individuals from the cohort follow up.

Adelaide University showed that whether or not the follow-up time of members of the cohort who are lost to contact is or is not included makes very little difference to the result – in men, the estimate varied by 0.01 (i.e. 1%) and in women by 0.02 (2%).(9)

For all analyses in this report the follow up date is up to:

- 30/11/2010 for mortality and 31/12/2008 for cancer
- Date of emigration
- Date of death if found on NDI
- Date of death notification if not found on NDI, but a death has been reported.

2.5.2. External Measures of Comparison: the SMR and SIR

Health Watch compares death and cancer incidence rates in the petroleum industry with the national rates to produce measures called the standardised mortality ratio (SMR) and the standardised incidence ratio (SIR).

The SMR is a measure of the death rate occurring in the *Health Watch* cohort compared with the death rate occurring in the national population. This ratio can be measured for the whole cohort or any subset, for any particular cause of death, or for all causes. The SMR tabulations show the number of deaths observed in the *Health Watch* population and the calculated expected number which would arise in a group of the same age and sex in the Australian national population.

The expected number is computed from the national rates (by age, sex and year of occurrence) provided by the AIHW (29) and the number of person-years spent by cohort members in each age, sex and year-of-occurrence stratum. Comparison of the observed number of deaths recorded by *Health Watch* to the expected number as shown in the tables produces the SMR. If the deaths in the *Health Watch* cohort are occurring at the same rate as they do in the national population, then the SMR will be 1.0. If the SMR is greater than 1.0 then deaths in the cohort are occurring more frequently than would be expected if national death rates applied to the *Health Watch* population. If the SMR is less than 1.0 then deaths in the cohort are occurring less frequently than they do in the national population. Thus the SMR forms a measure of the risk of mortality in the *Health Watch* cohort compared to the Australian population as a whole, with age and sex taken into account.

When measuring the risk of developing cancer the standardised incidence ratio (SIR) is calculated. Incidence measures cancer as it arises as opposed to when it causes death. All cases of cancer except non-melanoma skin cancers are reported to the relevant State Cancer Registry by the treating medical specialist. Providing that cancer registration is reliable, as it is in Australia, cancer incidence measures are a more valid indicator of cancer risk than are cancer mortality measures. The SIR is calculated in a similar way to the SMR and is age-and sex standardised. To calculate SIRs, calculation of expected numbers from national cancer incidence is required. The national data are derived from the ACD.(30)

2.5.3. Internal Measures of Comparison: the RMR and RIR

Health Watch also uses internal comparisons to look at the health effects of working in the petroleum industry. Where a measure or ranking of exposure can be obtained, a relative risk of death or cancer can be calculated, comparing those who have less exposure to those who have more. (SMRs and SIRs are generally unsuitable for comparing different categories of exposure.) Generally, it would be expected that if the exposure is causing the effect, then those with more exposure, in time or intensity, would suffer more effects on their health, and this would show up in the health outcomes. This is known to apply, for example, to the number of cigarettes smoked and the risk of lung cancer. Relative risk can also be used to examine whether members of subgroup such as specific job categories, have more or less risk of death or cancer than other subgroups.

For any particular exposure or subgroup, a baseline group is chosen, and represented as having a risk of 1.0. All other exposure groups or ranks are then calculated for risk in comparison with the baseline group. The measures of these comparisons are the relative mortality ratio (RMR) when death is the outcome or relative incidence ratio (RIR) when cancer is the outcome.

The baseline category for these analyses is usually the least exposed group. For smoking it is people who have never smoked. If the RMR or RIR for any group in *Health Watch* is 1.0 then deaths or cancers, respectively, are occurring at the same rate as they do in the baseline group. If the RMR or RIR is greater than 1.0 then deaths or cancers are occurring more frequently than they do in the baseline group. If the RMR or RIR is less than 1.0 then deaths or cancers are occurring less frequently than they do in the baseline group.

2.5.4. Confidence Intervals and Risk Estimates

The rate ratios, SMR, SIR, RMR and RIR, are accompanied by 95% confidence intervals (95% C.I.). The value attributed to the ratio is actually a statistical estimate of the true ratio. However, the true ratio cannot be known exactly. The spread of estimates of the ratios within which it is 95% certain that the true figure will lie can be calculated. This spread is called the confidence interval.

The choice of 95% confidence intervals is commonly used in health studies, and simply means that the certainty of the result is such that the odds of the true figure lying outside the confidence interval are about 5% or 1 in 20.

Confidence intervals are influenced by the size of the group however. Two groups may have the same point estimate of risk, but the larger group will have narrower confidence intervals. This may mean that larger groups such as onshore production workers have statistically significant results but the same point estimates for smaller groups such as offshore production workers that may not be statistically significant, as in Table 24. In addition as deaths or cancer cases accumulate in the cohort and the general population, increased or decreased risk estimates may reach statistical significance.

The importance of this lies in the interpretation of the ratios in terms of risk appraisal. Where a ratio is higher than 1.0 then a risk may be present, but if the lower end of the confidence interval extends below 1.0, then it is possible that the real ratio is 1.0 or less and no risk is present. However, when the lower end of a confidence interval is above 1.0 then we can say with some certainty that an increased risk does exist. This is often described as being a statistically significant result. If both confidence intervals are below 1 then the risk is said to be statistically significantly lower than that of the reference group.

2.5.5. The Problem of Multiple Analyses

In this report, the convention of 95% probability is used to interpret risk estimates. This convention accepts that there is a 1 in 20 chance that an increased or decreased risk has happened by chance. When multiple comparisons are carried out, as in this report, it is possible that some chance findings may be found to be statistically significant. It is important therefore not to accept or dismiss a finding based on a single risk estimate but to interpret the risk estimate in the context of the body of information in this and previous reports and the findings from other studies.(31-35) In this report the risk estimates are discussed with reference to those from previous reports, to aid interpretation.

2.5.6. Confounding Variables

Confounding variables are factors (other than those under investigation) which may affect the cohort health outcomes being studied. Where these factors can have large influences on outcomes, such as with smoking and cancer, it is necessary to account for them in the analyses. Even small differences in exposure to tobacco smoke can cause large differences in lung cancer rates. To cause confounding, a variable has to be a cause of the disease in its own right, and to be unequally distributed between the different groups being compared and not measured or are unable to be adjusted for in the analyses.

Differences in risk between various exposure groups could therefore be masked or falsely calculated if confounding variables are not allowed for.

What is a Confounder?

A confounder is a term used in epidemiological studies in which a group with a particular exposure history is compared with a group without the exposure. In such studies, the presence of a confounder can lead to a misleading result.

To cause confounding, a variable has to be a cause of the disease in its own right, and to be unequally distributed between the different groups being compared.

For example, the lung cancer rate in a group of workers exposed to a carcinogen (say asbestos) may be compared with the rate in a group of workers not exposed. Since smoking can cause lung cancer, smoking prevalence is a potential confounder in this analysis. If the group exposed to asbestos happens to have a higher proportion of smokers than the comparison group, an excess of lung cancer in the former may be incorrectly attributed to the asbestos, whereas it may be partly or wholly due to the difference in smoking. In such a case the variable "smoking prevalence" is a confounder, where smoking rates are unknown.

2.5.7. Adjustments to SMR and SIR analyses

In the SMR and SIR estimates, adjustment is made for age and calendar year. These variables were used, as they are known to have major effects in the Australian population. For example, in the case of calendar year, the incidence rate and mortality rates of many cancers have undergone marked changes over the period since *Health Watch* began. Confounding by sex is avoided by separate analyses of men and women.

Adjustment for tobacco smoking is more difficult. Although *Health Watch* has obtained good smoking data on members of the cohort, comparable data are not readily available for the general population. Data on smoking prevalence in the Australian population by age group in the mid-1990s are available,(36) and by comparing this with the smoking prevalence of the *Health Watch* cohort, and by using information on the strength of any association between smoking and a particular disease, it is possible to estimate the likelihood that a particular outcome is smoking-related. Another indirect method of estimating whether the smoking prevalence differs from the general population is to examine the cancer rate or death rate from diseases almost exclusively due to smoking, such as emphysema and laryngeal cancer.

2.5.8. Adjustments to RMR and RIR analyses

Because disease rates vary with age and over time in the population, the age at death or cancer diagnosis and the calendar period must be taken into account in the analyses. All RMR and RIR analyses were adjusted for age and calendar period of follow-up and smoking status.

The confounding effect of smoking is more readily dealt with in RMR/RIR analyses, since unlike SMR/SIR analyses; no reference to national smoking rates is required. Therefore direct adjustment has been made for the confounding effect of smoking in estimating relative rates for all cancers and mortality comparisons. For the purposes of these adjustments, smokers are categorised into two categories – *ever smoked* vs *never smoked*.

2.5.9. Time-related Variables

Analyses were carried out using three time-related variables which might throw light on any occupational cause for excess death rates or cancer rates. These are:

- period of first employment in the industry
- duration of employment in the industry
- time from first employment in the industry.

Period of first employment analyses may provide clues as to whether exposures in particular calendar periods may have had risks attached to them. Because technology and work procedures, and therefore exposure, have been constantly changing in the industry over the past decades, health outcomes must be explored to ascertain whether they are related to historical exposures or reflect current risks. If hazardous exposures were present in higher concentrations in the 1970s than in the 1990s, and if some cancer types occurred at a higher rate in the former period, it could be inferred that the exposure may be a cause of that type of cancer.

The analyses for duration of employment in the industry help to investigate whether an excess death or cancer rate may be work-related, even though the specific causal agent in the workplace is not known. It may be expected that total or cumulative exposure will increase with increasing duration of employment. Therefore if the workforce is divided into different categories according to duration of employment, the death or disease rate will increase with increasing employment duration if it is related to an exposure at work. Where a person leaves and later returns to work with a participating company, the time away is deducted from the total duration.

Consideration of elapsed time from first employment to diagnosis of cancer or death is an attempt to explore what latency periods might be involved with the development of disease, particularly cancer.

Employment here refers to employment with one of the participating companies (or a contracting company in the case of Tanker Drivers who were formerly employed by a participating AIP company). The date of commencement was obtained from members of the cohort in the survey interviews. Termination dates are obtained from companies. Duration of employment should not be confused with follow-up time, which continues after members of the cohort cease working for participating companies.

2.5.10. Analysis by Workplace Type

In addition to comparing the overall *Health Watch* cohort with national rates, separate analyses have been performed on different categories of workplace. There are five types of workplace in this report: Refinery, Terminal, Airport, Onshore production and Offshore production. Where a subject has worked in more than one workplace type, he or she is assigned to the workplace worked most recently.

2.5.11. Analysis by Self-reported Smoking and Drinking Status

Lifestyle choices affect health outcomes, so mortality and cancer incidence have been analysed according to the self-reported rates of smoking and drinking alcohol.

2.5.12. Analysis by Job Type

Analysis of health outcomes for specific categories of job (single AIP Job code) is dependent on there being sufficient members of the cohort who carry out this particular job. The largest groups of employees in the industry are Driver, Refinery Operator, Terminal Operator, Maintenance (terminal and refinery combined), Office (Clerical and Managerial) and Shift worker. The latter three categories are composite groups brought together to allow for job type analyses and have been used in previous reports.

We have revised the job groups formed from the AIP job codes that appear in this report, mainly to remove overlaps and ships' personnel. Accordingly, with the exception of drivers, whose coding has not changed, it is not appropriate to make direct comparisons between the risks for these groups in this report and the groups in previous reports. The AIP job codes grouped in this report are *Drivers* (NB295x), *Refinery operators* (not including ship personnel) (BA, BB, BC, HX, IB, PA, PB, PC, RF), *Terminal operators* (BA, BB, BC, HX, IB, NA, PA, PC, RF) and *Maintenance* (refinery or terminal based not upstream) (IB, CA, CB, CC, CD, CE, CF, DA, DB, DC, DD, EA, EB, EC, FA, FB, GX, MX), *Office workers* (AX) and *Shift workers*. Shift work was a self-assessed category drawn from the questionnaire and employees in this group also belong in other job groups including operators and maintenance workers.

3. GENERAL RESULTS FOR THE COHORT

Results are reported for cause of death (mortality) and cancer incidence, for men and women in the cohort. Because of the small number of women, analyses cannot be reliably done to the same level of detail as for men.

The results come from analyses of various occupational factors and categories, smoking, and alcohol, using age-standardised population rates. Diseases and cancer types are identified by standard ICD-10 coding.(28)

3.1. The Cohort Population

3.1.1.Description of Cohort Population at 30th November 2010

There are 16639 men and 1374 women in the *Health Watch* cohort population included in the current analyses being those who meet the eligibility criteria for this study. These numbers reflect the preponderance of men employed in the industry. The state of the cohort as at 30/11/2010 is shown in Table 1.

Table 1: State of the cohort as at 30/11/2010 (does not include lost to contact)

	Male	Female	Total
Died in Australia found on NDI	2265	64	2329
Death notifications not found on NDI	39	3	42
Still employed	2916	148	3064
Excluded from further participation[a]	177	62	239
Retired from industry	11230	1097	12327
(Of which emigrated[b])	14	3	17
Overseas Deaths before 30/11/2004[c]	12	0	12
Total	16639	1374	18013

a. Exclusion due to withdrawal of one company from AIP.

b. Follow-up time of members of the cohort known to have emigrated as of 2001 or known to be resident in New Zealand ceased from estimated departure date.

c. Overseas deaths and death notifications not found on the NDI are not included in the estimates of mortality rates.

Table 1 does not show the number of members who are lost to contact. There was no attempt to locate those members who did not respond to the 2007 Health Letter. Of the 15,771 letters sent to eligible members, 6,225 (40%) returned the mini survey. It should be noted that non-response does not equate to lost to follow up.

The age of the cohort is indicated in Table 2, which shows the distribution of year of birth of the cohort. Although the cohort was closed to recruitment in 2000, an additional 24 men from the last survey have reached their five year qualifying period since the cut-off dates of the 13th Report. There have been 5 withdrawals since the last report.

The number of new entrants is now very small in relation to the whole cohort. This means that the cohort is aging as a whole. This factor strongly influences the death rate from most non-infectious diseases, as well as increasing the incidence (rate of occurrence in the population) of many cancers, e.g. prostate cancer. However, when estimates are made of the risk of death or disease from any particular cause in the *Health Watch* population compared with the risk in the general population, allowance is made for the increasing age of the *Health Watch* cohort by comparing to the rates in the general population with the same age distribution.

Table 2: Distribution of year of birth for *Health Watch* cohort members

Year of Birth	Men		Women		Total	
	N	%	N	%	N	%
1900-1919	78	0.5	1	0.1	79	0.4
1920-1929	1673	10.1	52	3.8	1725	9.6
1930-1939	2874	17.3	144	10.5	3018	16.8
1940-1949	4836	29.1	271	19.7	5107	28.4
1950-1959	4833	29.0	399	29.0	5232	29.0
1960-1969	2100	12.6	397	28.9	2497	13.9
1970-1979	245	1.5	110	8.0	355	2.0
Total	16639	100.0	1374	100.0	18013	100.0

3.1.2. Person-years of Observation in the Cohort

With each succeeding calendar year, the number of years of observation increases for each surviving member of the cohort population. Each subject completes a person-year of observation for each year since entry into the cohort until death (or emigration). The number of person-years of observation of the cohort is the sum of the person-years contributed by each cohort member. *Health Watch* has now accumulated 376,601 person-years of observation in men and 26,852 person-years in women. The accumulation of person-years by calendar period is shown in Table 3.

Table 3: Person-years of observation

Sex	Number of cohort members	1981-1985	1986-1990	1991-1995	1996-2000	2001-2005	2006-2010	Total
Male	16639	29368	56650	68935	74934	75179	71536	376601
Female	1374	1334	3031	4408	5595	6291	6193	26852

3.2. Person-years and Mortality and Cancer Incidence Rates

When estimating the mortality rate of the *Health Watch* population relative to the Australian population, there is a degree of uncertainty as a result of the lack of knowledge of whether members of the cohort lost to contact are actually alive and living in Australia. As discussed in Section 2.2.7, some of those lost to contact may have emigrated and their deaths will not be recorded in the database. However, previous searches of DIMA records have shown the rate of emigration to be extremely low, so this is unlikely to have any detectable effect on the mortality rate in the cohort (see Section 2.5.1).

For this report, only 17% of the cohort is classified as employed in an AIP participating company (including contract drivers). No active tracing of those who are lost to follow up has taken place since 2003 although Health letters were sent in 2007 to the last known address, of which, 40% returned the survey. The date of last contact for many participants is therefore before 2003. Thus it is not possible in these analyses to censor the person-years.

For all analyses in this report (as in most previous reports) only one method of estimating SMR (and SIRs for cancer) was used. The follow-up time of members of the cohort lost to contact was included until the cut-off date of 30/11/2010 for mortality and 31/12/2008 for cancer incidence. Estimates of SMR and SIR could therefore be underestimated because some of those lost to contact could be dead, but the error is most likely to be negligible.

Several deaths have occurred in the cohort since the cut-off date of November 2010; however, since comparison data were not available for this period, they have not been included in these analyses. They will be included in future analyses as the comparative data becomes available.

3.3. All-cause Mortality – Men and Women

Up to the 30th November 2010, 2,265 deaths had occurred in men and 64 in women. The SMR estimate with follow-up time of members of the cohort to the cut-off date is shown in Table 4.

The SMR for men and women continues to show that the death rate in this workforce is significantly lower than in the general population (adjusting for age differences and using yearly rates which account for the general increase in life expectancy occurring in the Australian population in recent decades). This low mortality rate is often noted in working groups and is known as the *healthy worker effect*.(37-39)

Table 4: All-cause mortality by sex, adjusted for age and calendar period of follow-up, compared to the Australian population

Sex	Person-years	Observed	Expected	SMR	95% C.I.
Male	376601	2265	3127.84	*0.72*	*0.69 - 0.75*
Female	26852	64	87.99	*0.73*	*0.56 - 0.93*

3.4. Cancer Incidence and Mortality – Men and Women

The incidence of cancer and the mortality rates from cancer are dealt with together in this section. Cancers are classified under the International Classification of Diseases (ICD), Revision 10 by morphological type (i.e. where it arises in the body) and/or by histology (cell type). Cancers occurring in *Health Watch* members are analysed according to workplace type and smoking effects.

Table 5 and Table 6 show the cancer incidence and the cancer mortality in the *Health Watch* population of men and women. The SIR for cancer in men is identical to that of the general population. In women, the SIR is slightly less than women in the general population, but the decrease is not statistically significant. The SMR for cancer in men is significantly low in comparison with the general male population (SMR 0.83, 95% C.I. 0.78-0.89).

The low SMR for cancer is probably a reflection of the *healthy worker effect*. As discussed in the section on all-cause mortality (page 35), this is believed to be largely a selection effect, that is, people in good health are more likely to obtain secure employment and to have a longer life expectancy as a group compared with the general population. Other possible factors are the higher standard of living and ready access to medical services for employed workers.

