

THE AUSTRALIAN WORK EXPOSURES STUDY (AWES): LEAD AND LEAD COMPOUNDS



November 2014

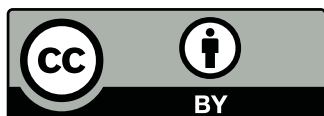
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SAFE WORK AUSTRALIA

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PREFACE

The Australian Work Health and Safety Strategy 2012-2022 (the Strategy) describes work-related cancer as a priority disorder and understanding current hazardous exposures and the effectiveness of controls as a research priority. The Australian Work Exposures Study (AWES) was a national survey that investigated work-related exposures among Australian workers to 38 agents classified by the International Agency for Research on Cancer (IARC) as known or suspected carcinogens.

Some forms of lead are considered to be probable carcinogens and the work described in this report uses AWES data to:

- estimate the prevalence of work-related exposure to lead during relatively common workplace activities
- identify the main circumstances of those exposures, and
- identify the use of workplace control measures designed to decrease those exposures.

This report describes those exposures that occur when typical work activities are carried out by Australian workers—it does not specifically focus on high risk lead work or ‘lead’ industries.

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KEY MESSAGES

- Approximately 307 (6.1%) of workers who participated in the Australian Work Exposures Study (AWES) were probably exposed to lead when performing common tasks like soldering, preparing surfaces for painting, or machining metal at work.
- The health risks posed by exposures to lead should be well understood, particularly by those undertaking work which falls within the scope of lead-specific regulations. Model Codes of Practice and work health and safety guides identify common tasks where lead exposure is a potential hazard and provide advice on preventing exposures using the hierarchy of controls.
- However, when information on the use of controls was provided by AWES respondents, many reported:
 - only using respiratory protective equipment (RPE), or
 - not using any controls to prevent exposures.
- As a result, many of these workers were assessed as having high or medium task-based exposures to lead. While most of these workers will not develop cancer as a result of work-related exposures to lead, they are at greater risk.
- Awareness-raising and education efforts are required to increase the use of well-known and readily available controls to prevent exposures like using lead-free alternatives, soldering or welding booths, area ventilation, or fitting dust collectors to power tools in Australian workplaces.

EXECUTIVE SUMMARY

Background

Cancer is a priority disorder under the Australian Work Health and Safety Strategy 2012-2022 (the Strategy). Better understanding current hazardous exposures and the effectiveness of controls is a research priority under the Strategy. While some forms of lead are considered to be probable carcinogens there is little information about the nature of general workplace exposures to lead in Australia—regulations and data collection tend to focus on activities defined as ‘lead risk work’ where high levels of workplace exposures may occur frequently.

The Australian Work Exposures Study (AWES) is a recently-conducted nationwide survey which investigated the current prevalence of work-related exposure to 38 known or suspected carcinogens, including lead, among Australian workers. The AWES data provide an opportunity to better understand the extent and circumstance of exposure of the Australian workforce to lead.

The aim of the work described in this report was to use AWES data to estimate the prevalence of work-related exposure to lead during relatively common workplace activities, to identify the main circumstances of exposures, and to identify the use of workplace control measures designed to decrease those exposures. This report is concerned with those exposures that occur when typical work activities are carried out by Australian workers—it does not specifically focus on high risk lead work or ‘lead’ industries.

Approach

The information presented in this report comes primarily from analyses of data from the AWES project. The AWES project involved computer-assisted interviews of approximately 5000 Australian workers. OccIDEAS—an automated process of expert assessment—was used to assess the likelihood of exposures and estimate exposure levels to 38 known or suspected carcinogens based on self-reported information on work tasks and the controls being used by workers. The likelihood of exposure was assessed as none, possible or probable. Data on tasks that could result in lead exposures were extracted and examined for this report.

Prevalence estimates based on the proportion of workers in the AWES sample probably exposed to lead were applied to the Australian Bureau of Statistics 2011 Census data to provide prevalence estimates for the Australian working population. The AWES information was supplemented with limited Australian data from other sources, including from the 2008 National Hazard Exposure Worker Surveillance (NHEWS) Survey and the published literature. National level estimates were compared to prevalence estimates found in major overseas studies.