Table 5: All-site cancer incidence, men and women, adjusted for age and calendar period of follow-up, compared to the Australian population

Sex	Person-years	Observed	Expected	SIR	95% C.I.
Male	348752	2586	2596.54	1.00	0.96 - 1.04
Female	24425	94	111.22	0.85	0.68 - 1.03

Table 6: All-site cancer mortality, men and women, adjusted for age and calendar period of follow-up, compared to the Australian population

Sex	Person-years	Observed	Expected	SMR	95% C.I.
Male	376601	951	1144.90	*0.83*	*0.78 - 0.89*
Female	26852	38	39.03	0.97	0.69 - 1.34

As was pointed out in the 12th and 13th Report, a *healthy worker effect* is clearly demonstrable when mortality is used as the outcome measure, but not when cancer incidence is used. The 12th Report suggested that the *healthy worker effect* could be a consequence of greater survival rather than of a reduced disease incidence.(40)

The cancer incidence and cancer mortality data presented in Table 5 and Table 6 are not exactly comparable, as the cancer analysis has been updated only to the end of 2008, whereas the mortality analysis has been updated to the end of 2010 (as is evident from the difference in person-years of observation). Nevertheless, the differences in person-time could not account for the finding that cancer mortality is significantly reduced for men, whereas cancer incidence is not.

The Healthy Worker Effect

One cause of the "healthy worker effect" is the relative social and economic advantage of employed people, especially for people with relatively secure employment. Unemployed people as a whole tend to have lower socioeconomic status. This commonly correlates with lower income, fewer years of education, lower health status and higher age-adjusted mortality rates than employed people.

Hence when the mortality of occupational cohorts is compared with that of the general population, the mortality rate is higher in the latter because it includes many socially disadvantaged people.

Another factor is that people with life-threatening conditions, such as cancer, tend not to seek or obtain employment after diagnosis: this further lowers the mortality rate in the workforce compared with the general population, especially in the years immediately following recruitment of members of the cohort into Health Watch.

3.5. Results in Women

The ability of *Health Watch* to carry out analyses of the risk for women is limited to major groupings of common conditions because of the small number of women in the study population. When cancer or mortality counts are less than 3, the observed numbers are not reported. This is to keep in line with confidentiality practices and reducing the risk for potentially identifying a cohort member.

3.5.1. Mortality by Major Cause for Women

Table 7 shows the mortality by major cause for women. Ischaemic Heart Disease (ICD) and Chronic Obstructive Pulmonary Disease (COPD) are subcategories of Circulatory and Respiratory Diseases respectively and are not added twice in 'all cause' mortality. Because of the small number of women in the petroleum industry, and the low counts in all categories except cancer and circulatory mortality, the SMRs for the remaining other categories may be unreliable. Mortality from cancer is almost identical to that of the general female population although these rates are based on small numbers. A very low mortality for *all causes of death* was also reported in the 13th report and this SMR continues to be low.

Table 7: Mortality by major cause for women, adjusted for age and calendar period of follow-up, compared to the Australian population

	ICD-10	Observed	Expected	SMR	95% C.I.
Cancer	**C00-C97, D45-D46, D47.1, D47.3**	38	39.03	0.97	0.69 - 1.34
Circulatory	**100-199**	10	21.52	*0.46*	*0.20 – 0.85*
Ischaemic Heart Disease	120-125	7	10.41	0.67	0.27 – 1.39
Respiratory Disease	**J00-J99**	6	6.05	0.99	0.36 – 2.16
COPD[a]	J40-J44	3	3.23	0.93	0.19 – 2.72
Digestive	**K00-K93**	-	3.11	0.32	0.01 – 1.79
External Causes	**V01-Y98**	-	5.75	*0.17*	*0.00 – 0.97*
All Other Causes	**-**	8	12.53	0.64	0.28 - 1.26
All Causes	**A00-Z99**	64	87.99	*0.73*	*0.56 - 0.93*

[a]Chronic obstructive pulmonary disease

3.5.2. Cancer in Women

The overall and site-specific cancer incidence rates in women are shown in Table 8. Overall, the SIR is slightly but not significantly lower than the population rate (SIR 0.85, 95% C.I. 0.68-1.03), based on 94 cases.

Table 8: Cancer incidence by major anatomical site for women, adjusted for age and calendar period of follow-up, compared to the Australian population

Anatomical Site	ICD-10	Observed	Expected	SIR	95% C.I.
Colo-Rectal	C18-C21	13	12.87	1.01	0.54 - 1.73
Melanoma	C43	14	12.53	1.12	0.61 - 1.87
Breast	C50	31	37.78	0.82	0.56 - 1.16
Cervix	C53	4	3.42	1.17	0.32 - 3.00
Bladder	C67	-	1.06	0.95	0.02 - 5.28
Pancreas	C25	3	1.72	1.74	0.36 - 5.08
Lung	C33-C34	10	7.09	1.41	0.68 - 2.59
Thyroid	C73	3	3.07	0.98	0.20 - 2.86
Other cancers	-	15	31.68	*0.47*	*0.26 - 0.78*
All cancers	-	**94**	**111.22**	**0.85**	**0.68 - 1.03**

There were three cases of leukaemia in eligible women identified in this registry search.

None of the cancer types in Table 8 has occurred in statistically significant excess in the cohort. There was a significant reduction in incidence for the *Other Cancers* category, however, all comparisons are based on very low numbers as indicated by the wide confidence intervals. Due to the small number of female cancers, further analyses cannot be undertaken by workplace types, or time variables. Nor can they be analysed by any exposure measures, about 72% of the jobs held by women in *Health Watch* were in the lowest exposure category.

Results for Women in Health Watch

The proportion of women in the Health Watch program remains very small and this prevents much detailed analysis.

Women in the industry have death rates which are lower than that of women in Australia generally.

No cancer type has occurred in a statistically significant excess, but the numbers of individual cancer types is too low for meaningful analyses.

3.6. Mortality in Men

3.6.1. Mortality among Men by Major Cause

The SMRs for all major categories of cause of death are shown in Table 9. In all major categories, including that for external causes (accidents, violence and suicide), there are fewer deaths than expected, and so all the SMRs are below 1.0. The upper limits of confidence intervals are all below unity (1.0), i.e. mortality rates are significantly lower than in the general male population in all major categories of cause of death.

Pneumoconiosis, a subcategory of respiratory disease, is elevated compared to the general population. However, this elevation is not statistically significant and is based on small numbers.

Ischaemic heart disease (IHD) mortality, based on 497 male deaths, continues to be low with an SMR of 0.74, with the upper limit of the confidence interval at 0.81. This low death rate would suggest that the incidence of IHD itself in this cohort is also low, and comparable with that in the more advantaged groups in Australian society.

Table 9: Mortality by major cause for men, adjusted for age and calendar period of follow-up, compared to the Australian population

Cause	ICD-10	Observed	Expected	SMR	95% C.I.
Cancer (Malignant)	**C00-C97, D45-D46, D47.1, D47.3**	951	1145.07	*0.83*	*0.78 - 0.89*
Circulatory	**100-199**	729	1036.49	*0.70*	*0.65 – 0.76*
Ischaemic heart disease	120-125	497	667.61	*0.74*	*0.68 - 0.81*
Stroke	I60 - I69	113	169.31	*0.67*	*0.55 - 0.80*
Respiratory disease	**J00-J99**	154	222.58	*0.69*	*0.59 - 0.81*
Pneumoconiosis	J60 – J64	5	3.41	1.47	0.48 - 3.42
Asbestosis	J61	5	2.77	1.80	0.59 – 4.21
COPD	J40 – J44	86	131.67	*0.65*	*0.52 – 0.81*
All diseases of the digestive system	**K00 – K93**	75	120.79	*0.62*	*0.49 - 0.78*
External Causes (e.g. accidents, violence, suicide)	**V01 – Y98**	144	235.82	*0.67*	*0.52 – 0.72*
All other causes	**-**	212	367.57	*0.54*	*0.50 – 0.66*
All causes	**A00 – Z99**	**2265**	**3128.32**	***0.72***	***0.69 - 0.75***

3.6.2. All-cause Mortality and Time Relationships

Internal and external comparisons have been carried out for all causes of death combined, to identify any association with the era of first employment in the industry, duration of employment in the industry and time lapse between first employment in the industry and death. All internal analyses have been adjusted for age and calendar period of follow-up and smoking status.

All-cause mortality among men by period of first employment

Table 10 shows an external comparison between male cohort members according to the period of first employment in the industry and the general population. For the group starting after 1985, the SMR is 0.51, the SMRs of the workers employed between 1975 and 1984 is 0.63. The SMRs for those employed before 1965 are all above 0.70. Strictly, SMRs of different subcategories cannot be compared with each other, but this analysis suggests that the trend to increasing SMR with earlier date of first employment is due to a low death rate, in absolute terms, in those members of the cohort who entered the industry most recently. This is probably a manifestation of the *healthy worker effect* discussed in Section 3.3 (page 35), which is commonly found to decrease (i.e. the SMR increases), as cohorts are followed over time.

Table 10: Mortality among men by period of first employment, adjusted for age and calendar period of follow-up, compared to the Australian population

Period of First Employment	Person-years	Number Employees	Observed	Expected	SMR	95% C.I.
Post 1985	59420	3715	80	157.66	*0.51*	*0.40 - 0.63*
1975-1984	143959	5953	381	602.92	*0.63*	*0.57 - 0.70*
1965-1974	110412	4296	709	945.28	*0.75*	*0.70 - 0.81*
1955-1964	43083	1815	678	853.80	*0.79*	*0.74 - 0.86*
Pre 1954	19727	860	417	568.17	*0.73*	*0.67 - 0.81*

Table 11 shows the cohort mortality rates of males, within the cohort, according to the period of first employment in the industry. The comparisons are made with the category of most recent entrants to the industry – members of the cohort who have started since 1975.

The relative mortality rate for all-causes combined is higher for those entering the industry before 1975. There is evidence of a trend of increasing all-cause mortality with earlier date of first employment in the industry. This could be a result of a very low absolute mortality rate in the baseline group, as shown by the data in Table 11.

Table 11: All-cause mortality among men by period of first employment, adjusted for age, calendar period of follow-up and smoking (ever vs never), compared to those employed after 1975

Period of First Employment	Person-years	Number Employees	Deaths	RMR	95% C.I.
Post 1975	203379	9670	461	1.00	
1965-1974	110412	4294	709	*1.23*	*1.08 - 1.40*
1955-1964	43083	1815	678	*1.41*	*1.22 - 1.64*
Pre 1954	19727	860	417	*1.39*	*1.17 - 1.65*

Test for heterogeneity p = 0.0001 Test for trend p = 0.0001

All-cause mortality among men by duration of employment

Table 12 shows the mortality rates of male cohort members according to the duration of employment in the industry compared to the general population. The findings are similar to those relating to period of entering the industry, and are largely due to a low absolute mortality rate in the baseline group employed for 5-9 years. The SMR for this group was 0.70. This is also likely to be due to the low mortality rate of those who entered the industry most recently, since those employed longest are likely to also be in the group who entered the cohort in earlier years.

Table 12: Standardised all-cause mortality among men by duration of employment, adjusted for age and calendar period of follow-up, compared to the Australian population

Duration of Employment	Person-years	Number Employees	Observed	Expected	SMR	95% C.I.
5-9 Years	75402	10649	164	234.35	*0.70*	*0.60 - 0.82*
10-15 Years	81986	10612	302	383.23	*0.79*	*0.70 - 0.88*
16-19 Years	72661	9462	346	490.02	*0.71*	*0.63 - 0.78*
20-24 Years	57893	7701	358	520.48	*0.69*	*0.62 - 0.76*
≥ 25 Years	88551	6046	1095	1499.00	*0.73*	*0.69 - 0.78*

Table 13 shows the mortality rates of males within the cohort according to the duration of employment in the industry. The comparisons are made with the category of shortest duration in the industry – members of the cohort who were employed between five and nine years. It should be noted that individual members of the cohort can contribute to person-years in more than one category as their duration of employment increases.

Compared with the baseline group (employed for 5-9 years), the mortality rate from all causes combined is similar in all categories of duration of employment. There is no trend of increasing risk with increasing duration of employment.

Table 13: Relative all-cause mortality among men by duration of employment, adjusted for age, calendar period of follow-up and smoking (ever vs never), compared to those employed for 5-9 years

Duration of Employment	Person-years	Number Employees	Deaths	RMR	95% C.I.
5-9 Years	75402	10651	164	1.00	
10-15 Years	81986	10614	302	1.05	0.87 - 1.27
16-19 Years	72661	9464	346	0.90	0.74 - 1.09
20-24 Years	57893	7701	358	0.87	0.72 - 1.06
≥ 25 Years	88551	6048	1095	0.93	0.77 - 1.10

Test for heterogeneity p = 0.14 Test for trend p = 0.16

All-cause mortality among men by time since first employment

Table 14 shows mortality rates for male cohort members according to the time since first employment in the industry compared to the general population. It shows that all groups have lower mortality than the age matched general population. In addition, external comparison with the general population shows that there is a very low SMR in the baseline category of 0.51.

Table 15 shows the mortality rates for males, within the cohort, according to the time since first employment in the industry. The comparisons are made with the category of shortest time - members of the cohort who were employed between five and nine years ago. It should be noted that individual members of the cohort can contribute to person-years in more than one category as their time since first employment increases.

The mortality significantly increases with time since first employment (trend test 0.01) and is highest in the group employed for 25 years or more. The *healthy worker effect* is known to diminish with age and is the most likely explanation for this finding.

Table 14: Standardised all-cause mortality among men by time since first employment, adjusted for age and calendar period of follow-up, compared to the Australian population

Time Since First Employment	Person-years	Number Employees	Observed	Expected	SMR	95% C.I.
5-9 Years	40618	10653	41	80.63	*0.51*	*0.36 - 0.69*
10-15 Years	57107	12709	97	149.08	*0.65*	*0.53 - 0.79*
16-19 Years	63757	13861	131	230.25	*0.57*	*0.48 - 0.68*
20-24 Years	61981	13953	203	320.68	*0.63*	*0.55 - 0.73*
≥ 25 Years	153134	12894	1793	2347.18	*0.76*	*0.73 - 0.80*

Table 15: Relative all-cause mortality among men by time since first employment, adjusted for age, calendar period of follow-up and smoking (ever vs never), compared to the those first employed 5-9 years ago

Time Since First Employment	Person-years	Number Employees	Deaths	RMR	95% C.I.
5-9 Years	40618	10653	41	1.00	
10-15 Years	57107	12709	97	1.30	0.89 - 1.91
16-19 Years	63757	13861	131	1.14	0.77 - 1.68
20-24 Years	61981	13953	203	1.23	0.84 - 1.82
≥ 25 Years	153134	12894	1793	*1.46*	*1.00 - 2.14*

Test for heterogeneity p = 0.03 Test for trend p = 0.01

Overall Mortality of Men in the Health Watch Cohort

For men, overall death rates are low. Death rates in all major disease categories – circulatory, including heart disease, cancer, respiratory disease, diseases of the digestive system, and external causes (accidents, violence etc) – are also significantly lower than the corresponding population.

There is no trend of increasing mortality with increasing duration of employment. There is evidence of a trend by time period of first employment and time since first employment.

The overall mortality is particularly low for the most recently employed men compared to the general population. It may be the low mortality in the baseline comparative group that explains the apparent increase in mortality in those first employed in earlier years.

3.6.3. Incidence of Site-specific Cancer among Men

Site-specific cancer incidence ratios for men are shown in **Table 16**. This table lists the number of cases from particular cancers observed in the *Health Watch* population, the number expected, and the calculated SIRs.

Table 16: Cancer incidence by major anatomical site in men by ICD-10 codes, adjusted for age and calendar period of follow-up, compared to the Australian population

Anatomical Site	ICD-10	Observed	Expected	SIR	95% C.I.
Lip, oral cavity and pharynx	C00-C14	98	123.03	*0.80*	*0.65 - 0.97*
Oesophagus	C15	41	38.69	1.06	0.76 - 1.44
Stomach	C16	65	65.91	0.99	0.76 - 1.26
Colon	C18	205	216.03	0.95	0.82 - 1.09
Rectum	C19-C21	158	151.58	1.04	0.89 - 1.22
Liver	C22	17	31.68	*0.54*	*0.31 - 0.86*
Gallbladder	C23-C24	8	13.14	0.61	0.26 - 1.20
Pancreas	C25	46	51.67	0.89	0.65 - 1.19
Larynx	C32	27	35.14	0.77	0.51 - 1.12
Lung	C33-C34	245	309.98	*0.79*	*0.69 - 0.90*
Melanoma	C43	331	278.55	*1.19*	*1.06 - 1.32*
Mesothelioma	C45	39	22.95	*1.70*	*1.21 - 2.32*
Connective tissue	C47-49	9	15.10	0.60	0.27 - 1.13
Prostate	C61	730	639.59	*1.14*	*1.06 - 1.23*
Testis	C62	23	20.10	1.14	0.73 - 1.72
Bladder	C67	83	81.94	1.01	0.81 - 1.26
Kidney	C64-C66, C68	76	82.12	0.93	0.73 - 1.16
Eye	C69	6	7.54	0.80	0.29 - 1.73
Brain & nervous system	C70-C72	45	42.78	1.05	0.77 - 1.41
Non-Hodgkin lymphoma	C82-C85, C96	101	100.10	1.01	0.82 - 1.23
Multiple myeloma	C90	37	31.75	1.17	0.82 - 1.61
Leukaemia	C91-C95	55	68.60	0.80	0.60 - 1.04
Acute lymphatic leukaemia	C910	3	2.94	1.02	0.21 - 2.99
Chronic lymphatic leukaemia	C911	23	28.49	0.81	0.51 - 1.21
Acute myeloid leukaemia	C920	10	16.13	0.62	0.30 - 1.14
Chronic myeloid leukaemia	C921	10	7.81	1.28	0.61 - 2.36
Other leukaemia	C91-C95, **but not** C910, C911, C920, C921	9	13.24	0.68	0.31 - 1.29
Acute non-lymphocytic leukaemia (ANLL)	C920, C924, C925, C930, C940, C942, C944, C945, C950	14	20.24	0.69	0.38 - 1.16
[a]**Myelodysplastic Syndrome**	D46.9	14	10.24	1.37	0.75 - 2.29
Unspecified or unknown sites	C76-C80, C26, C39	60	77.50	0.77	0.59 - 1.00
Other sites	-	58	75.76	*0.75*	*0.57 - 0.97*
Total	-	**2586**	**2596.54**	**1.00**	**0.96 - 1.04**

[a] Nine Myelodysplastic Syndrome (MDS) cases have not been included in this table because they were diagnosed before 2003 and the national population data set for MDS needed to calculate the SMR, is only available from 2003 onwards.

There are statistically significant excess cases of mesothelioma and melanoma of the skin. These excesses were also observed in the previous report. The excess of prostate cancer was observed previously and has now reached statistical significance. The incidences of chronic myeloid leukaemia and myelodysplastic syndrome (MDS) are somewhat elevated however the increases are not statistically significant. MDS has been found to be associated with benzene exposure in the petroleum industry.(41)

There is a statistically significant lowering of incidence of lung and liver cancer and cancer of the lip, oral cavity and pharynx. These reductions were also observed in the previous report, however, the reduction in liver cancer is now statistically significant.(5)

3.6.4.Cancer and Time Relationships for Men

Cancer incidence and mortality according to period of first employment

Table 17 shows that there is no significant trend in cancer incidence with period of first employment. Cancer mortality rates, however, are significantly higher for those men in the earlier periods of initial employment in the industry (p=0.03).