Key findings

Of the workers who completed the AWES survey:

- 307 (6.1%) had probable exposure to lead
- almost all workers with probable exposure were male
- just over half of all workers with probable exposure worked in technical occupations, and
- almost half of those with probable exposure worked in the construction industry.

The main tasks associated with probable exposures were, in decreasing order: soldering; painting old houses, ships or bridges; plumbing work; cleaning up or sifting through the remains of a fire; radiator repair work; machining metals or alloys containing lead; mining; and welding leaded steel. Some workers worked at or used indoor firing ranges. Exposure levels were assessed as being high or medium for most tasks (approximately 77%).

The main control measures workers reported using were designed to decrease the chance of exposure to lead dusts or fumes by inhalation, for example, using soldering or welding hoods, wearing respiratory protective equipment (RPE) such as face masks or half-face respirators, working outdoors or using area ventilation. However, the use of these controls was inconsistent. For example soldering was found to be the most common form of exposure to lead but the use of appropriate exposure control measures such as using respiratory protective equipment was uncommon with this activity.

If AWES estimates are applied to the Australian working population approximately 6.6% of all workers could be considered as probably exposed to lead at work. This estimate is much higher than that found in major overseas studies and is probably due primarily to differences in study methodologies in terms of the type of data collected and the approach used to estimate exposure.

Limitations

The AWES is a national population-based study providing representative exposure information on relatively common activities. Information will be lacking on most industry sub-sectors, specific occupations and specific tasks which are less common or which are undertaken by a relatively small number of people. Thus, workers undertaking tasks such as manufacturing or recycling lead-acid batteries that might result in significant lead exposures were not included in the random sample of 5023 workers—they are a small proportion of the workforce.

Subjects included in the AWES sample were asked a series of questions about their job and the tasks involved. Some information was also obtained on the use of control measures. However, the information that could be collected on controls was somewhat limited. This was because questions asked in AWES primarily assessed if exposure could occur and then, if possible, assessed the likely level of exposure; and because there were limitations on the number of questions that could be asked while still encouraging people to participate in the project. Survey modules were based on exposures via the inhalation route. Specific questions on the

provision of washing facilities or wipe-downs of dusty areas which might prevent ingestion of lead dust through hand-mouth transfers were not asked.

Exposure assessments were qualitative and refer to task or activity based exposure levels rather than to exposure standards or blood lead levels. There is therefore not necessarily any close quantitative correlation between exposures levels assessed in this study and blood-lead levels, although they would be expected to be qualitatively similar in many instances.

Policy implications

Approximately 6.6% of Australian workers are estimated to be exposed to lead when performing relatively common tasks at work. More information is required to understand the level of risk arising from these exposures in terms of cancer outcomes.

Some of the health risks posed by exposures to lead, the tasks that might result in such exposures and the methods of preventing exposure should be well understood, particularly by those undertaking work which falls within the scope of lead-specific regulations. However, the use of controls by workers in the AWES sample was generally poor. Where information on the use of controls was collected many respondents reported using RPE or reported not using any controls to prevent exposures. There is an opportunity to prevent work-related exposures to lead through efforts to increase the number of workplaces that consistently use high order controls and good work practices to eliminate or reduce these exposures. Based on the results presented in this report, some high exposures could be lowered by:

- encouraging the use of soldering booths, area ventilation, or where this is not practicable, RPE when workers are soldering, and
- ensuring that power sanders are fitted with dust collectors and that workers wear appropriate respiratory protective equipment when workers sand old structures prior to painting or repairing them.

Initial efforts could focus on initiatives that raise awareness or educate persons conducting a business or undertaking (PCBUs) and workers about using lead-free alternatives or using well-known and readily available controls to prevent exposures to lead.

Further research

The AWES was a population-based study and only provides exposure information on relatively common activities—it is not a dedicated study of workers employed solely in the lead industry or workers who mostly perform lead risk work. Detailed information about exposure circumstances in specific industry sectors and sub-sectors or during specific activities such as manufacturing or recycling lead-acid batteries can be obtained much more efficiently from (smaller) targeted studies.

Collecting actual measures of lead exposure when some of the tasks identified in this report are undertaken may help validate the AWES data

and help better understand lead exposure levels. This information may comprise blood lead levels or air monitoring results. Blood lead levels will reflect the amount of lead absorbed through any route of exposure while air monitoring will provide information on the effectiveness of controls. Additional research examining the relationship between occupational lead exposure and cancer occurrence would also be useful.

The work presented in this report could be complemented by the collection of more widespread and more detailed information on the use of control measures when workers might be exposed to lead when undertaking relatively common activities. Further research could also help understand why appropriate control measures are not used. Work health and safety policy-makers and practitioners might be interested in aspects such as identifying the extent to which:

- PCBUs and workers understand the hazards and associated potential risks
- PCBUs and workers understand the need for various control measures and how they operate
- higher order controls are used
- current regulations and guidance are adequate for preventing exposures, and
- current methods for providing risk management information and assistance to PCBUs are effective.

BACKGROUND

Introduction

Cancer is a priority disorder under the Australian Work Health and Safety Strategy 2012-2022(Safe Work Australia 2012c). Better understanding current hazardous exposures and the effectiveness of controls is a research priority under the Strategy. Lead is a probable carcinogen and inorganic lead compounds are classified by the International Agency for Research on Cancer (IARC) as Group 2A—Probable Human Carcinogen¹ (International Agency for Research on Cancer 2006).

Lead and lead compounds, collectively referred to throughout this report as 'lead', are used in the manufacture of lead-acid batteries, alloys for solder and ammunition, and some plastics, protective coatings and ceramics. Past and current use of these products means that workers in a number of industries might be exposed to lead from typical work-related activities which generate lead-containing dusts or fumes. Typical work-related activities include restoration or demolition of old homes, soldering, lead casting, recycling batteries and other electronic equipment, or burning lead-stabilised plastics. While it is expected that some of these activities are undertaken in Australia there is little information about the nature of general workplace exposures. Information on the nature of exposures to lead will help inform current workplace chemicals policy development activities.

The early efforts of Australian researchers to estimate the number of workers who might be exposed to known or suspected carcinogens such as lead relied on applying overseas estimates to Australian labour force data (Australian Bureau of Statistics 2002; Fritschi & Driscoll 2006; Mathers et al. 1999; Morrell et al. 1998; Winder & Lewis 1991). The 2008 National Hazard Exposure Worker Surveillance (NHEWS) Survey attempted to collect information on chemicals used by workers and the controls provided by persons conducting a business or undertaking (PCBUs) to help address this information gap (de Crespigny 2010; MacFarlane et al. 2012). However, the data collected through the NHEWS Survey have limited utility in determining the extent of exposures to specific chemicals or the manner in which workers use controls to prevent exposures. This is because it relied on workers being aware of the specific chemical hazards with which they worked, it provided a low level of detail on controls measures, and the sampling approach meant the results were not representative of the Australian workforce.

The recent work on the Australian Workplace Exposure Study (AWES) (Carey et al. 2014) provided the opportunity to obtain information on the prevalence of lead exposure during typical work activities at a national level. The main part of this report presents an analysis of relevant AWES data. This is followed by a consideration of the implications of the results for policy activity and future work health and safety research.

1. The IARC classifications are described briefly in Appendix 1.

Lead as a carcinogen

The most authoritative information on the possible carcinogenicity of lead is provided by the IARC. Inorganic lead compounds are classified by the IARC as a Group 2A—Probable Human Carcinogens. Organic lead compounds are not classifiable as to their carcinogenicity to humans (IARC Group 3). This does not mean they are not carcinogenic but that current evidence is insufficient to allow a more definitive assessment to be made. The basis of these classifications is described in IARC Monograph 87 (International Agency for Research on Cancer 2006). Most forms of lead encountered in the occupational environment are inorganic, with leaded fuels previously the most common source of exposure to organic lead. Organic lead compounds are sometimes used as stabilisers in plastics (Gidlow 2004).