Table 17: Cancer incidence and cancer mortality by period of first employment, adjusted for age and calendar period of follow-up, and ever/never smoker compared to those employed after 1975

Period of First Employment	Cancers	Incidence RIR	95% C.I.	Deaths	Mortality RMR	95% C.I.
Post 1975	724			209		
1965-1974	874	1.07	0.96 - 1.19	308	1.15	0.95 - 1.39
1955-1964	625	1.10	0.96 - 1.26	268	*1.27*	*1.02 – 1.60*
Pre 1954	363	1.12	0.96 - 1.32	166	*1.32*	*1.01 - 1.71*

Incidence: Test for heterogeneity p = 0.50 Test for trend p = 0.15
Mortality: Test for heterogeneity p = 0.15 Test for trend p = 0.03

Cancer incidence and mortality according to duration of employment

Table 18 shows relative cancer incidence and mortality by duration of employment. There is no significant trend in cancer incidence and cancer mortality with increasing duration of employment.

Table 18: Cancer incidence and cancer mortality by duration of employment, adjusted for age and calendar period of follow-up, and ever/never smoker compared to those employed for 5-9 years

Duration of Employment	Cancers	Incidence RIR	95% C.I.	Deaths	Mortality RMR	95% C.I.
5-9 Years	214	1.00		64	1.00	
10-15 Years	351	0.97	0.82 - 1.16	135	1.16	0.86 - 1.57
16-19 Years	400	0.86	0.72 - 1.02	142	0.89	0.65 - 1.20
20-24 Years	458	0.95	0.80 - 1.13	154	0.89	0.66 - 1.21
≥ 25 Years	1161	0.98	0.84 - 1.15	456	0.96	0.73 - 1.28

Incidence: Test for heterogeneity p = 0.19 Test for trend p = 0.61
Mortality: Test for heterogeneity p = 0.18 Test for trend p = 0.34

Cancer incidence and mortality by time since first employment

Table 19 shows relative cancer incidence and mortality by time elapsed from first employment to date of diagnosis or death. Note that this is not employment time but rather time elapsed since first employed. The findings are very similar to those according to duration of employment. There is no relationship between cancer incidence and time since first employment. Cancer mortality for those employed more than ten years prior to diagnosis is increased relative to those whose cancer arose within ten years of joining the industry. This is likely to be attributable to a low absolute mortality rate in the baseline category of those members of the cohort employed 5-9 years previously.

Table 19: Cancer incidence and mortality by time since first employment, adjusted for age and calendar period of follow-up, and ever/never smoker compared to those first employed 5-9 years ago

Time Since First Employment	Cancers	Incidence RIR	95% C.I.	Deaths	Mortality RMR	95% C.I.
5-9 Years	51	1.00		8	1.00	
10-15 Years	132	*1.26*	*1.00 - 1.76*	43	*2.73*	*1.25 - 5.94*
16-19 Years	192	1.06	0.76 - 1.48	52	1.92	0.87 - 4.25
20-24 Years	302	1.14	0.81 - 1.59	90	2.12	0.96 - 4.68
≥ 25 Years	1908	1.22	0.88 – 1.70	758	*2.40*	*1.10 - 5.24*

Incidence: Test for heterogeneity $p = 0.26$ Test for trend $p = 0.23$
Mortality: Test for heterogeneity $p = \mathit{0.04}$ Test for trend $p = 0.18$

Cancer Incidence and Mortality among Men in the Health Watch Cohort

The chance of getting cancer is the same for men in the petroleum industry as for the general Australian population. This is so for all cancers combined and for most individual cancer types. However some cancers – mesothelioma, melanoma of the skin and prostate cancer - have occurred at significantly higher rates compared with the general population. Prostate cancer was observed to be in excess in the previous report but had not reached statistical significance. Melanoma incidence is linked with sun exposure and it is unlikely that the excess is caused by a factor in the workplace in this industry. The incidence of prostate cancer, particularly compared to the previous report, suggest improved screening compared to the general population and a screening bias.

There is a significant lowering of the rates of liver and lung cancer and cancers of the lip, oral cavity and pharynx compared with the general population. The age-adjusted mortality rate from all cancers combined is significantly less than in the general population.

Those who worked in the industry in earlier times have not been at a significantly greater risk of developing cancer than those who entered the industry more recently.

Cancer mortality rates are particularly low in the early years following entry into the industry, possibly due to a selection effect; that is, people who are diagnosed with cancer do not enter or remain in the workforce for five years so they do not qualify to enter the cohort. This might explain why in the earlier years of follow-up, the death rate in the workforce is so much lower than in the general population.

3.6.5. Workplace Type and Health Outcomes among Men

Analyses were undertaken for the five principal workplace types – refineries, terminals, airports, onshore production and offshore production. Men were grouped by the site of their most recent job. Table 20: Numbers of male members of the cohort in each workplace type

Workplace Type	Number of men in cohort	%	Person-years	% of person-years
Refinery	6492	39.0	149072	39.6
Terminal	6478	38.9	147999	39.3
Airport	604	3.6	14196	3.8
Onshore Production	2326	14.0	48381	12.8
Off Shore Production	739	4.4	16953	4.5
Total	**16639**	**100.0**	**376601**	**100.0**

Table 20: Numbers of male members of the cohort in each workplace type

Workplace Type	Number of men in cohort	%	Person-years	% of person-years
Refinery	6492	39.0	149072	39.6
Terminal	6478	38.9	147999	39.3
Airport	604	3.6	14196	3.8
Onshore Production	2326	14.0	48381	12.8
Off Shore Production	739	4.4	16953	4.5
Total	**16639**	**100.0**	**376601**	**100.0**

The all-cause mortality by workplace type is shown in Table 21. All-cause mortality continues to be significantly lowered in all workplace types.

Table 21: All-cause mortality in men by workplace type, adjusted for age and calendar period of follow-up, compared to the Australian population

Workplace Type	Number of men in cohort	Person-years	Observed	Expected	SMR	95% C.I.
Refinery	6492	149072	888	1305.94	*0.68*	*0.64 - 0.73*
Terminal	6478	147999	1060	1343.36	*0.79*	*0.74 - 0.84*
Airport	604	14196	90	133.05	*0.68*	*0.54 - 0.83*
Onshore production	2326	48381	175	264.85	*0.66*	*0.57 - 0.77*
Offshore Production	739	16953	52	80.65	*0.64*	*0.48 - 0.85*
Total	**16639**	**376601**	**2265**	**3127.84**	***0.72***	***0.69 - 0.75***

Table 22 shows mortality from ischaemic heart disease by workplace type. SMRs are lowered in each workplace type and the difference is statistically significant except for Offshore Production workers where there are small numbers.

Table 22: Ischaemic heart disease (ICD-10 I20-I25) mortality for men by workplace type, adjusted for age and calendar period of follow-up, compared to the Australian population

Workplace Type	Number of men in cohort	Person-years	Observed	Expected	SMR	95% C.I.
Refinery	6492	149072	191	281.78	*0.68*	*0.59 - 0.78*
Terminal	6478	147999	251	290.63	*0.86*	*0.76 - 0.98*
Airport	604	14196	12	28.61	*0.42*	*0.22 - 0.73*
Onshore production	2326	48381	32	51.38	*0.62*	*0.43 - 0.88*
Offshore Production	739	16953	11	15.14	0.73	0.36 - 1.30
Total all workplaces	**16639**	**376601**	**497**	**667.53**	**0.74**	***0.68 - 0.81***

Table 23 shows the incidence of cancer in the different workplace types. All five categories of workplace type show total cancer risks which are no different from that of the general population.

Table 23: Cancer incidence among men by workplace type, adjusted for age and calendar period of follow-up, compared to the Australian population

Workplace Type	Number of men in cohort	Person-years	Observed	Expected	SIR	95% C.I.
Refinery	6492	138049	1039	1054.23	0.99	0.93 - 1.05
Terminal	6478	137758	1134	1108.25	1.02	0.96 - 1.08
Airport	604	13182	114	110.92	1.03	0.85 - 1.23
Onshore production	2326	44160	229	243.17	0.94	0.82 - 1.07
Offshore Production	739	15603	70	79.97	0.88	0.68 - 1.11
Total all workplaces	**16639**	**348752**	**2586**	**2596.54**	**1.00**	**0.96 - 1.04**

As shown in Table 24, cancer mortality is lower than population rates in all workplace types, but the difference is statistically significant for refinery and on-shore production workers only. The SMR for Terminal workers is 0.91, however, this reduction is no longer statistically significant as it was in the 13th Report, with the upper confidence limit now equalling one. The SMRs for the other production workers are similar to that of refinery workers but do not reach statistical significance.

Table 24: Cancer mortality among men by workplace type, adjusted for age and calendar period of follow-up, compared to the Australian population

Workplace Type	Number of men in cohort	Person-years	Observed	Expected	SMR	95% C.I.
Refinery	6492	149072	358	472.36	*0.76*	*0.68 - 0.84*
Terminal	6478	147999	452	494.98	0.91	0.83 - 1.00
Airport	604	14196	40	49.42	0.81	0.58 - 1.10
Onshore production	2326	48381	77	97.67	*0.79*	*0.62 - 0.99*
Offshore Production	739	16953	24	30.47	0.79	0.50 - 1.17
Total all workplaces	**16639**	**376601**	**951**	**1144.90**	***0.83***	***0.78 - 0.89***

Health and Workplace Type

The health of male employees as measured from the Health Watch results differs very little between those who worked at the various types of workplaces in the industry, such as upstream production sites and downstream refineries, terminals and distribution sites. That is, the chances of dying, or of getting cancer or heart disease are very similar no matter where Health Watch people worked.

3.7. Non-malignant Disease from Asbestos Exposure

Apart from its association with certain types of cancer (mesothelioma and lung cancer), asbestos exposure can cause non-malignant conditions, including pleural plaques and asbestosis. Pleural plaques are deposits of fibrous tissue (sometimes becoming calcified) on the pleural lining of the chest cavity. They are the commonest manifestation of asbestos exposure, but in general, they are not disabling.

Asbestosis is a disease affecting the lung tissue itself, and can cause breathlessness and other respiratory symptoms, associated disability such as reduced walking tolerance, and can be fatal. Asbestosis can also lead to an increased risk of lung cancer. There is also increasing evidence that asbestos exposure in itself, even in the absence of asbestosis, can increase the risk of lung cancer, although there is no universal agreement on this conclusion.(42,43)

Five members of the *Health Watch* cohort have died from asbestosis (SMR 1.80, C.I. 0.59 – 4.21). This does not represent the full picture because an additional 100 members of the cohort have reported asbestos related illnesses. It is important to note that these self-reported illnesses are not validated and are therefore not included in any analyses. Asbestosis is not necessarily a fatal condition and it is not possible to identify all living cases. Unlike cancer, there is no universal register for asbestosis or pleural plaques which have not resulted in death.

A previous report examined the reporting of asbestos related diseases by members of the cohort.(9) As the 12th Report stated,

"It is likely that these figures understate the prevalence of effects of asbestos exposure, especially of pleural plaques. Not all members of the cohort reply to the periodic questionnaires. Moreover, since pleural plaques commonly produce no symptoms, they may remain undiagnosed unless the subject has a chest x-ray.

Full enumeration of these effects of asbestos exposure would require a study of different design to *Health Watch*."

Non-malignant Asbestos Diseases

Non-malignant asbestos-related diseases are found in the cohort, both through the mortality data and self-report. The significance of the self-report finding cannot be assessed because there are no suitable comparative data collected in the general population. In addition, the voluntary nature of the reporting probably underestimates the prevalence in the cohort.

4. LIFE STYLE FACTORS AMONG MALE MEMBERS OF THE COHORT

4.1. Tobacco Smoking

4.1.1. Smoking Status

The smoking status of each member of the cohort used in the analyses in this report is based on smoking habits reported at initial and later interviews, with information at the last interview being the category used in the analyses below. After retirement or leaving the industry, additional information has been derived from postal surveys of all retired and resigned members carried out during 1994, 1996 and 1999 in combination with the Health Letters, the last one being in 2007.

In the 11th *Health Watch* Report, (11) the smoking prevalence was compared with national smoking data based on 1995 estimates, using direct standardisation for age. The *Health Watch* male smoking rate was 24.1% compared with the Australian population rate of 28.2%. On this basis, the age-standardised smoking prevalence was slightly less than in the Australian national population. In the 12th Report, updated figures were used based on the proportion of Australian smoking rates from 1980 to 2001.(36) Age-specific comparisons showed that for older people (over 50) the smoking rates were 5-10% higher in *Health Watch* but for the younger people (under 30) the smoking rates in *Health Watch* were much lower, about half of that in the general population.

Figure 2 shows that a minority of men in the *Health Watch* cohort smoke and comparison with the 13th Report shows that there are slightly more ex-smokers now than previously reported.

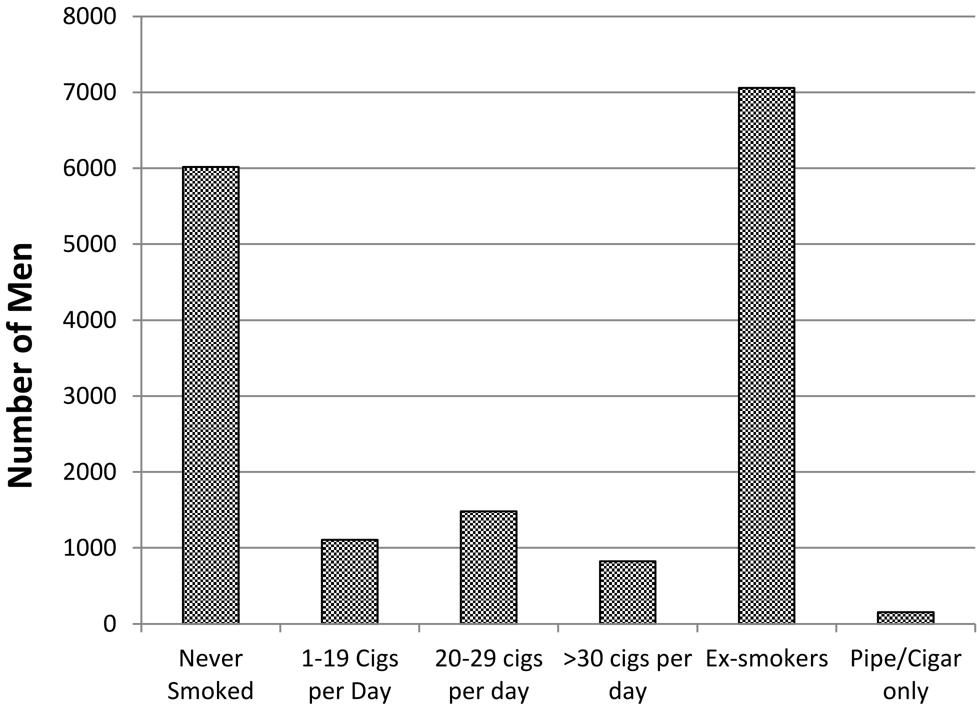


Figure 2: Current smoking status of the men in the *Health Watch* cohort

Table 25 shows that some of the data used for the smoking analyses were collected as long ago as the early 1980s. It is possible that some of these individuals have changed their smoking habits but have not informed the study team. Since more individuals reported being smokers than being non-smokers and the trend in Australia has been to quit, it is probable that a survey of current smoking habits would report a reduction in smoking rates. That is, it is possible that fewer of the older people in the cohort, those recruited in Surveys 1 and 2, remain smokers.

Table 25: Source of most recent smoking data for individuals in the cohort.

Source of Data	Period	Number	Percentage
Survey 1	1981-83	1583	8.8
Survey 2	1986-87	2279	12.6
Survey 3	1991-93	3609	20.0
Survey 4	1996-2000	3997	22.2
Survey 5	2003	1881	10.4
Health letter updates	Various	4675	25.9
Total		**18024**	**100.0**

4.1.2. Smoking and All-cause Mortality among Men

In Table 26 the relative mortality ratios among men for all-cause mortality are shown according to smoking habit. These tables compare various categories of smokers relative to a baseline of those who have never smoked. The comparison clearly shows a marked increase in age-adjusted mortality with increasing tobacco use. Men smoking up to 19 cigarettes a day have two and a half times the age-adjusted death rate from all causes combined, compared with those who have never smoked. For those smoking 20-29 cigarettes per day there is a 3 fold increase in risk, and there is nearly a four-fold risk at 30+ cigarettes per day. Unlike in the 13th report, ex-smokers also have a statistically significant increase in mortality risk, although this increase is much less than for current smokers. The trend for increasing age-adjusted mortality with increasing smoking level is highly statistically significant. This analysis once again shows a strong and steep effect as did the results in the 13th Report.

Table 26: All-cause mortality by smoking category, adjusted for age and calendar period of follow-up, compared to those who never smoked

Smoking Category	Person-years	Deaths	RMR	95% C.I.
Never	133560	488	1.00	
1-19 / day	23248	167	*2.55*	*2.14 - 3.04*
20-29 / day	31770	322	*3.06*	*2.65 - 3.52*
30+ / day	17680	224	*3.83*	*3.27 - 4.49*
Ex-smoker	166993	1032	*1.16*	*1.04 - 1.30*
Pipe/cigar only	3350	32	*2.54*	*1.78 - 3.64*

Test for heterogeneity $p < 0.0001$ Test for trend $p < 0.0001$

4.1.3. Smoking and Ischaemic Heart Disease (ICD-10 I20-I25)

Many studies have shown that smoking is a major risk factor for ischaemic heart disease and this is confirmed in the *Health Watch* cohort. Table 27 shows that smoking dramatically affects the chance of dying from heart attack for men in the *Health Watch* cohort. It is reasonable to assume that smoking similarly increases the risk of suffering a heart attack, even if death is not the outcome. Quitting appears to dramatically reduce the risk, however the risk is still slightly elevated compared to those who have never smoked.

Table 27: Ischaemic heart disease mortality (ICD-10 I20-I25) among men by smoking category, adjusted for age and calendar period of follow-up, compared to those who never smoked

Smoking Category	Person-years	Deaths	RMR	95% C.I.
Never	133560	101	1.00	
1-19 / day	23248	34	*2.30*	*1.56 - 3.40*
20-29 / day	31770	69	*3.03*	*2.23 - 4.12*
30+ / day	17680	61	*4.75*	*3.45 - 6.53*
Ex-smoker	166993	221	*1.30*	*1.03 - 1.65*
Pipe/cigar only	3350	11	*4.17*	*2.23 - 7.76*

Test for heterogeneity $p < 0.0001$ Test for trend $p < 0.0001$

4.1.4. Smoking and Cancer among Men

Table 28 and Table 29 show the relationship between total cancer incidence and total cancer mortality and smoking. As with all-cause mortality, both of these outcomes show a striking and significant increase in risk with increasing tobacco use. Unlike the results reported in the 13th report, ex-smokers appear to have a slightly greater risk of cancer and cancer mortality compared to those who have never smoked.