Lead has been implicated as being a risk factor for lung, stomach, kidney and brain cancer in workers exposed to lead in a work-related context. None of the studies on which IARC made its determination were definitive, with small numbers and the potential for residual confounding making a definitive determination of the results difficult. There is strong animal evidence in the rat and mouse that exposure to lead in a range of forms increases the risk of renal cancer, and there was evidence in one animal study of an increase in the risk of gliomas (a tumour of the brain). This combined with the limited epidemiological evidence in humans, lead to the IARC classification of inorganic lead as a Group 2A agent. Other organisations have classified lead similarly to the IARC (Committee on Potential Health Risks from Recurrent Lead Exposure of DOD Firing-Range Personnel et al. 2012; National Toxicology Program 2011).

Under Australian work health and safety regulations manufacturers or importers must determine if a chemical is a hazardous chemical. At the current time, two classification schemes may be used for this purpose—the Approved Criteria for Classifying Hazardous Substances [NOHSC:1008(2004)] (the Approved Criteria) (National Occupational Health and Safety Commission 2004) or the Globally Harmonised System of Classification and Labelling of Chemicals 3rd Revised Edition (the GHS) (United Nations 2009). The Hazardous Substances Information System (HSIS) (Safe Work Australia 2012b) lists substances that have been classified by an authoritative source such as the European Commission or National Industrial Chemicals Notification and Assessment Scheme (NICNAS) in accordance with the Approved Criteria and provides classification details. Part 3 of Annex VI of Directive 67/548/EEC - Classification, packaging and labelling of dangerous substances lists hazardous substances for which GHS classifications have been established at European Community level. Only a very limited number of inorganic lead compounds are listed in HSIS with carcinogenic classifications at the current time. In contrast, IARC classifies all inorganic lead compounds as probable human carcinogens.

The main non-carcinogenic health effects of lead are well described in many publications. These effects include a range of adverse effects on the foetus; cognitive dysfunction, with children particularly vulnerable; renal failure; hypertension; and a range of haematological effects, particularly anaemia (Australian Institute of Occupational Hygienists 2009; Gidlow 2004; International Agency for Research on Cancer 2006; Safe

Work Australia 2013b). As the focus of this report is lead as a probable carcinogen, the non-carcinogenic effects of lead are not considered further in this report. However, Safe Work Australia undertook a comprehensive review of toxicology studies to inform blood lead removal level policy work.

In 2009 the Australian Institute of Occupational Hygienists recommended that the national standard for lead in blood be lowered, arguing that it does not offer sufficient protection to workers, particularly to women 'of reproductive capacity'. This recommendation was not made specifically to decrease the risk of malignancy, although clearly lower body burden is likely to result in lower risk. In addition, the Institute recommended lowering the exposure standard from 0.15 mg/m³ to 0.10 mg/m³ (TWA) (Australian Institute of Occupational Hygienists 2009). Further consideration of the merits of these two recommendations is beyond the scope of the current report.

Information on exposure and control measures

Information from published literature

The relevant IARC monograph (International Agency for Research on Cancer 2006) (International Agency for Research on Cancer 2006) (International Agency for Research on Cancer 2006)(International Agency for Research on Cancer 2006)(International Agency for Research on Cancer 2006) identified the main industries in which work-related exposure to lead occurs as "lead smelting and refining industries, battery manufacturing plants, steel welding or cutting operations, construction, painting and printing industries, firing ranges, vehicle radiator-repair shops and other industries requiring flame soldering of lead solder, and gasoline stations and garages". Lead exposure could also be expected to occur in lead glass manufacturing. Some of these exposure circumstances (such as petrol stations and garages) are less relevant in Australia now because of the near universal use of unleaded petrol.

In terms of occupations, IARC separated the relevant occupations into those where workers had on-going exposure (i.e. exposure as a common part of their job activities), those who had a moderate frequency of exposure and those who were exposed but at a low frequency. The identified occupations were:

- **on-going exposure:** battery-production workers, battery-recycling workers, foundry workers, lead chemical workers, lead smelter and refinery workers, leaded-glass workers, pigment workers, vehicle radiator-repair workers and traffic controllers
- **moderate frequency of exposure:** firing-range instructors, house renovators, lead miners, newspaper printers, plastics workers, rubber workers, jewellery workers, ceramics workers and steel welders and cutters, and
- **low frequency of exposure:** automobile-repair workers, cable-production workers, construction workers, demolition workers, firing-range participants, flame solder workers, plumbers and pipefitters, pottery-glaze producers, ship-repair workers and stained-glass producers.

The level and frequency of exposure varies considerably across these occupations, from regular and potentially significant, to occasional and likely to be only at low level.

The CAREX database provides information on prevalence of exposure to a range of probable and definite carcinogens as classified by the IARC. It contains estimates of the numbers of workers exposed to carcinogens at work by industry in 15 countries of the European Union (EU) (exposure data from 1990-93) and four of the 10 countries that joined the EU in 2004 (exposure data from 1997). It also contains summarised exposure data, definitions of carcinogenic exposure, descriptions of the estimation procedures and bibliographic references. The work was undertaken in two phases. Initially estimates were derived from national workforce data and exposure prevalence estimates from two reference countries (the United States (US) and Finland) which had the most comprehensive data available on carcinogen exposures. The most valid value of prevalence (usually the mean of the US and Finnish values) was used as the default value. There was also some modification of estimates based on data in some individual European countries. The overall CAREX data were produced to reflect exposures in the early 1990s in Europe. Information is only available for males and females combined. The prevalence of work-related exposure to inorganic lead overall in CAREX was 1.1%, with highest prevalence in electricity, gas and water (2.7%), manufacturing (2.3%), construction (1.6%), mining (1.1%) and transport and storage (1.0%) (Finnish Institute of Occupational Health 1998). As mentioned, exposure prevalence and levels might have changed since the time represented by the CAREX data, due particularly to the introduction of unleaded fuel. It is likely that over the last two decades improvements in work practices and approaches to exposure control, changes in industry distribution and regulatory restrictions on the use of lead in some products would also have resulted in a decrease in exposure prevalence levels in Australia compared to the estimates at the time the CAREX database was developed.

A more recent carcinogen exposure database, CAREX Canada, provides more up to date data and it estimates the overall occupational exposure prevalence for lead to be about 2%. The CAREX Canada database identifies the main occupational exposures (in terms of number of people exposed) as being welders, police officers and, for men, car mechanics, plumbers and pipefitters. Industries with the highest prevalence of exposure were public administration, building equipment and contractors, automotive repair and maintenance, and commercial and industrial machinery repair and maintenance (CAREX Canada 2014).

A recent major study of the work-related burden of cancer in Great Britain considered brain, lung and stomach cancer arising from lead exposure (Brown et al. 2012; Rushton et al. 2012)(Brown et al. 2012; Rushton et al. 2012). This study estimated exposure prevalence using data from Great Britain. The overall prevalence of exposure to lead was 4.2% for men and 2.0% for women. This figure represents the proportion of the working cohort that were 'ever exposed' in the 10 to 50 year exposure period used for the project. AWES (Carey et al. 2014) estimates the point prevalence. Exposure prevalence in individual industries or occupations was not provided. The main industries and industry sub-sectors that were deemed to have the highest numbers of exposed persons were construction (47% of all exposed persons); manufacture of electrical machinery, apparatus,

appliances and supplies (13%); manufacture of plastic products not elsewhere classified (13%); and non-ferrous metal basic industries (11%) (Van Tongeren et al. 2012). Note that these percentages are of the total number of exposed persons, NOT the percentage of persons within the industry who are exposed.