Table 28: Cancer incidence among men by smoking category, adjusted for age and calendar period of follow-up, compared to those who never smoked

Smoking Category	Person-years	Cancers	RIR	95% C.I.
Never	122860	700	1.00	
1-19 / day	21443	137	*1.36*	*1.13 - 1.63*
20-29 / day	29542	230	*1.42*	*1.23 - 1.65*
30+ / day	16517	155	*1.70*	*1.43 - 2.03*
Ex-smoker	155271	1341	*1.11*	*1.01 - 1.22*
Pipe/cigar only	3119	23	1.21	0.80 - 1.83

Test for heterogeneity $p <0.0001$ Test for trend $p < 0.0001$

Table 29: Cancer mortality among men by smoking category, adjusted for age and calendar period of follow-up, compared to those who never smoked

Smoking Category	Person-years	Deaths	RMR	95% C.I.
Never	133560	200	1.00	
1-19 / day	23248	75	*2.78*	*2.13 - 3.62*
20-29 / day	31770	135	*3.08*	*2.47 - 3.83*
30+ / day	17680	95	*3.89*	*3.04 - 4.97*
Ex-smoker	166993	437	*1.20*	*1.02 - 1.42*
Pipe/cigar only	3350	9	1.70	0.87 - 3.32

Test for heterogeneity $p <0.0001$ Test for trend $p < 0.0001$

Table 30 shows the relationship between smoking and lung cancer incidence. For this outcome, the relationship to smoking is very strong; a 16-fold increase in risk in those smoking up to 19 cigarettes per day compared with the risk in those who have never smoked, a 21-fold increase in risk for those who smoke 20-29 cigarettes per day, and a 41-fold increase in risk for those who smoke 30+ cigarettes per day. Those who report having quit smoking have a 6-fold increase in risk compared to those who never smoked. The risks of lung cancer are higher than those reported in the last report, except for cigar smokers where the numbers are very small.

This analysis reaffirms that lung cancer in people who have never been active smokers is a rare disease. There are only ten lifelong non-smokers in the cohort who have developed lung cancer, a small baseline group so the estimates of increasing risk with increasing tobacco use are approximate only. Nevertheless one of the great strengths of *Health Watch* is that the smoking histories have been collected prospectively. In most epidemiological studies, smoking histories are collected retrospectively, giving lung cancer cases the opportunity to deny previous tobacco use or to minimise their tobacco consumption.

It should be emphasised that the comparisons in Table 30 showing excess risk are comparisons made within the cohort. The *Health Watch* cohort as a whole has a significantly reduced rate of lung cancer incidence compared with the general male population (Table 16)

Table 30: Lung cancer incidence (ICD-10 C33-C34) among men by smoking category, adjusted for age and calendar period of follow-up, compared to those who never smoked

Smoking Category	Person-years	Cancers	RIR	95% C.I.
Never	122860	10	1.00	
1-19 / day	21443	21	*15.86*	*7.46 - 33.71*
20-29 / day	29542	45	*20.71*	*10.43 - 41.12*
30+ / day	16517	50	*41.25*	*20.90 - 81.43*
Ex-smoker	155271	116	*6.22*	*3.26 - 11.87*
Pipe/cigar only	3119	3	*11.56*	*3.18 - 42.04*

Test for heterogeneity p <0.0001 Test for trend p< 0.0001

Table 31 shows the association between smoking and lung cancer mortality for men. Here the trend is similar to that of lung cancer incidence but the estimates of relative risk, which are greater than those for lung cancer incidence, are less reliable because the baseline comparison group of non-smokers contains only five deaths.

Table 31: Lung cancer mortality (ICD-10 C33-C34) among men by smoking category, adjusted for age and calendar period of follow-up, compared to those who never smoked

Smoking Category	Person-years	Deaths	RMR	95% C.I.
Never	133560	5	1.00	
1-19 / day	23248	19	*28.72*	*10.72 - 76.97*
20-29 / day	31770	45	*41.45*	*16.44 -104.50*
30+ / day	17680	43	*70.96*	*28.08 -179.40*
Ex-smoker	166993	88	*9.44*	*3.83 -23.26*
Pipe/cigar only	3350	3	*22.90*	*5.47 -95.88*

Test for heterogeneity p <0.0001 Test for trend p <0.0001

4.1.5. Smoking and Bladder Cancer (ICD-10 C67)

An analysis was performed on the association between bladder cancer and smoking by smoking category. The results are shown in Table 32. There is a strong and statistically significant trend of increased bladder cancer incidence with increasing tobacco use. The estimated relative risk in the category of smoking 1-19 or more cigarettes per day is two and half times greater (but not statistically significantly) than those who have never smoked. This lack of significance may be attributable to there being only three cases in this category producing very broad confidence intervals. The remaining categories all show a statistically significant increase in bladder cancer, up to more than five times for those who smoke more than 30 cigarettes per day, compared to those who have never smoked.

Table 32: Bladder cancer incidence (ICD-10 C67) by smoking category, adjusted for age and calendar period of follow-up, compared to those who never smoked

Smoking Category	Person-years	Cancers	RIR	95% C.I.
Never	122860	9	1.00	
1-19 / day	21443	3	2.51	0.68 - 9.27
20-29 / day	29542	9	*4.49*	*1.78 -11.33*
30+ / day	16517	6	*5.39*	*1.92 -15.18*
Ex-smoker	155271	53	*3.08*	*1.52 - 6.26*
Pipe/cigar only	3119	3	*12.29*	*3.32 -45.48*

Test for heterogeneity p = 0.0005 Test for trend p = 0.003

4.1.6. Deaths Attributable to Smoking among Men in the Cohort

Health Watch cannot identify which individual deaths are caused by smoking but can provide an indication of the numbers of premature deaths attributable to the smoking habit. The effect is so critical to the future health of those in the cohort, that even crude figures are felt to be worth publishing (

Figure **3** and Figure 4). NB note the difference in scale between Figure 3 and Figure 4.

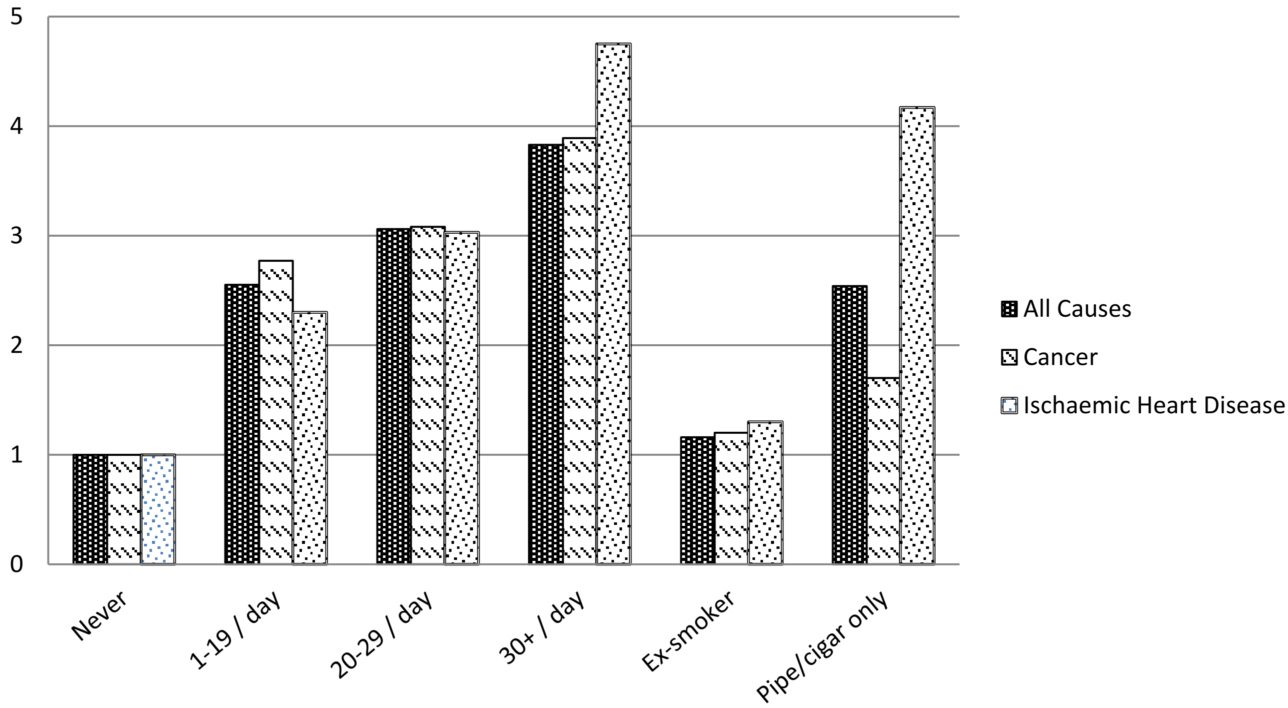


Figure 3: Relative risk of dying from any cause, of cancer or of ischaemic heart disease among men for different smoking categories, compared to those who never smoked. (The RMRs are adjusted for age and calendar year)

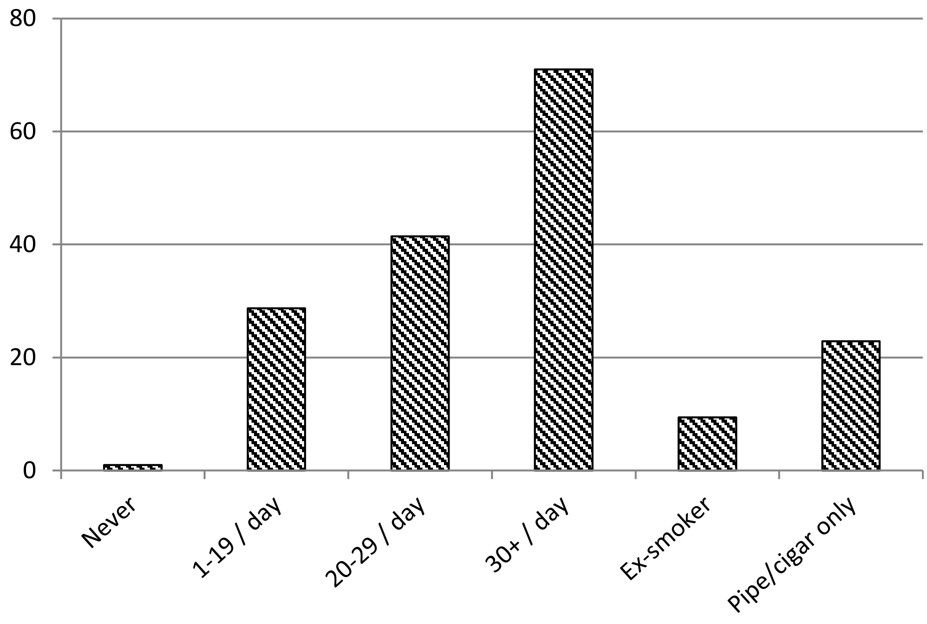


Figure 4: Relative risk of dying from lung cancer among men for different smoking categories compared to those who never smoked. (The RMRs are adjusted for age and calendar year)

The effect of smoking on health risks for members of *Health Watch* is demonstrated in the results for lung cancer and ischaemic heart disease, being specific causes of death which can be analysed for smoking. It is likely that other smoking-related diseases are also occurring in the cohort, just as they are in the Australian population as a whole. Crude analyses[1] of the results indicate that smoking probably causes about 43% of the ischaemic heart disease deaths and therefore about 214 men in the cohort have died of heart attacks over the past 33 years due to smoking. Smoking accounts for nearly all lung cancers in the cohort but many other cancers are smoking-related as well.

Altogether it is estimated that smoking has been a contributing factor to about 41% of all male cancer deaths in the cohort, i.e. about 390 men. Combining all-causes of death, it is estimated that smoking has played a part in the deaths of about 883 men, or 39% of the 2265 deaths that have occurred in the *Health Watch* cohort.

4.1.7.Effects of Quitting

Men who give up smoking have better outcomes than those who continue to smoke. The effects of quitting are of interest to those in the cohort who have quit, and to those who might be encouraged to do so. The benefit of quitting smoking on mortality and cancer incidence can clearly be seen in the *Health Watch* cohort.

[1] The estimates of excess deaths was computed by comparing the actual numbers of deaths with the number expected if the smokers had the same mortality rate as non-smokers. The expected numbers were derived by multiplying the rates for non-smokers by number of person-years of follow-up in all the smoking categories combined. These were not age standardised.

The RMR for deaths from all-causes is about 16% higher in ex-smokers compared with those who have never smoked (RMR 1.16, 95% C.I. 1.04-1.30). In the case of death from ischaemic heart disease the RMR in ex-smokers is greater than of those who have never smoked (RMR 1.30, 95% C.I. 1.03 - 1.65), but is nearly one-half of the risk relative to those who continue to smoke 1-19 cigarettes per day and much less than those who smoke more. In the 13th Report, the relative risk of overall mortality was 1.04 (95% C.I. 0.09 - 1.19) and the ischaemic heart disease risk was (RMR1.18, 95% C.I. 0.89 - 1.55) which was not statistically different to those of non-smokers at that time.

For all cancer deaths combined, the rate in ex-smokers was not statistically significantly different from that of those who have never smoked in the 13th report (RMR 1.02, 95% C.I. 0.82 - 1.27). The risk is slightly more elevated in this analysis (RMR 1.20, 95% C.I. 1.02 - 1.42).

For lung cancer mortality the risk in ex-smokers remains higher than in those who have never smoked (RMR 9.44, 95% C.I. 3.83 - 23.26) but only a third of the risk in those who continue to smoke 1-19 cigarettes per day. In the 13th Report lung cancer RMR among ex-smokers was 10.75 (95% C.I. 2.60 - 44.43).

For lung cancer incidence, the risk in ex-smokers remains higher than in those who have never smoked (RIR 6.22, 95% C.I. 3.26 – 11.87), but less than half of the risk in those who continue to smoke 1-19 cigarettes per day. In the 13th Report lung cancer RIR among ex-smokers was 6.58 (95% C.I. 2.65 - 16.35).

These data show a slightly higher risk than that reported previously for all-cause mortality, IHD mortality, all cancer mortality and lung cancer mortality among ex-smokers when compared to never smokers. Relative risk for lung cancer incidence is slightly lower than that reported previously. Other studies have shown that the risk of lung cancer in men and women declines as the time since quitting increases.(44-46)

4.2. Alcohol Consumption among Men

All-cause mortality is influenced by alcohol intake. Table 33 shows the relationship between drinking alcohol and death from all-causes. Because many important causes of death from alcohol are also affected by smoking, adjustment has been made in the analysis to allow for the influence of smoking. Consumption of more than five alcoholic drinks per day (at least 36 per week) is associated with an increase in age-standardised mortality compared with total abstainers. A significant increase in risk of all-cause mortality is observed in those that reported consuming more than 7 alcoholic drinks per day. The significant reduction in risk observed in previous reports is associated with those men that reported drinking fewer than 22 drinks per week.

Table 33: All-cause mortality by alcohol category for men, adjusted for age, calendar year and smoking (ever vs never), compared to those who never drank alcohol

Number of Drinks/Week	Person-years	Deaths	RMR	95% C.I.
Nil	64519	483	1.00	
1-7	91923	465	*0.80*	*0.70 - 0.90*
8-21	115287	558	*0.79*	*0.70 - 0.89*
22-35	48903	304	0.94	0.81 - 1.09
36-49	28988	210	1.14	0.97 - 1.34
50+	26980	245	*1.31*	*1.12 - 1.53*

This protective effect of low to moderate drinking produces a "U-shaped" or “J-shaped” curve, as shown in Figure 5. This finding has been reported in other studies including a meta-analysis of 34 different studies. (47-49)

Table 34 shows the association between alcohol consumption and mortality from ischaemic heart disease. This analysis also adjusted for tobacco use, which is an important contributing factor to heart disease. This table shows a significant reduction in mortality from heart disease in those consuming less than 36 drinks per week compared with total abstainers. The protective effects of alcohol consumption are observed at a higher volume of alcohol consumption compared to the 13th report where the protective effects of alcohol was diminished at more than 21 drinks per week. The risk of ischaemic heart disease is increased compared with alcohol abstainers when alcohol consumption exceeds 50 or more drinks per week.

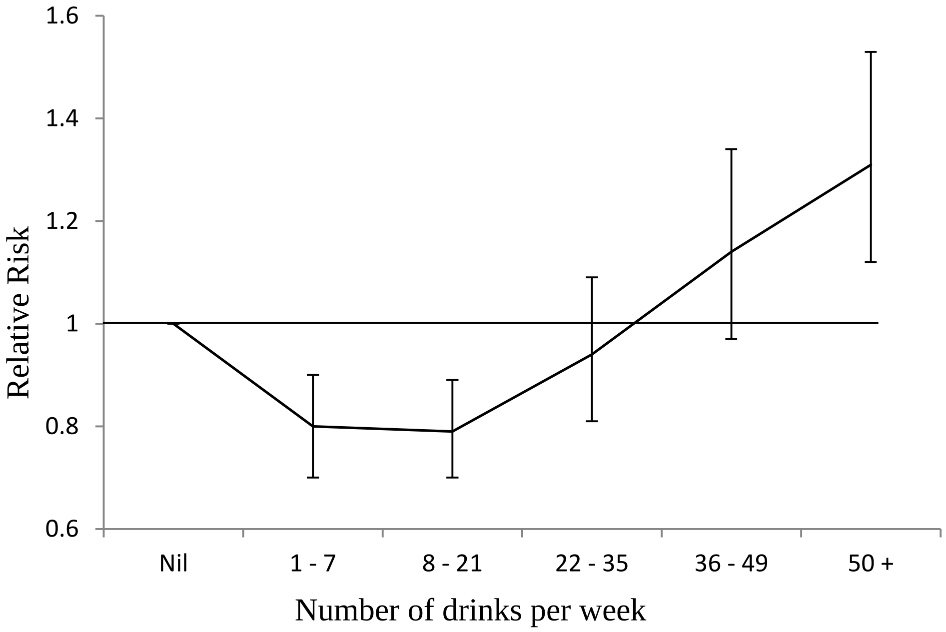


Figure 5: Relative risk of dying (all-cause mortality) for men with different levels of alcohol consumption, compared to those men who never drank alcohol. (The RMRs are adjusted for age, calendar year and smoking)

Table 34: Ischaemic heart disease (ICD-10 I20-125) by alcohol category, adjusted for age, calendar year and smoking (ever vs never), compared to those who never drank alcohol

Number of Drinks/Week	Person-years	Deaths	RMR	95% C.I.
Nil	64519	120	1.00	
1-7	91923	101	*0.71*	*0.54 - 0.92*
8-21	115287	129	*0.76*	*0.59 - 0.97*
22-35	48903	53	*0.66*	*0.48 - 0.92*
36-49	28988	38	0.84	0.58 - 1.22
50+	26980	56	1.20	0.87 - 1.65

Analyses by Tobacco Smoking and Alcohol Drinking

There is a clear pattern that increasing smoking category is associated with increasing risk of overall mortality, specifically ischaemic heart disease mortality, increasing risk of overall cancer incidence and mortality, and of bladder cancer incidence.