A recent Australian study examined cancer incidence and mortality from various causes in a cohort of lead-exposed workers. All included subjects had jobs that were considered to be lead risk work- under the relevant state government regulations. Subjects primarily came from the manufacturing, construction, public order and safety services, transport and trade industries, but there was no information on exposure prevalence. The study found a slightly higher overall mortality but a lower overall cancer incidence (Gwini et al. 2012).

Information from the National Hazard Exposure Worker Surveillance (NHEWS) Survey

The NHEWS study (Australian Safety and Compensation Council 2008; 2009) was a study of Australian workers designed to examine the frequency of exposure to a range of hazards, including workplace chemicals. The study initially focused on key industries (agriculture, forestry and fishing; manufacturing; construction; transport, postal and warehousing; and health and community services) but included all industries in the second phase of data collection. Some information on provision of exposure controls was also collected.

The survey was conducted in 2008 via telephone. All information on exposure to specific hazards and on controls was from self-report. The nature of the data collection meant that the data could not be considered representative of the whole Australian working population, or even necessarily quantitatively representative of the specific industries included. However, it did provide useful qualitative information and some quantitative information.

Potentially relevant reports published from NHEWS examined exposures to chemicals through skin contact (MacFarlane et al. 2012) and airborne exposures (de Crespigny 2010) but neither report has useable information specifically on lead exposures. Examination of the unit record data for this study identified seven respondents who reported exposure through any route to lead. Two reported exposure to lead fumes (one specifically identified these arising from welding) and five reported lead dust from various sources. The activities involved were:

- exposure to lead paint dust while drilling and cutting while working as a welder, fabricator and fitter in the construction industry
- exposure to lead dust working in a lead smelter as a supervisor (the person was employed in the construction industry and was supervising some installation work)
- exposure to lead dust working as a machinist in the manufacturing industry
- exposure to lead paint dust and welding fumes working as a welder and labourer in the manufacturing industry
- exposure to soil possibly contaminated with lead working as an environmental engineer in the construction industry

-
- exposure to lead fumes while working as a teacher in the manufacturing industry, and
 - exposure to lead dust working as a leading hand in the mining industry.

The primary control measures identified by the seven people who reported lead exposure at work were masks, respirators, ventilation systems, and reduced time spent in an exposure situation. Most of these measures were reported by most of the seven respondents as being used. One or more of the other choices provided by the survey (monitoring gases, use of gloves, wearing other protective clothing, labelling and warning signs, washing facilities and training on safe handling of chemicals) were reported by only two of the seven people who reported lead exposure. The survey did not ask questions about biological or air monitoring (MacFarlane et al. 2012).

Australian lead regulations and guides

In Australia work health and safety requirements for working with hazardous chemicals are set out in Part 7.1 of the model Work Health and Safety Regulations 2011 (model WHS Regulations) (Safe Work Australia 2011)². These include requirements for airborne contaminants and PCBUs must ensure the workers are not exposed to lead dusts at concentrations higher than the relevant exposure standard. A number of work activities that might involve significant exposure to lead are defined as ‘lead processes’ in Part 7.2 of the model WHS Regulations³ which sets out additional requirements for these activities. Information on meeting work health and safety requirements is provided in the model Code of Practice: Managing Risks of Hazardous Chemicals in the Workplace (model Hazardous Chemicals Code) (Safe Work Australia 2012a).

PCBUs would be expected to follow the hierarchy of control, particularly measures to stop the release of lead into the work environment and measures designed to minimise the opportunity for workers to come into contact with lead through breathing lead fumes or dusts or touching or swallowing lead-contaminated materials. PCBUs must also assess lead processes to determine if ‘lead risk work’—work carried out in a lead process that is likely to cause the blood lead level of a worker carrying out the work to exceed relevant blood lead removal levels—is undertaken in the workplace. Where workers might carry out lead risk work health surveillance is required. Where blood lead removal levels are exceeded workers must be removed from lead processes until blood lead levels have been reduced to acceptable levels. The blood lead levels referred to in regulations are not based on preventing carcinogenic outcomes. Rather, they are based on potential effects on the foetus in women and on neurologic, renal and haematological effects in workers more generally.