It is clear that all these risks are lower for ex-smokers than continuing smokers.

Moderate drinkers, <22 drinks per week, have decreased mortality compared to total abstainers. Heavy drinking, more than 49 drinks per week, remains associated with increased overall mortality.

There is a significant reduction in mortality from heart disease in those male members of the cohort consuming up to 35 drinks per week compared with total abstainers, which was not seen in the previous analysis where there was no significant difference for this group. This apparent anomaly may be explained by the lack of updating of alcohol consumption data and previously identified heavier drinkers may have reduced their alcohol intake because of other alcohol related diseases.

5. SPECIFIC CANCERS

5.1. Mesothelioma (ICD-10 C45)

There were 39 mesotheliomas in the cohort. This is a statistically significant excess compared to the general population (SIR 1.70, 95% C.I. 1.21-2.32).

Of the 39 cases of mesothelioma, 37 are now deceased and were identified on the NDI. Of these 37 deaths from mesothelioma before 2008, 28 were coded as mesothelioma deaths, and six other cases have died but have been coded to lung cancer. There were an additional four mesothelioma deaths on the NDI not found on the cancer registry, as the death analysis contained additional years of follow up. Mesothelioma deaths before 1997 were coded under the ICD-9 scheme which did not have mesothelioma as a specific code. All cancers have been recoded from ICD-9 to ICD-10 by the cancer registries but the deaths have not been recoded on the NDI.

Mesothelioma risk is strongly related to asbestos exposure. Although the disease is most common in workers who have been heavily exposed, cases do occur in workers whose exposures have been too low to cause asbestosis. Moreover smoking does not appear to be a risk factor for mesothelioma.(50-52)

Because mesothelioma is nearly always associated with a history of exposure to asbestos, every case should be regarded as significant in itself, irrespective of the statistical significance of the SIR. The occupational histories of the 39 cases of mesothelioma show that 26 of the 39 cases occurred in refinery workers and six were among drivers (one of these drivers had previously worked in a refinery). The dates of hire of these members of the cohort were examined. Six of the 39 cases entered the industry in the 1950s, 12 in the 1960s, 16 in the 1970s and five in the 1980s. This time distribution may be a consequence of measures taken in recent years to eliminate asbestos exposures; on the other hand it may be a consequence of the long induction latency period between exposure and diagnosis of mesothelioma.

5.2. Lung Cancer (ICD-10 C33-C34)

There were ten cases of lung cancer among women. This rate was slightly higher than the general female population, however, the numbers are quite small and statistical significance was not achieved. The incidence rate of lung cancer among men in the *Health Watch* cohort is significantly lower than those in the general male population (SIR 0.79, 95% C.I. 0.69 – 0.90).

As shown in Table 16 on page 43, the incidence of laryngeal cancer is below that of the general male population, although the reduction is not statistically significant (SIR 0.77, 95% C.I. 0.51-1.12). Cancer of the lip, oral cavity and pharynx was significantly lower than that of the reference population (SIR 0.80, 95% C.I. 0.65-0.97). Chronic obstructive pulmonary disease (COPD) is at least as strongly associated with smoking as is lung cancer. Indeed, these diseases (mainly chronic bronchitis and emphysema) are uncommon in non-smokers. The mortality rate from COPD is significantly reduced (86 deaths vs 132 expected, SMR 0.65, 95% C.I. 0.52-0.81). These figures suggest that the low lung cancer rate in the *Health Watch* population is likely to be due to low average lifetime tobacco use compared with the general population.

All jobs for *Health Watch* cohort members from first employment in the industry to 30/11/2010 were assigned a workplace type based on the company site code. Time in a job was measured as the time between each job or until retirement/resignation.

A comparison of lung cancer incidence was also made between refinery workers and all other workers, adjusted for age, calendar period and smoking. The relative risk was similar for the two groups (RIR 1.05, 95% C.I. 0.79 – 1.40). Lung cancer incidence was also explored between maintenance workers and all other workers among refinery workers. The relative risk was slightly lower in the maintenance group, however, the incident numbers were small and the confidence intervals are wide (RIR 0.85, 95% C.I. 0.48 - 1.50).

5.3. Melanoma of the Skin (ICD-10 C43)

Melanoma is one of the commonest cancers in the *Health Watch* cohort, second only to prostate cancer in men and breast cancer in women. There were 14 cases of melanoma in women. The incidence is slightly higher than in the general female population, but the increase is not statistically significant.

There were 331 melanoma cases in men, and the incidence of melanoma is significantly raised (SIR 1.19, 95% C.I. 1.06-1.32). Table 35 shows that the melanoma incidence in men is elevated in most workplace types, and is significantly elevated in refinery and terminal workers. The lack of statistical significance in the other categories may be due to the relatively low numbers of members of the cohort in these workplaces.

Table 35: Melanoma (ICD-10 C43) incidence in men by workplace type, adjusted for age and calendar period of follow-up, compared to the Australian population

Workplace Type	Number of men in cohort	Person-years	Observed	Expected	SIR	95% C.I.
Refinery	6492	138049	135	111.19	*1.21*	*1.02 - 1.44*
Terminal	6478	137758	146	115.15	*1.27*	*1.07 - 1.49*
Airport	604	13182	14	11.48	1.22	0.67 - 2.05
Onshore production	2326	44160	25	30.20	0.83	0.54 - 1.22
Offshore Production	739	15603	11	10.53	1.04	0.52 - 1.87
Total	**16639**	**348752**	**331**	**278.55**	***1.19***	***1.06 - 1.32***

The following three tables analyse melanoma incidence according to period of first employment, categories of duration of employment, and lapse of time between first employment and diagnosis of melanoma. There is no significant difference between categories and no significant trend in any of these analyses.

The highest rate of melanoma incidence is in members of the cohort employed for the shortest period of time, 5-9 years whilst those employed for 20 – 24 years have a significantly lower risk of melanoma. The rationale for this is not clear, but it suggests that a causal association with any exposure in the workplace is unlikely.

Table 36: Melanoma (ICD-10 C43) incidence among men by period of first employment, adjusted for age and calendar period of follow-up, compared to those employed after 1985

Period of First Employment	Person-years	Cancers	RIR	95% C.I.
Post 1985	52429	30	1.00	
1975-1984	133202	83	0.96	0.62 - 1.49
1965-1974	103461	103	1.14	0.71 - 1.84
1955-1964	40840	75	1.48	0.84 - 2.59
Pre 1954	18820	40	1.46	0.77 - 2.75

Test for heterogeneity p= 0.31 Test for trend p = 0.07

Table 37: Melanoma (ICD-10 C43) incidence in men by duration of employment, adjusted for age and calendar period of follow-up, compared to those employed for 5-9 years

Duration of Employment	Person-years	Cancers	RIR	95% C.I.
5-9 Years	71495	48	1.00	
10-15 Years	77461	46	0.66	0.44 - 1.00
16-19 Years	68041	51	*0.65*	*0.43 – 0.98*
20-24 Years	52469	43	*0.60*	*0.39 - 0.93*
≥ 25 Years	79193	144	0.95	0.64 - 1.40

Test for heterogeneity p = 0.01 Test for trend p = 0.49

Table 38: Melanoma (ICD-10 C43) incidence in men by time since first employment, adjusted for age and calendar period of follow-up, compared to those first employed 5-9 years ago

Time Since First Employment	Person-years	Cancers	RIR	95% C.I.
5-9 Years	40618	13	1.00	
10-15 Years	56671	32	1.30	0.67 - 2.52
16-19 Years	62214	39	1.11	0.56 - 2.20
20-24 Years	57302	41	0.99	0.49 - 2.02
≥ 25 Years	131942	206	1.20	0.59 - 2.41

Test for heterogeneity p = 0.77 Test for trend p = 0.86

The excess incidence of melanoma varies by the State of the work site, (see Table 39). Men working in Queensland have the highest incidence compared to national data, and those working in Victoria and South Australia the lowest. This suggests a link with sun exposure. (The number of employees in Tasmania was small resulting in wide confidence intervals.) It should be noted that some workers may not reside in the same state as they work e.g. off shore workers.

Table 39: Melanoma (ICD-10 C43) incidence compared to national rates for men by state of last employment

State	Years	Observed	Expected	SIR	95%C.I.
VIC	114133	82	88.14	0.93	0.74 - 1.15
ACT	20	-.	0.02	-	-
NSW	94129	102	80.29	*1.27*	*1.04 - 1.54*
NT	2201	-	1.80	-	-
QLD	44342	63	35.02	*1.80*	*1.38 - 2.30*
SA	39861	29	31.28	0.93	0.62 - 1.33
TAS	3292	4	3.06	1.31	0.36 - 3.35
WA	50773	51	38.94	1.31	0.98 - 1.72
All areas	**348752**	**331**	**278.55**	***1.19***	***1.06 - 1.32***

However, as melanoma incidence can vary by state, further analyses were undertaken using state-based rather than national comparison rates. These are presented in Table 40 and show reductions in risk compared to using the national rates. This suggests that the risk is associated with working (and for most, residing) in the sunnier states.

Table 40: Melanoma (ICD-10 C43) incidence compared to state specific rates for men by state of last employment

State	Years	Observed	Expected	SIR	95%C.I.
VIC	114133	82	65.28	1.26	1.00 - 1.56
NSW	94129	102	82.81	1.23	1.00 - 1.50
QLD	44342	63	48.76	1.29	0.99 - 1.65
WA	50773	51	42.65	1.20	0.89 - 1.57

5.4. Prostate Cancer (ICD-10 C61)

Prostate cancer is the most common cancer in men in the *Health Watch* cohort. There were 730 cases, and the incidence was statistically significantly elevated in the cohort (SIR 1.14, 95% C.I. 1.06-1.23). In the previous report this elevation was not statistically significant.(5) Prostate cancer mortality, however, is the same as that of the general population (SMR 0.92, 95% C.I. 0.74 – 1.12). These findings may suggest that members of the cohort are screened for prostate cancer at a greater rate than the general population and may indicate a screening bias whereby more cases are detected earlier, but at a stage when treatment is likely to have a more successful outcome.

5.5. Bladder Cancer (ICD-10 C67)

There were 83 bladder cancers in men. A non-statistically significant excess of bladder cancer was also reported in the 12th *Health Watch* report (SIR 1.07, 95% C.I. 0.89-1.50) (9) and the 13th Report (SIR 1.11, 95% C.I. 0.85-1.43).(5) The most recent analysis has shown that there is no longer an excess of bladder cancer in the general cohort (SIR 1.01, 95% C.I. 0.81-1.26), however, bladder cancer among drivers, remains elevated (SIR 1.60, 95% C.I. 0.96-2.49) and is of borderline statistical significance.

5.6. Kidney Cancer (ICD-10 C64-C66, C68)

There were 76 cases of kidney cancer among men in the *Health Watch* cohort. This analysis has shown that the incidence rate of this cancer has dropped compared to the 12th and 13th reports, (5, 9) now suggesting that the rates are similar to the general population (SIR 0.93, 95% C.I. 0.73-1.16). Drivers were the exception showing an elevated, but not statistically significant increase of risk of kidney cancer (SIR 1.46, 95% C.I. 0.86-2.31).

5.7. Leukaemias (ICD-10 C91-C95)

There were 55 leukaemia cases found in men. The incidence among men is less than in the general population, but the difference from the population rate is not statistically significant (SIR 0.80, 95% C.I. 0.60-1.04).

There were 13 new chronic leukaemia cases, ten new chronic lymphatic and three new chronic myeloid leukaemias since the last *Health Watch* report. In individual leukaemia subtypes, the rates were close to, or less than the population rates, except for chronic myeloid leukaemia, however, this increase was not statistically significantly elevated (SIR 1.28, 95% C.I. 0.61-2.36). The non-significant increase in acute lymphatic leukaemia observed in the 13th report is no longer evident.(5)

Table 41 shows that there was no significant excess of leukaemia incidence in any workplace type. When cancer or mortality counts are less than three, the observed numbers are not reported. This is to keep in line with confidentiality practices and reducing the risk for potentially identifying a cohort member.

Table 41: Leukaemia (ICD-10 C91-C95) incidence among men by workplace type, adjusted for age and calendar period of follow-up, compared to the Australian population

Workplace Type	Number of men in cohort	Person-years	Observed	Expected	SIR	95% C.I.
Refinery	6492	138049	25	27.96	0.89	0.58 - 1.32
Terminal	6478	137758	24	29.14	0.82	0.53 - 1.23
Airport	604	13182	-	2.90	0.69	0.08 - 2.49
Onshore production	2326	44160	3	6.48	0.46	0.10 - 1.35
Offshore Production	739	15603	-	2.13	0.47	0.01 - 2.62
Total	**16639**	**348752**	**55**	**68.60**	**0.80**	**0.60 - 1.04**

The following three tables analyse leukaemia incidence according to period of first employment, categories of duration of employment, and lapse of time between first employment and diagnosis of leukaemia. There is no evidence of a trend in the relative incidence in any of these analyses.

Table 42: Leukaemia (ICD-10 C91-C95) incidence by period of first employment, adjusted for age, calendar period of follow-up and smoking (ever vs never), compared to those employed after 1975

Period of First Employment	Person-years	Cancers	RIR	95% C.I.
Post 1975	185631	14	1.00	
1965-1974	103461	19	1.39	0.64 - 3.03
1955-1964	40840	16	1.78	0.68 - 4.65
Pre 1954	18820	6	1.15	0.34 - 3.88

Test for heterogeneity p = 0.58 Test for trend p = 0.66

Table 43: Leukaemia (ICD-10 C91-C95) incidence in men by duration of employment, adjusted for age, calendar period of follow-up and smoking (ever vs never), compared to those employed for 5-9 years

Duration of Employment	Person-years	Cancers	RIR	95% C.I.
5-9 Years	71495	5	1.00	
10-15 Years	77461	9	1.43	0.47 - 4.34
16-19 Years	68041	12	1.92	0.65 - 5.73
20-24 Years	52469	9	1.72	0.54 - 5.46
≥ 25 Years	79193	20	1.87	0.64 - 5.52

Test for heterogeneity p = 0.76 Test for trend p = 0.31

Table 44: Leukaemia (ICD-10 C91-C95) incidence in men by time since first employment, adjusted for age, calendar period of follow-up and smoking (ever vs never), compared to those first employed 5-9 years ago

Time Since First Employment	Person-years	Cancers	RIR	95% C.I.
5-9 Years	40618	3	1.00	
10-15 Years	56671	5	1.04	0.24 - 4.55
16-19 Years	62214	5	0.87	0.19 - 4.13
20-24 Years	57302	10	1.67	0.37 - 7.52
≥ 25 Years	131942	32	1.33	0.29 - 6.17

Test for heterogeneity p = 0.82 Test for trend p = 0.55

5.7.1. Acute Non-Lymphocytic Leukaemia (ANLL) (ICD-10 C920, C924, C925, C930, C940, C942, C944, C945, C950)

There were only three new ANLL cases since the 13th Report.(5) The incidence of ANLL remains below the general population rate, however, this reduction was not statistically significant (SIR 0.69, 95% C.I. 0.38-1.16).

Table 45 shows the distribution of ANLL cases by workplace type.

Twelve of the 14 cases occurred in refinery or terminal employees. The SIRs are lowered in these categories and higher among the on-shore production, but, as can be seen from the wide confidence intervals, the numbers are too low for meaningful analyses.

Table 45: ANLL (ICD-10 C920, C924, C925, C930, C940, C942, C944, C945, C950) incidence by workplace type, adjusted for age and calendar period of follow-up, compared to the Australian population

Workplace Type	Number of men in cohort	Person-years	Observed	Expected	SIR	95% C.I.
Refinery	6492	138049	5	8.26	0.61	0.20 - 1.41
Terminal	6478	137758	7	8.59	0.81	0.33 - 1.68
Airport	604	13182	-	0.85	1.18	0.03 - 6.55
Onshore production	2326	44160	-	1.91	0.52	0.01 - 2.92
Offshore Production	739	15603	0	0.62		
Total	**16639**	**348752**	**14**	**20.24**	**0.69**	**0.38 - 1.16**

5.8. Multiple Myeloma (ICD-10 C90)

There were 37 multiple myeloma cases in men in the cohort. The incidence is not statistically significantly higher than that in the general population (SIR 1.17, 95% C.I. 0.82-1.61).

As shown in Table 46, multiple myeloma is elevated amongst all of the workplaces and elevated overall (Table 16), however, these elevations are not significant.

Table 46: Multiple myeloma (ICD-10 C90) incidence among men by workplace type, adjusted for age and calendar period of follow-up, compared to the Australian population

Workplace Type	Number of men in cohort	Person-years	Observed	Expected	SIR	95% C.I.
Refinery	6492	138049	15	12.93	1.16	0.65 - 1.91
Terminal	6478	137758	19	13.59	1.40	0.84 - 2.18
Airport	604	13182	0	1.37		
Onshore production	2326	44160	3	2.91	1.03	0.21 - 3.01
Offshore Production	739	15603	0	0.96		
Total	**16639**	**348752**	**37**	**31.75**	**1.17**	**0.82 - 1.61**

Comments on Specific Cancers in Men

Mesotheliomas, melanoma of the skin and prostate cancer all occurred in statistically significant excess in men in the Health Watch cohort compared to national rates.

There was a statistically significant lowering of lung cancer, liver cancer and cancers of the lip, oral cavity and pharynx and COPD which is probably a result of less tobacco consumption by members of the cohort than by the reference population.

There is no excess of lung cancer in refinery maintenance workers compared with refinery non-maintenance workers. However this analysis was based on a small number of cancer cases.

There is a statistically significant increase in the incidence for melanoma among men in the cohort. The rate does not increase with increasing duration of employment and is bordering on statistical significance when compared to relevant state rates. On this basis it is unlikely that the excess is caused by a factor in the workplace in this industry.

Bladder and kidney cancers in the cohort remain similar to the general population, as does multiple myeloma. Prostate cancer incidence in the cohort is now statistically significantly higher than in the general population, however prostate cancer mortality remains similar to that of the general population.

There is no excess incidence of any leukaemia subtype or when all leukaemia types are combined. Acute non-lymphocytic leukaemia, which is most likely to be causally associated with benzene exposure, is not significantly elevated compared to the general population. There are too few ANLL cases for statistical analysis according to duration of employment.

6. HEALTH OUTCOMES IN SPECIFIC JOBS

The ability to assess risk in particular jobs as defined by their AIP Job code is recognised to be a most useful method of assessing risk in the industry because workplace categories, e.g. all refinery workers, includes many jobs having very different exposures. However, analysing by AIP Job code is limited by the numbers of employees in any particular job. This number, with the multiplier arising from the length of time *Health Watch* has been in operation, produces person-years of observation for analysis. When person-years reach a sufficient size, analysis of risk for the employees holding that job can be done.

The job groups analysed in this report are *Drivers* (NB295x), *Refinery operators* (not including ship personnel) (BA, BB, BC, HX, IB, PA, PB, PC, RF), *Terminal operators* (BA, BB, BC, HX, IB, NA, PA, PC, RF) and *Maintenance* (refinery or terminal based not upstream) (IB, CA, CB, CC, CD, CE, CF, DA, DB, DC, DD, EA, EB, EC, FA, FB, GX, MX), *Office workers* (AX) and *Shift workers* (self reported at interview). Each person's full job history since 1980 was checked and categorised according to whether the person has ever held the particular job classification. Those who have held more than one category appear in both categories in the analysis, so their deaths and person years are counted more than once.

Analysis has been done for some major health outcomes including all-cause mortality, ischaemic heart disease, cancer mortality, and accidents and violence mortality in addition to cancer incidence. For many other health outcomes, numbers are low and thus unreliable.

6.1. All-cause Mortality in Men by Job Group

As shown in Table 47, all-cause mortality for each of these occupations is similar to the all-cause-mortality for the male members of the whole cohort (SMR 0.72, CI 0.69 - 0.75). Those members who ever worked in offices show an even lower mortality rate.

Table 47: All-cause mortality among men by Job Group (ever held), adjusted for age and calendar period of follow-up, compared to the Australian population

Job	Number of men in cohort	Person-years	Observed	Expected	SMR	95% C.I.
Driver	2229	53362	351	442.59	*0.79*	*0.71 - 0.88*
Refinery operator	3208	75211	423	586.17	*0.72*	*0.65 - 0.79*
Terminal operator	2220	50579	389	419.04	0.93	0.84 – 1.03
Maintenance	3894	90090	616	748.87	*0.82*	*0.76 - 0.89*
Office worker	5763	132254	694	1128.82	*0.61*	*0.57 - 0.66*
Shift worker	7892	184302	1008	1402.81	*0.72*	*0.67 - 0.76*

6.2. Cancer Incidence in Men by Job Group

There remains an increase in all-cancer incidence in drivers which is significantly different compared to the general population (SIR 1.12, 95% C.I. 1.01 – 1.23). This increase was not significant in the last report(5) but was similar to the risks presented in the 12th report.(9)

Table 48: Cancer incidence among men by Job Group (ever held), adjusted for age and calendar period of follow-up, compared to the Australian population

Job	Number of men in cohort	Person-years	Observed	Expected	SIR	95% C.I.
Driver	2229	49689	432	387.06	*1.12*	*1.01 - 1.23*
Refinery	3208	69732	532	505.72	1.05	0.96 - 1.15
Terminal	2220	47102	350	350.80	1.00	0.90 - 1.11
Maintenance	3894	83774	580	609.30	0.95	0.83 - 1.03
Office worker	5763	122569	911	934.04	0.98	0.91 - 1.04
Shift worker	7892	170768	1248	1214.90	1.03	0.97 - 1.09

6.2.1. Incidence of Cancer among Drivers

Table 49 presents the cancer incidence rates for selected major anatomical sites. There was a small elevation in the total cancer incidence rate among drivers (SIR 1.12, 95% C.I. 1.01-1.22). Although most of the cancers in the broad cancer categories were raised among drivers, the only increased cancer rate that was statistically significantly raised was melanoma (SIR 1.35, 95% C.I 1.02- 1.75). There are small numbers in many of the individual cancer types however, which makes statistical significance difficult to achieve.

Cancer of the kidney was in excess, (SIR 1.46, 95% C.I. 0.86-2.31) as was cancer of the bladder (SIR 1.60, 95% C.I. 0.96-2.49) but these excesses were not statistically significant. Because there were only 18 and 19 cases respectively, it was not possible to conduct a meaningful analysis in terms of time-related factors.

Drivers also had greater than expected numbers of oesophagus cancer, cancer of the colon and rectum, mesotheliomas, cancers of the testis, brain and nervous system, and myelodysplastic syndrome (Table 49). None of these increases was statistically significantly in excess. The lung cancer rate in drivers was lower than that of the general population and similar to the cohort as a whole.

Comparisons of specific cancers and mortality were conducted between cohort members who were ever a tanker driver and those who only ever worked in an office and adjusted for age, calendar period and smoking. All-cause mortality was similar in these two groups (RMR 0.99, 95% C.I. 0.85- 1.14). Cancer mortality and cancer incidence were also similar in both job group (RMR 0.92, 95% C.I. 0.73- 1.16) and (RIR 1.00, 95% C.I. 0.88- 1.15) respectively. Risk of ischaemic heart disease was the same in both groups (RMR 0.99, 95% C.I. 0.73- 1.35) while prostate cancer rates were similar (RIR 0.81, 95% C.I. 0.63- 1.04).

External causes of death (eg accidents, violence, suicide) was elevated in the ever driver group compared to the office only workers. However, this increase was not statistically significant (RMR 1.41, 95% C.I. 0.74-2.70). There were more cases of kidney cancer among drivers compared with office only workers, but again the difference was not statistically significant (RIR 1.8, 95% C.I. 0.84-3.86).

Leukaemia was statistically elevated among tanker drivers compared with the office only group however, there were fewer than three cancers in the office only group producing a very broad confidence interval (RIR 5.52, 95% C.I. 1.19- 25.49).

Bladder cancer incidence was statistically elevated in the ever driver group by nearly 2.5 times compared to the office only group (RIR 2.42, 95% C.I.1.09- 5.37).

Table 49: Cancer incidence by selected anatomical site, for drivers by ICD-10 codes, adjusted for age and calendar period of follow-up, compared to the Australian population.

Anatomical Site	ICD-10	Observed	Expected	SIR	95% C.I
Lip, oral cavity and pharynx	C00-C14	20	18.52	1.08	0.66-1.67
Oesophagus	C15	8	5.77	1.39	0.60-2.73
Stomach	C16	9	9.72	0.93	0.42-1.76
Colon	C18	38	32.29	1.18	0.83-1.62
Rectum	C19-C21	28	22.93	1.22	0.81-1.76
Liver	C22	3	4.70	0.64	0.13-1.87
Gallbladder	C23-C24	-	1.94	-	-
Pancreas	C25	9	7.67	1.17	0.54-2.23
Larynx	C32	7	5.33	1.31	0.53-2.70
Lung	C33-C34	37	45.68	0.81	0.57-1.12
Melanoma	C43	56	41.52	*1.35*	*1.02-1.75*
Mesothelioma	C45	6	3.45	1.74	0.64-3.78
Connective tissue	C47-49	-	2.22	0.90	0.11-3.26
Prostate	C61	106	96.88	1.09	0.90-1.32
Testis	C62	5	2.49	2.01	0.65-4.69
Bladder	C67	19	11.91	1.60	0.96-2.49
Kidney	C64-C66, C68	18	12.34	1.46	0.86-2.31
Eye	C69	-	1.12	0.89	0.02-4.97
Brain & nervous system	C70-C72	10	6.39	1.56	0.75-2.88
Non-Hodgkin lymphoma	C82-C85, C96	13	14.89	0.87	0.46-1.49
Multiple myeloma	C90	4	4.73	0.85	0.23-2.16
Leukaemia	C91-C95	10	10.09	0.99	0.48-1.82
Acute lymphatic leukaemia	C910		0.42		
Chronic lymphatic leukaemia	C911	5	4.26	1.17	0.38-2.74
Acute myeloid leukaemia	C920		2.36		
Chronic myeloid leukaemia	C921	-	1.13	0.89	0.02-4.94
Other leukaemia	C91-C95, but not C910, C911, C920, C921	4	1.93	2.08	0.57-5.32
Acute non-lymphocytic leukaemia (ANLL)	C920, C924, C925, C930, C940, C942, C944, C945, C950	-	2.95	0.68	0.08-2.45
[a]**Myelodysplastic Syndrome**	D46.9	3	1.46	2.05	0.42-6.00
Unspecified or unknown sites	C76-C80, C26, C39	7	11.28	0.62	0.25-1.28
Other sites	-	11	11.05	1.00	0.50-1.78
Total	-	**432**	**387.06**	**1.12**	***1.01-1.23***

6.3. Cancer Mortality in Men by Job Group

As shown in Table 50, there were no excesses in all-cancer mortality in any of the occupational groups studied including drivers. The mortality rates were significantly lower than population rates in all groups except for Terminal operators and Maintenance workers. The results are similar to those reported in the 13th Report although the confidence intervals are narrower as a result of increased numbers in the analyses.

Table 50: Cancer mortality in men by Job Group (ever held), adjusted for age and calendar period of follow-up, compared to the Australian population

Job	Number of men in cohort	Person-years	Observed	Expected	SMR	95% C.I.
Driver	2229	53362	141	167.17	*0.84*	*0.71 – 0.99*
Refinery Operator	3208	75211	187	218.26	*0.86*	*0.74 – 0.99*
Terminal Operator	2220	50579	160	154.04	1.04	0.88 – 1.21
Maintenance	3894	90090	237	270.46	0.88	0.77 – 1.00
Office worker	5763	132254	307	414.29	*0.74*	*0.66 - 0.83*
Shift worker	7892	184302	436	521.69	*0.84*	*0.76 - 0.92*

6.4. Ischaemic Heart Disease (ICD-10 I20-125) Mortality in Men by Job Group

Ischaemic heart disease mortality is significantly lower in the cohort as whole, compared to the general population (SMR 0.74, 95% C.I. 0.68 – 0.81). Table 51 shows that this decrease is also significantly reduced in Refinery Operators (SMR 0.63, 95% C.I. 0.50-0.79) and Office Workers (SMR 0.62, 95% C.I. 0.53-0.73). The absence of excess mortality in shift workers from this list is notable, since some epidemiological studies have suggested that shift work is a risk factor for heart disease.(53) The self categorisation as a shiftworker makes the interpretation difficult however.

Table 51: Ischaemic heart disease (ICD-10 I20-125) mortality in men by Job Group (ever held), adjusted for age and calendar period of follow-up, compared to the Australian population

Job	Number of men in cohort	Person-years	Observed	Expected	SMR	95% C.I.
Driver	2229	53362	78	94.11	0.83	0.66 – 1.03
Refinery Operator	3208	75211	78	123.95	*0.63*	*0.50 – 0.79*
Terminal Operator	2220	50579	107	89.95	1.19	0.97 – 1.44
Maintenance	3894	90090	165	160.93	1.03	0.87 – 1.19
Office worker	5763	132254	150	240.91	*0.62*	*0.53 - 0.73*
Shift worker	7892	184302	213	294.51	*0.72*	*0.63 - 0.83*

6.5. Mortality from Accidents and Violence (ICD-10 V00-V99, W00-W99, X00-X99, Y00-Y99) in Men by Job Group

As shown in Table 52 mortality rates from accident/violence in each of these occupational groups is significantly lower than the general population and is similar to that of the cohort as a whole (SMR 0.61, 95% CI 0.52 – 0.72).

Table 52: Mortality from accident/violence (ICD-10 V00-V99, W00-W99, X00-X99, Y00-Y99) in men by Job Group (ever held), adjusted for age and calendar period of follow-up, compared to the Australian population

Job	Number of men in cohort	Person-years	Observed	Expected	SMR	95% C.I.
Driver	2229	53362	23	32.21	0.71	0.45 – 1.07
Terminal Operator	3208	75211	17	31.63	*0.54*	*0.31 – 0.86*
Refinery Operator	2220	50579	35	45.93	0.76	0.53 – 1.06
Maintenance	3894	90090	30	57.59	*0.52*	*0.35 – 0.74*
Office worker	5763	132254	31	82.98	*0.37*	*0.25 – 0.53*
Shift worker	7892	184302	82	112.25	*0.73*	*0.58 – 0.91*

Results for Men by Job Group in Health Watch

Overall mortality rates are lower for men in Health Watch than general population rates in each of the occupational groups studied particularly in Office Workers. These decreased rates are statistically significant for all groups except Terminal Operators. Cancer mortality is also lower for men in all occupational groups investigated compared to the general population and is statistically so except for Terminal Operators and Maintenance workers.

Cancer incidence for most job groups was similar to that of the population as a whole except for drivers where the risk of cancer was statistically significantly elevated. Drivers also exhibited a non-statistically significant increased risk of external causes such as accidents and suicides, compared with office only workers, while all-cause mortality remained the same between both groups. Leukaemia, kidney and bladder cancers were also elevated in the driver group compared with office only workers but only statistically significantly so for bladder cancer.

Mortality rates from heart disease are lower in all occupational groups except Terminal Operators, where the risk was similar to the general population

Deaths from accidents and violence were statistically significantly lower than that of the general population for all job groups except for drivers and refinery operators where the rate is lower but not statistically so.

7. DISCUSSION

7.1. Strengths and Weaknesses of the Study

7.1.1. Individual Interview Data

A major strength of *Health Watch* is that there is at least one personal interview record for every subject in the cohort. Written consent has been obtained from members of the cohort to search for their names in periodic searches of Cancer Registry data. The interview-based data provides considerable detail about jobs and tasks performed in the industry. It also means that detailed smoking history and alcohol intake is available for each subject although much of this data was collected many years ago and smoking rates may have changed over time.

7.1.2. High Participation Rate

Participation in *Health Watch* is voluntary. This could cause one source of volunteer bias if those motivated to participate had a different health status from non-participants. This is not likely given that recruitment was an active process and participation rates were so high. Site rolls were provided to the survey interviewers, and each individual approached and invited to participate. Refusal to participate was uncommon, and the reason for the missing employees is in most cases difficulty in locating them through temporary absence such as shift work or annual leave. The high participation rates (93%) in the first two surveys make volunteer bias very unlikely. The participation rates were lower in the Third and Fourth surveys (estimated at 84% and 73% respectively). The latter resulted in a lack of recruits to the cohort in the Fourth Survey from offshore production,(9) although this did not significantly alter the composition of the cohort: 4.0% of the cohort were in the offshore production sector, prior to the Fourth Survey and 3.7% afterwards.

7.1.3. Volunteer Bias

Another source of volunteer bias could be the ability of employees to volunteer to participate after becoming ill; that is members of the cohort could have initially refused to participate in a *Health Watch* survey, but having then developed a disease, could then volunteer to participate in a later survey. This could cause an upward bias, i.e. an overestimate, of the mortality rate, but since all mortality rates of all major disease categories and of most individual cancers were lower than expected, this is unlikely to have caused any misleading results. Joining the *Health Watch* cohort after developing cancer cannot affect the cancer analysis, because follow-up time does not commence until the person becomes a cohort member this is at interview or after five years in the industry whichever is the later), and cancers occurring before this point are excluded from the analysis.

7.1.4. Unverified Date of Employment

A potential weakness of the study is that the date of first employment for members of the cohort is obtained from members at the time of interview. This could affect analyses by time-related variables, i.e. period of employment, duration of employment and time since employment. Unfortunately, the personnel records of most companies have been overhauled in recent years, making access to records from the era when most members of the cohort were first employed very difficult. It has therefore been judged impractical to conduct an audit of the date of employment obtained at interview against dates from company records. Nevertheless error is likely to be random and hence unlikely to lead to bias. Moreover errors from imperfect recollection of the year of hire are likely to be small in relation to the size of time-related categories (e.g. period of employment categories are pre-1954, 1955-64, 1965-74, post-1975).

Date of termination is obtained from participating companies. Even here, however, information was not always complete. An audit of those classified as still employed by participating companies disclosed that many were no longer employed.(9) Following a further check of company employment records and other follow-up measures, the errors from this source were minimised.(9). In recent years, company update information has not always been readily forthcoming. A proportion of employment histories may not be up to date for those whose employing companies did not return a recent company update and for those employees who did not return the latest Health Letter in 2007.

7.1.5. Complete Cancer Identification

Identification of cancer is a major strength of the study as cancer registration is mandatory in all Australian States and Territories, and registration is virtually complete. However complete matching cannot be guaranteed due to privacy restrictions in releasing uncertain matches, and some problems have occurred in reconciling information from the ACD held by the AIHW and the State Cancer Registries which supply the information to it.(54) This has been discussed in Section 2.4.4 (page 26).

7.2. The Healthy Worker Effect (HWE)

In the Australian petroleum industry the *healthy worker effect* is very strong with SMRs for workers in the industry lower than many reported from other occupational cohorts.(55) This may be partly because workers must serve for five years in the industry before entering the cohort. This is a longer qualifying period than for many other occupational cohorts. There is an argument for using a reference population composed of workers with similar demographic characteristics including the likelihood of obtaining and retaining employment rather than the general population.(56)

New research also suggests that higher amounts of overall sitting time or an inactive lifestyle are positively associated with increased overall mortality (57, 58). Many jobs recorded in this cohort are largely active with minimal sedentary periods which also support the strong healthy worker effect in the petroleum industry.

Figure 6 presents the SMRs and SIRs for men in *Health Watch*. This analysis was compiled with all new data obtained from the most recent linkage with the cancer and death registries and can therefore not be compared to figures from previous *Health Watch* reports. A common finding with the *healthy worker effect* is that it decreases as the cohort ages, that is, the SMR tends to increase with time, approaching the general mortality experience of the population. This tendency seems to be becoming evident for men shown by the trend lines in Figure 6. The SIRs for men in the *Health Watch* cohort are reducing and are also becoming closer to population data, the SIR for 2008 being exactly the same as the general population.

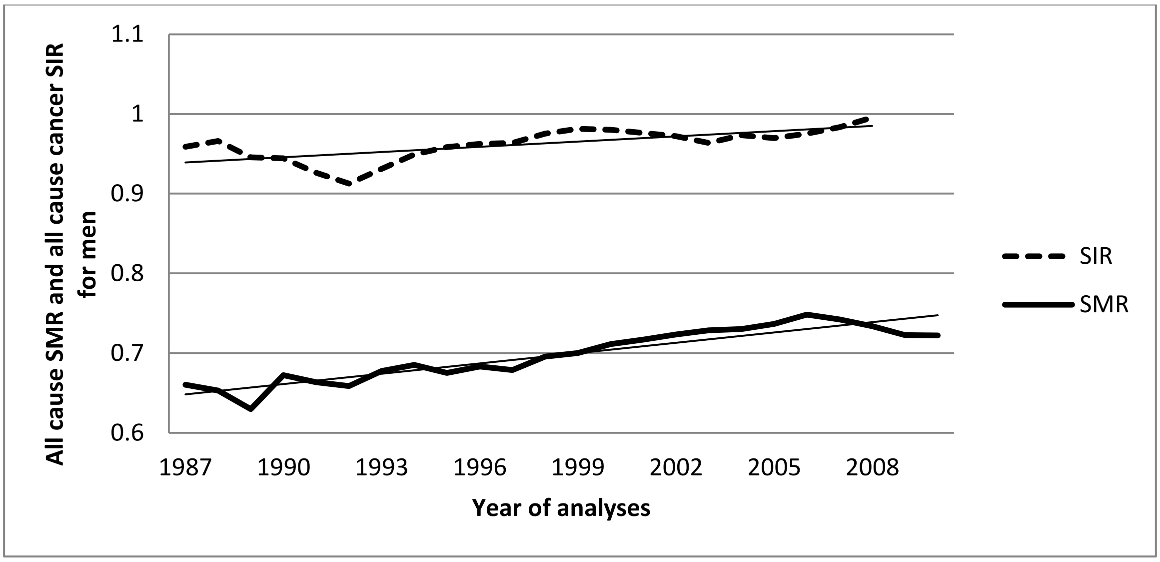


Figure 6: All Cause SMR, all cancer SIRs for men in *Health Watch*, plotted at yearly intervals

The SMRs and SIRs for women were based on very few cases, particularly in the early years. No SIRs for women presented in previous reports have been significantly different to that of the general population but this may be a result of the small numbers.

7.3. Mesothelioma and other Asbestos-related Conditions

There are a number of self-reports of asbestos-related conditions in members of the *Health Watch* cohort such as pleural plaques and asbestosis. Five cohort members have died from asbestosis. In addition, the occurrence of 39 cases of mesothelioma is an indication of past asbestos exposure and is consistent with the findings of other studies in oil refinery workers.(59-62) Of course, it is possible that some of these cases are attributable to asbestos exposure prior to entering the petroleum industry but asbestos insulation was used in refineries in particular in the 1950s and 1960s. There is a long latency period between initial exposure to asbestos and occurrence of the disease.(63, 64) Stringent regulations to prevent asbestos exposure have been in place for some years and there is now a much greater awareness of the hazards of asbestos, so that recent exposures are likely have been much less than that which occurred in the 1950s and 1960s. Nevertheless mesotheliomas can occur after quite low exposures, and it is important that any potential sources of exposure be identified and removed or controlled.

7.4. Lung Cancer

The low lung cancer rate may appear unexpected given the fact that the standardised prevalence of smoking in the cohort was only slightly less that of the Australian male population when the data was collected (see 4.1.1). However lung cancer risk is also predicted by factors such as the number of cigarettes smoked, age at starting, age at quitting and tar content.(46, 65) Thus although the prevalence of current smokers was similar in the *Health Watch* cohort and the general male population, it is quite possible that the average lifetime tobacco consumption in the *Health Watch* cohort is much less. This could be because *Health Watch* smokers on average may smoke less than other Australian men, or those who have quit may have done so at an earlier age than in the general population, or if more have quit since their data were collected (Table 25). These factors could be an explanation for the low lung cancer incidence in the *Health Watch* cohort.

Evidence of the low average lifetime tobacco use in the *Health Watch* cohort may also come from analyses relating to other diseases strongly related to smoking such as cancers of the lip, oral cavity and pharynx, laryngeal cancer and chronic obstructive pulmonary diseases which are lower than in the general population. These figures suggest that the low lung cancer rate in the *Health Watch* population is likely to be due to low average lifetime tobacco use compared with the general population.

The occurrence of a number of cases of mesothelioma in the *Health Watch* cohort, and in other studies of oil refinery workers, raises the possibility of an increased asbestos-related lung cancer risk. The concurrence of increased mesothelioma incidence with low lung cancer mortality rates, has been found in several studies in the petroleum industry,(66-69) although other studies have failed to confirm these findings.(70, 71) In some of these studies, the reduced risk of lung cancer could be attributed to lower smoking rates, as the analyses in most studies are confounded by lack of smoking data. Given the low overall lung cancer incidence in *Health Watch* there could be some asbestos-related lung cancers in refinery workers but the number must be small.(60, 66, 72)

This suggestion was investigated by comparing the lung cancer rate in refinery workers compared to the rest of the *Health Watch* cohort (because asbestos exposure was more likely in refineries than other worksites) and within the refinery workers' group by comparing maintenance workers with that in non-maintenance workers (because maintenance workers are more likely than other work groups to have come into contact with the asbestos). An advantage of such an analysis in this cohort is that smoking data, based on individual histories obtained prospectively from every subject in the cohort, are available. The analyses showed that after adjusting for smoking status, there was a minimal increase (not statistically significant) in lung cancer incidence among refinery workers compared to non-refinery workers (SIR 1.05, 95% C.I. 0.79-1.40); and within refineries there was a non-significantly reduced risk for lung cancer incidence in maintenance workers compared to non-maintenance workers within refineries (SIR 0.85, 95% C.I. 0.48-1.50). The analyses were based on small numbers of cancers however.

7.5. Melanoma

Figure 7 presents the SIRs and the cumulative incidence of melanoma among men in *Health Watch*. The analysis examined the state of the cohort every year since 1987 against data from the relevant time period. The risk of melanoma among men has remained significantly higher than that of comparable Australian national rates. As the number of cases increases the confidence intervals become narrower as shown in Table 53.

The significance of the excess melanoma incidence among men in the *Health Watch* cohort is not clear, but no causal association with the workplace is apparent because there is no trend for increasing risk with increasing duration of employment. Table 39 (page 61) shows that melanoma rates, when compared to national data, vary with state and so that the association may be a result of sun exposure.

Table 53: Melanoma (ICD-10 C43) cumulative incidence over time for men in the *Health Watch* cohort

Melanoma	**1987**	**1990**	**1993**	**1996**	**1999**	**2002**	**2008**
Cases	22	46	80	120	172	221	331
SIR	*1.10*	1.17	*1.27*	*1.29*	*1.32*	*1.27*	*1.19*
(95% C.I.)	*(0.69–1.67)*	(0.85–1.56)	*(1.01–1.58)*	*(1.07–1.54)*	*(1.13–1.53)*	*(1.11–1.45)*	*(1.06–1.32)*

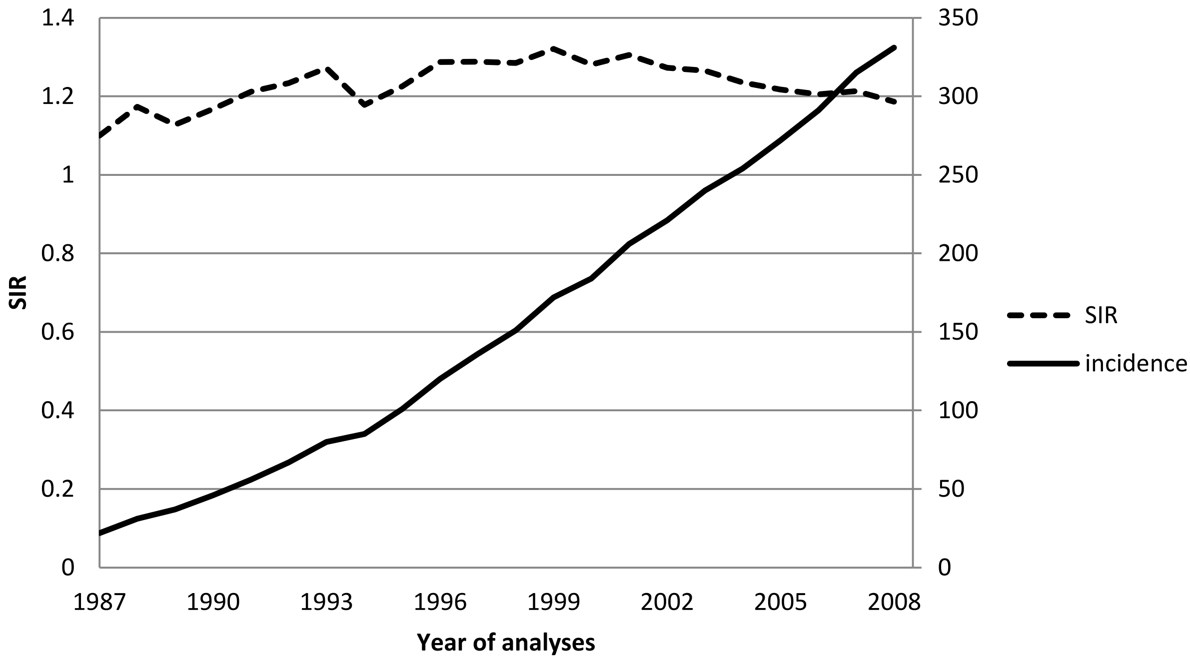


Figure 7: SIRs and cumulative melanoma incidence in men from 1987 - 2008

A statistically significant excess of melanoma mortality has been reported in UK refinery workers(73, 74) and a non-significant excess in USA refinery workers.(75) The highest SMR for melanoma was reported for Imperial Oil Limited (IOL) employees at upstream operations in Canada: SMR 6.00, 95% C.I. 2.19-13.06.(67) The only other cancer incidence study in the industry (an IOL cohort which overlapped with that reported previously), showed a non-significant excesses of melanoma in both men (SIR 1.25, 95% C.I. 0.82-1.83), and women (SIR 1.46, 95% C.I. 0.83-1.27).(62)

Thus an excess of melanoma in this industry is not unusual, but no occupational cause is apparent. Apart from the well-established association with exposure to solar radiation, melanoma has a tendency to occur in higher socioeconomic groups.(76) There is no reason to suspect socioeconomic status to be of special significance in this cohort, which has mostly excluded senior management.

7.6. Bladder Cancer

Bladder cancer was found in significant excess in the 11th Report (SIR 1.37, 95% C.I. 1.00 to 1.83).(4, 11) In the 12th and 13th *Health Watch* Reports, the excess was smaller and not statistically significant (SIR 1.17, 95% C.I. 0.89-1.50) and (SIR 0.84, 95% C.I. 0.45-1.43).(9, 5) The current results show that bladder cancer incidence is now similar to those of the general population (SIR 1.01, 95% C.I. 0.81-1.26).

Bladder cancer incidence was found to be significantly elevated among drivers compared with office only workers. This comparison has not been analysed in previous *Health Watch* reports and will be closely monitored in future analyses.

7.7. Leukaemia

Leukaemia has been a cancer of special concern in this industry because of its association with benzene exposure. The analyses early in the history of the *Health Watch* cohort indicated an excess of LH cancers among men. This is a broad category which includes the leukaemias, multiple myeloma and non-Hodgkin lymphoma, but not Hodgkin disease. Subsequent analyses showed that the excess was mainly from leukaemia cases.(6-8, 10) In our serial reanalyses, the excess was statistically significant at more than 2 fold in 1987, and has been reducing over time. The successive leukaemia incidences are shown in Table 54 and in Figure 8.

Table 54: Leukaemia incidence for men reported over time in the *Health Watch* cohort

Leukaemia	**1987**	**1990**	**1993**	**1996**	**1999**	**2002**	**2008**
Cases	10	18	20	26	31	37	55
SIR (95% C.I.)	*2.18* *(1.05-4.01)*	*2.05* *(1.22-3.24)*	*1.39* *(0.85-2.16)*	1.22 (0.80-1.79)	1.03 (0.70-1.46)	0.90 (0.63-1.23)	0.80 (0.60-1.04)

It can be seen that there is now no significant excess of leukaemias in the *Health Watch* cohort. Moreover, internal analysis within the cohort shows no significant trend in leukaemia incidence with duration of employment. This finding is not unexpected, since "leukaemia" is not a single disease, but a composite of leukaemia types which are in fact different disease entities. Of these, only acute non-lymphocytic leukaemia is commonly associated with benzene exposure, however there is some data suggesting that CLL may be associated with benzene exposure.(20, 77, 78)

7.7.1. Acute Non-Lymphocytic Leukaemia (ANLL)

ANLL is the leukaemia category of greatest interest because of its association with benzene.(20, 77-83) Overall there is no excess compared with the general population (14 cases observed and 20 expected). This may suggest that benzene exposures in this industry may be too low to cause a detectable increase in the incidence of ANLL, however, Gun (2005) noted that the 11 cases in the 12th *Health Watch* report were clustered in the medium to higher categories of hydrocarbon exposure. There were no cases at all in the three lowest exposure categories.(9) Interpretation of whether or not this association is causal needs to include consideration of the SIR; that is, the overall incidence compared to that of the general population. The SIR for ANLL in this analysis is 0.69 (95% C.I. 0.38-1.16) which would suggest that the incidence is similar to that in the general population.

A number of case-control studies in the industry have been published. In a study of petroleum marketing and distribution workers in the UK, the authors concluded that there was some suggestion of a relation between exposure to benzene and myeloid leukaemia, particularly acute myeloid leukaemia.(21) A case-control study nested within the Canadian cohort in 1996 showed a relationship between duration of exposure to benzene and risk of leukaemia but no association between increasing benzene exposure and risk of leukaemia, but the power of the study was low.(84) On the other hand the nested case-control study in the *Health Watch* cohort has found a strong association with increasing benzene exposure.(19, 20, 85) CONCAWE funded a combined study of three petroleum industry case-control studies. This found no convincing evidence for an association between benzene exposure and AML or other leukaemia subtypes.

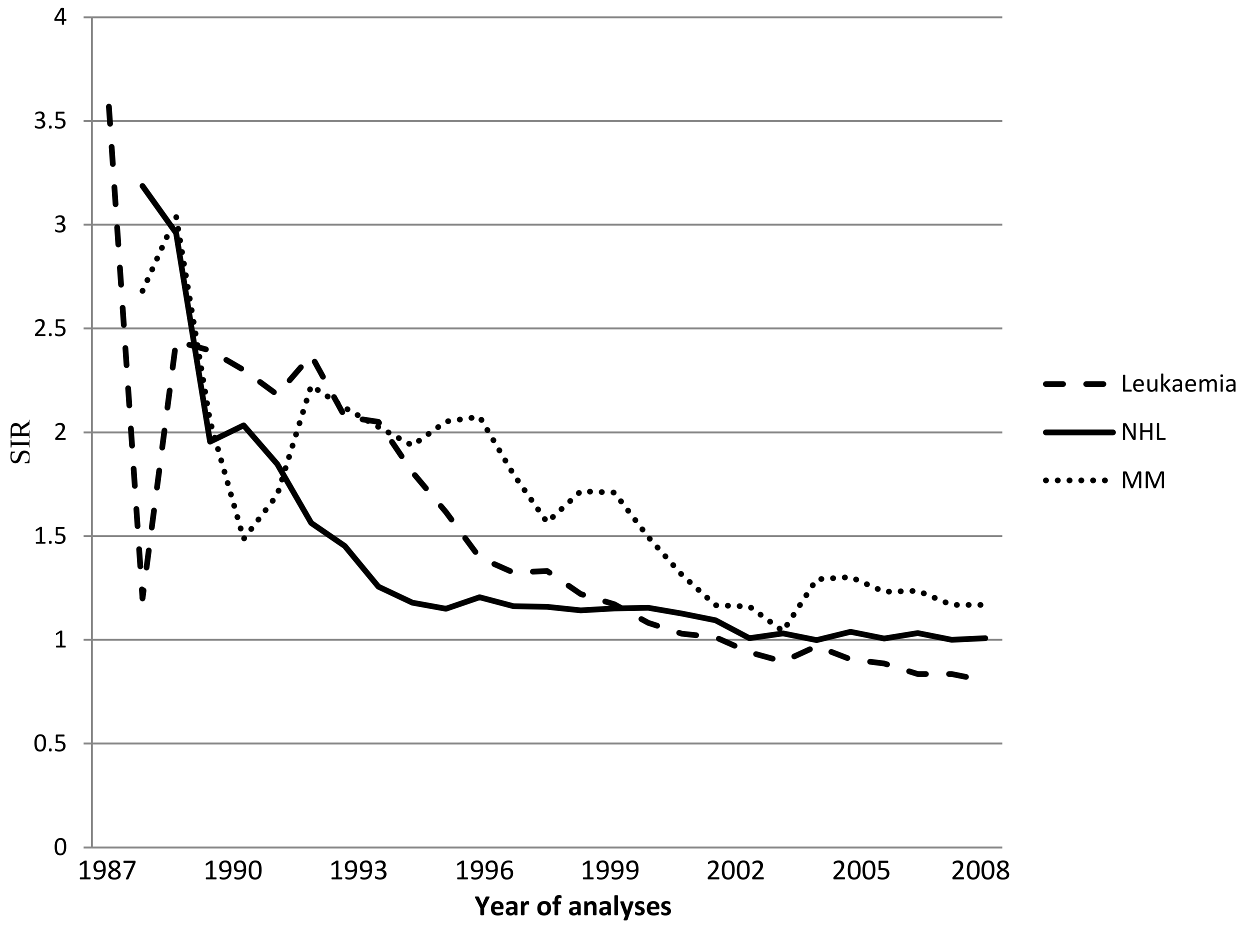


Figure 8: SIRs for leukaemia, NHL and MM in men from 1987 - 2008

7.8. Other Lympho-Haematopoietic Cancers in Men

Other cancers of the blood and bone marrow have been of interest in the *Health Watch* study because of an apparent excess of these conditions in earlier years of follow-up. At that time these conditions were grouped together because the numbers in the specific diseases in this category were very low. In more recent years, non-Hodgkin lymphoma (NHL), multiple myeloma (MM), and leukaemia have been analysed separately.

Table 55 presents reanalyses of NHL and MM incidence every 3 years since 1987 (except 2005) and shows that a statistically significant excess incidence of NHL in 1987 has been decreasing over the years and is now no longer in excess. The decline is also shown in Figure 8.

There was an excess of MM in the cohort in earlier years, which was statistically significant in one of the analyses, 1993. There has been a decline in the excess in recent years shown in Figure 8, with a slight but not statistically significant increase in 2008 but these are based on small numbers. Excess rates of MM have been reported in some studies but not others and there has been much debate in the literature about whether exposure to benzene is associated with increased risk of MM.(86-90)

Table 55: NHL (ICD-10 C82-C85, C96) and MM (ICD-10 C90) incidence for men in the *Health Watch* cohort

		1987	1990	1993	1996	1999	2002	2008
NHL	**Cases**	12	16	26	37	51	63	101
	SIR	*1.85*	1.26	1.20	1.14	1.13	1.03	1.01
	(95% C.I.)	*(0.95-3.23)*	(0.72-2.04)	(0.79-1.76)	(0.80-1.57)	(0.84-1.48)	(0.79-1.32)	(0.82-1.23)
MM	**Cases**	3	7	12	15	17	19	37
	SIR	1.70	2.02	*2.08*	1.72	1.31	1.04	1.17
	(95% C.I.)	(0.35-4.97)	(0.81-4.17)	*(1.07-3.63)*	(0.96-2.83)	(0.76-2.10)	(0.63-1.63)	(0.82-1.61)

7.9. Myelodysplastic syndrome (MDS)

Benzene is a well-known hematotoxin and leukemogen at a relatively high level of exposure (91-93). In 2009, the International Agency for Research on Cancer (IARC) reconfirmed that benzene causes the acute myeloid leukaemia (AML) subtype in humans and also noted that benzene is likely to be related to other leukaemia subtypes and lymphoid neoplasms.(94) However, recent meta-analyses differ in their interpretation of whether previous literature suggests a consistent relationship between benzene and lymphoid neoplasms.(86, 95-97)

A recent review using meta-regression to examine dose-response relationships suggests that benzene exposure less than 50 ppm-years results in a statistically significant elevated risk of all leukaemias in aggregate.(98) But few quantitative studies have examined risks between specific leukaemia subtypes and exposure to lower concentrations of benzene.(77) There is also sparse literature on specific myeloid tumors, such as myeloproliferative disorders (MPD) and myelodysplastic syndrome (MDS), which can precede and evolve into AML. MDS covers a group of hematopoietic malignancies that have become recognised relatively recently and so has been under-reported in the past. The IARC (94) did not mention these myeloid tumours in their recent evaluation of benzene carcinogenicity. The CONCAWE-funded a combined study, however, that found an association between benzene exposure and MDS at low exposure levels.(41)

Recognition of MDS as a discrete disease emerged slowly over the last century with vague and imprecise terminology often used to describe cases of MDS, such as “preleukemia,” “subacute leukemia,” “atypical leukemia” etc.(99) Approximately 20% of MDS patients will progress to AML but the two diagnoses are distinct diseases. (99) MDS was first defined in 1976 (100) and the diagnosis formalised in 1982.(101) In 2001, the World Health Organization included it in their LH cancer classification scheme.(102)

MDS was considered a reportable cancer by many cancer registries from 2001 but the reporting is not considered reliable in Australia until 2003 giving us only six years of analyses in this report. There were 14 cases recorded in this time frame producing an elevated, but not statistically significant risk in the cohort population (SIR 1.37, 95% C.I 0.75-2.29). As can be seen from the wide confidence intervals, the numbers are too small for meaningful analyses. This cancer will be monitored closely in future analyses as more data become available.

7.10. Regularity of Cohort Reports

In the early years of the cohort, until 1987, *Health Watch* reports tended to concentrate on the establishment of and recruitment to the cohort. *Health Watch* reported the state of the cohort on a yearly basis and presented the cancer morbidity and mortality findings. Later reports mainly presented mortality and cancer incidence findings because lower recruitment meant that the composition of the cohort changed little. From 1988 onwards, reports were on a 2-5 year basis, most reports covering a triennium of mortality and cancer incidence results. This report covers an additional six years of mortality and cancer incidence. Recent linkage to national data has showed limited changes between reports and linkages every five years appear to be sufficient.

7.11. Smoking

Smoking related diseases, lung cancer, cancer of the lip, oral cavity and pharynx, ischaemic heart disease mortality and chronic obstructive pulmonary disease mortality, are lower in the cohort than in the general population (see Section 4.1, Page 50).

However, within the cohort, it can be seen that smoking has a powerful influence on mortality. Altogether it is estimated that smoking has been a contributing factor to the death of 833 men, or 39% of the 2265 deaths in the *Health Watch* cohort. This includes increases in heart disease, lung cancer, bladder cancer and chronic obstructive pulmonary disease mortality.

The death rate from all causes increases significantly with increasing tobacco use. Compared to non-smokers, those who smoke 30 or more cigarettes a day show:

- a 4-fold increase in the death rate
- nearly a 5-fold increase in death rate from heart disease
- over a 40-fold increase in incidence of lung cancer

Risk of lung cancer and heart disease is clearly reduced by quitting smoking. Compared to non-smokers, those who quit show:

- only a slight increase in mortality
- the death rate from heart disease is only slightly raised
- the risk of lung cancer remains raised but drops to 6 fold, almost one seventh the risk for the highest smoking group.

8. CONCLUSIONS

Generally, the chances of dying at any age, or of getting cancer or heart disease are very similar no matter where *Health Watch* people worked, and compare favourably with the rates in all Australian men. The age-adjusted death rate in men and women is significantly lower than in the general Australian population. The strong *healthy worker effect* identified in previous studies continues to be observed.

The proportion of women in the *Health Watch* program remains very small and this precludes detailed analysis of contributory factors.

For men, death rates in all major disease categories are significantly lower than for the corresponding Australian population. A significant reduction in all-cause mortality is seen among men in each workplace type e.g. refinery, terminal.

Smoking related diseases are lower in *Health Watch* members, than in the general population. However, within the cohort, there is a clear pattern that increasing smoking category is associated with increasing risk of all-cause mortality and cancer. Smoking-related diseases are becoming more evident as the cohort ages. Quitting cigarette smoking greatly reduces the risks.

Two cancers, mesothelioma and melanoma, have been and still are occurring at significantly higher rates than in the general population. Prostate cancer is now also occurring at a statistically significantly higher rate than the general population. These are the only cancers in statistical significant excess. Cancer of the bladder and leukaemia and specifically ANLL are no longer in in excess. Overall, cancer mortality is statistically significantly lower than that of the general population.

Cancer mortality rates was similar across the main job groups, however, cancer incidence was slightly elevated among drivers. The only cancer that was statistically occurring at a higher rate among Drivers compared to the general population was melanoma. Leukaemia, kidney and bladder cancer rates were all higher in drivers compared to office only workers, bladder cancer being statistically significantly higher.

The statistically significant increase in the incidence of melanoma in men in the overall cohort is unlikely to be associated with exposure in the workplace. The apparent risk of melanoma is reduced when the cohort rates were compared with relevant State rates rather than the national rate.

The chance of contracting cancer is similar for men and women in this industry as for all Australians. However, mortality from cancer is reduced for *Health Watch* members, significantly so for men.

There is no evidence of increasing mortality, cancer incidence or increasing cancer mortality with any of the following:

- increasing duration of employment
- increasing time since first employment

Patterns of diseases are stable but the cohort is aging so a larger number of cancers and deaths might be expected to take place over the next five years. Another match to the cancer incidence and mortality data in five years would be of interest.

9. THE NEW *HEALTH WATCH* COHORT

A *Health Watch* Survey was offered to all current petroleum industry employees of Exxon-Mobil, BP, Shell, Caltex, Woodside and Chevron. This means that members of the original *Health Watch* study who were still employed, as well as new participants, were offered the opportunity to become part of a new study cohort. The decision to offer a survey to new employees was based on the declining proportion of current employees who were members of the existing cohort, in large part through natural attrition linked to an ageing cohort, and recognition by Monash University of the importance of maintaining a longitudinal health study of petroleum industry employees in Australia.

9.1.1. Eligibility

The 6th *Health Watch* Survey was a whole of site survey: i.e. all employees of participating companies located at an eligible worksite at the time of survey were invited to take part in the survey. This included existing members of *Health Watch* and staff with primarily administrative or management responsibilities.

An eligible worksite was one which deals directly with the production, refinery or distribution of petroleum products: for example, terminals, refineries and airport fuel depots. Existing members of *Health Watch* working in non-worksite contexts with a participating company (e.g. staff at Head Offices) were also invited to participate; however, their information will not be included in the overall analyses of the new cohort.

Although contractors engaged in activities at eligible worksites were not invited to participate in this survey, some may have completed the questionnaire but were advised that their contact with *Health Watch* will be limited where they are not existing members or participating company employees. Their data will be held but not included in the study analysis.

Table 56: Criteria for inclusion in 6th *Health Watch* Survey (2010—12)

EMPLOYMENT TYPE	**Included in survey? YES / NO**	**Included in new cohort? YES / NO**
Current employee at participating company worksite (e.g. trades, technical etc)	YES	YES
Current employee at participating company worksite (work mostly or entirely in site office)	YES	YES
Current employee of participating company AND existing member of *Health Watch*. Previously employed at eligible worksite but now working at Head Office	YES	NO
Current employee of participating company, not previously in *Health Watch* and working at Head Office	NO	NO
Former employee at participating company worksite, now working onsite as contractor. Existing member of *Health Watch*	NO*	NO
Former employee at participating company worksite. Never joined *Health Watch*	NO*	NO
Contractor working long or short term at eligible company worksite	NO*	NO
Former employee at participating company worksite, now retired or working elsewhere. Existing member of *Health Watch*	NO	NO

*Unless they volunteered at a site visit

9.1.2. Survey Implementation

The 6th *Health Watch* Survey broadly followed the format of previous surveys with the primary survey tool being an electronic questionnaire (offline or online). A print questionnaire was available for employees unable or unwilling to complete the survey electronically but they were not offered this option during a site visit. Participants could also complete the survey by arrangement remotely via telephone.

9.1.3. Informed consent

Potential participants were provided with an Explanatory Statement which outlined basic information in plain English about the study purpose, participant involvement, confidentiality and data storage and use. It also provided contact details for the project and for the University's research complaints mechanisms through Monash University Human Research Ethics Committee (MUHREC). Informed consent was mandatory for participation in the study and was obtained at the point of recruitment by the individual employee completing a Participant Consent Form.

10. Recruitment

10.1. Company site visits

Only onshore facilities received a site visit by *Health Watch*. Employees at offshore facilities received an invitation to complete the survey online; some may have been captured in transit at airports or heliports by arrangement or incidentally at other locations. Generally, only sites with more than 30 employees were assigned a dedicated scheduled site visit; however, some smaller sites were scheduled in conjunction with a visit to a larger site in reasonable proximity.

10.2. On-line Recruitment

The interface for the online database mirrored the laptop database. The front end can be accessed via the following website. https://healthwatch.coeh.monash.org

10.3. Email/Postal Invitation to employees

All eligible employees who had a work email address and who did not have the opportunity to complete the survey during a site visit were sent an email invitation to participate in the *Health Watch* study. If an employee did not have a work email, they were sent the same invitation by post to their worksite address. The email invitations were sent to the employees' email address and included a link to a direct entry point for their individual survey. The employee was then prompted to enter their Employee Number to gain access to the explanatory statement, consent form and the survey. Employees who received a postal invitation were prompted to go to the *Health Watch* website and enter their *Health Watch* ID which was provided in the letter.

10.4. Office Only Employees

Office only employees who were existing *Health Watch* participants were identified by participating companies. These members were added to the new database and invited to participate in the 6th *Health Watch* survey.

11. Non-Responders

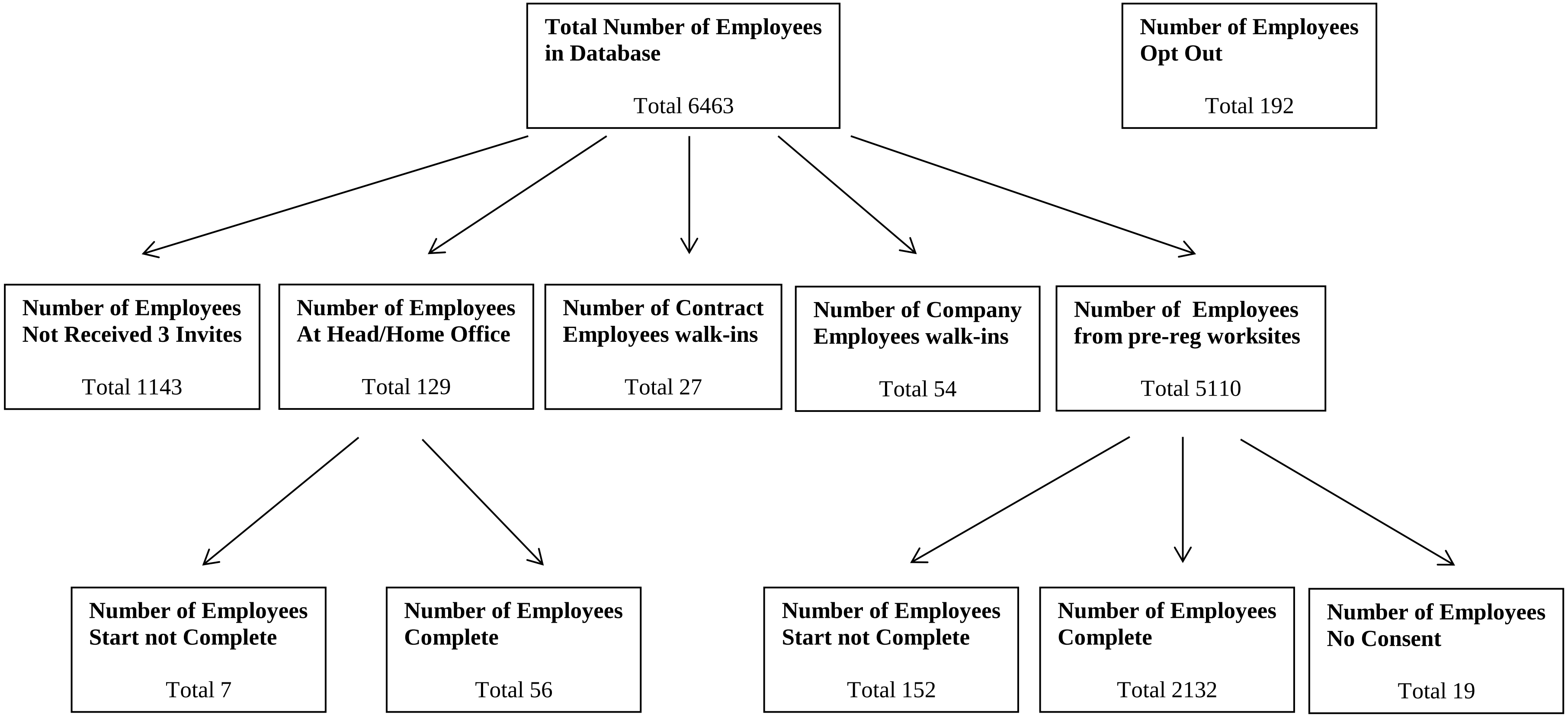
After the completion of the on-site and on-line survey, a list of non-responders were sent to corresponding companies to identify those employees who resigned/retired prior to receiving a

Health Watch invitation. Returned postal and email invitations were also recorded. Email returns were either a non-deliverable email, or an automated 'out of office' response. These returns were important to calculate participation rates.

12. Participation

The sixth *Health Watch* survey was received positively from about half of the employees from Company worksites. Figure 9 illustrates the breakdown of participation. Almost 45 % of employees at Worksites either completed a survey or consented to the study but did not complete the entire survey. Of the 5110 employees from pre-registered worksites, only 19 employees actively refused consent to participate in the study survey, i.e. they logged into the survey site and checked the 'no consent'. It should be noted that non-participation is not indicative of non-consent. There were over 1,000 employees pre-registered into the database who may not have received one or more invitations to the study for various reasons including resigned/retired, moved to different site, postal return to sender, etc. The majority of these employees were those who left their employment prior to one or more of their survey invitations.

Figure 9 Participation from the 2010-2012 6th *Health Watch* Survey



There were 129 existing *Health Watch* participants identified at the time as working in a head office or home office site. Fifty six of these employees either completed the survey or at least started the survey. There were 27 contract employees who completed a survey during a site visit. Some of these employees were either existing members of *Health Watch* but now employed as a contractor or were new employees who were keen to participate. As mentioned in Section 9.1.1, the information gathered from these employees will not be included in the overall analyses of the new cohort.

Fifty four company employees also completed a survey who were not included on the company lists but volunteered to participate during a site visit. These employees were not included in the participation calculations because it is unclear how many employees at each site fell into this category. Because they are company employees however, their data will be used in future analyses.

Table 57 shows a breakdown of participation for new and existing *Health Watch* members. Of the 5239 eligible employees, 38% of these were existing *Health Watch* participants. It is interesting to note that 54% of existing *Health Watch* employees either started or completed the survey compared to 39% of eligible new employees. This either illustrated the familiarity and loyalty to the *Health Watch* brand by existing members and or the ever increasing resistance to surveys in general.

Table 57. Breakdown of existing *Health Watch* members and new participants (including Head and Home Office Employees who were pre-registered into the database)

	Elig. No. in DB	*Existing HW Count (%)	New Emp Count (%)	No. Completed survey TOTAL (%)	Existing HW complete survey (%)	New Emps complete survey (%)	Total no. Consents (%)	Existing HW consent (%)	New Emps consent (%)
TOTAL	5239	1985 (38)	3254 (62)	2188 (42)	1002 (50)	1186 (36)	2347 (45)	1080 (54)	1267 (39)

* These figures were calculated by searching the existing *Health Watch* cohort database on Surname and Employee ID or Surname, DOB and the first three letters of first name. There may have been some existing *Health Watch* members that were missed and therefore underestimating these figures.

Visited worksites had a much higher participation rate overall. Fifty six percent of employees either completed or consented to the study at visited worksites, compared to 20% at non-visited sites (Table 58). Office sites were not visited but also had a relatively high participation rate (49%), however, this was due to the majority of these employees being existing *Health Watch* members. Office employees may also be more computer literate than worksite employees, increasing the likelihood of completing an online survey. For those who completed their surveys after an email/postal invitation, participation was higher after the initial invitation. Subsequent reminders to complete the survey produced slightly reduced participation.

Table 58. Participation at worksites. Visited worksites vs online/postal invitation only

	No. in DB	Complete at site visit (%)	Complete after 1 email or postal invite (%)	Complete after 2 emails (%)	Completes after 3+ emails (%)	Total Complete (%)	No Consent online/postal invite (%)	Total consent (%)
Visited worksites ONLY	3461	1641 (47)	137 (8)	59 (4)	40 (2)	1877 (54)	7 (0)	1951 (56)
Online/postal invites worksites ONLY	1649	*8 (0)	118 (7)	76 (5)	53 (4)	255 (15)	12 (1)	333 (20)
Office Sites Only	129	*9 (7)	25 (21)	13 (14)	9 (11)	56 (43)	0 (0)	63 (49)

* Employees may have completed a survey during an opportunistic visit to a worksite during a visit by a Monash researcher.

13. Summary

The sixth *Health Watch* survey was a whole site survey, open to all employees of participating companies at eligible worksites, including office staff at these sites. The survey broadly followed the format of previous surveys with the primary survey tool being an electronic questionnaire. The survey was administered during a site visit or independently online after an email or postal invitation.

In general, the survey was received positively by most employees. Almost 45 percent of employees at worksites either completed a survey or consented to the study but did not complete the entire survey. Only 19 employees who were invited to take part in the study actively refused consent.

Participation was higher among existing *Health Watch* members compared to new employees (54% vs 39%). Visited worksites had a much higher participation rate compared to worksites that weren't visited by a Monash researcher (56% vs 20%). It was expected that participation would be greater at visited sites with a Monash presence; however, it was not financially viable to visit many of the remote and smaller sites.

14. ACRONYMS

ABS	Australian Bureau of Statistics
ACD	Australian Cancer Database
ACTU	Australian Capital Territory Union
AEC	Australian Electoral Commission
AIHW	Australian Institute of Health and Welfare
AIP	Australian Institute of Petroleum
BDM	Births, Deaths, Marriages
CI	Confidence Interval
COD	Cause of Death
COPD	Chronic Obstructive Pulmonary Disease
CONCAWE	Conservation of Clean Air and Water in Europe
DEPM	Department of Epidemiology and Preventive Medicine
DIMIA	Department of Immigration, Indigenous and Aboriginal Affairs
DOB	Date of Birth
FPSO	Floating Production Storage and Offloading
HIC	Health Insurance Commission
HR	Human Resources
HW	*Health Watch*
HWAC	*Health Watch* Advisory Committee
ICD	International Classification of Diseases
IHD	Ischaemic Heart Disease
LH	Lympho-haematopoietic
MonCOEH	Monash Centre for Occupational and Environmental Health
MUHREC	Monash University Human Research Ethics Committee
NCIS	National Coronial Information System
NDI	Nation Death Index
MDS	Myelodysplastic Syndrome
MPD	Myeloproliferative Disorder
SIR	Standardised Incidence Ratio
SMR	Standardised Mortality Ratio
RIR	Relative Incidence Ratio
RMR	Relative Mortality Ratio
VCR	Victorian Cancer Registry

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