2. Victoria and Western Australia have not adopted the model WHS Regulations and specific regulatory requirements in these jurisdictions may differ.

3. Lead processes are also listed in Safe Work Australia (2013a). Health monitoring for exposure to hazardous chemicals. Guide for persons conducting a business or undertaking. Canberra.

METHODS

The Australian Workplace Exposure Study (AWES)

The analysis presented in this report uses AWES data (Carey et al. 2014)¹. The AWES project is a nationwide survey which investigated the current prevalence of work-related exposure to 38 known or suspected carcinogens, including lead, among Australian workers (Carey et al. 2014).

Study Population

The sample for the AWES was obtained from a commercial survey sampling firm and consisted of household contact details compiled from various public domain data sources such as telephone directories. Both landline and mobile phone numbers were included and the sample was stratified to reflect the approximate distribution of the Australian work force by state and territory as reported by the Australian Bureau of Statistics (ABS) Labour Force Survey from March 2011 (Australian Bureau of Statistics 2011a). Within these households currently employed residents aged between 18 and 65 were eligible to participate. Those with insufficient English language ability and those who were too ill to participate were ineligible. One eligible person within each household was selected for interview.

Of the 19 896 households telephoned during the course of this study, 2452 did not respond, 10 485 were ineligible, and 1936 refused to participate. 5023 interviews were completed and the response rate (excluding ineligible households) was 53%.

Data Collection

Interviews commenced in October 2011 and were completed in late 2012. All interviews were conducted by trained interviewers using computer-assisted telephone interviews. Respondents provided oral informed consent prior to any data being collected. Demographic information collected included age, gender, postcode of residence, country of birth, language spoken at home, and highest level of education.

The respondent's main job was then categorised as either exposed or unexposed to any of the 38 carcinogens by the use of a simple screening tool. Respondents whose job fitted into one of 13 predetermined categories of unexposed jobs such as white-collar professional or customer service were classified as unexposed and their interview terminated. A total of 2532 respondents were categorised as unexposed at this point and only minimal information was collected from these persons. Basic job information such as job title, main tasks at work, industry, frequency of work in terms of hours per week and weeks per year was collected from the remaining 2491 respondents and this information was used to assign them to one of 58 job specific modules (JSMs). These modules included questions about the completion of tasks likely to involve exposure to carcinogens and were developed by a team of occupational hygienists and epidemiologists. An example is provided in Appendix 2.

1. A detailed overview of the AWES study and the prevalence of exposures to the 38 carcinogens has been published (Carey et al. 2014). This section of the report summarises the research methodology.

All modules were completed using the OccIDEAS (Fritschi et al. 2009) online tool to manage interviews and exposure assessments. Each full interview took approximately 15 minutes. Following the interviews each job was coded according to the Australian and New Zealand Standard Classification of Occupations (ANZSCO) 2006 (Australian Bureau of Statistics 2006). These coded jobs were then categorised into one of 30 occupational groups which contained jobs which were judged to be relatively homogeneous in terms of exposure (Carey et al. 2014). Thirty respondents reported jobs with insufficient information to be classified and were excluded from further analysis, resulting in a final sample of 4993 respondents.

Exposure Assessment

Automatic assessments of the probability ('none', 'possible' or 'probable') and level ('low', 'medium', 'high') of exposure to lead were provided by OccIDEAS using predetermined rules developed on the basis of expert opinion. These rules were based on occupational hygienists' practical experience of workplace exposures and available exposure measures in the literature. These rules took into account the amount of time spent working on relevant tasks and the use of exposure control measures where this information was available. All automatic assessments were reviewed by project staff for consistency. The assessments were qualitative and referred to:

- exposure levels relevant to suspected carcinogenic outcomes—i.e. they do not necessarily correlate to exposures standards or to blood lead removal levels, and
- the level of exposure whilst undertaking the relevant task—they are not an assessment of the time-weighted average exposure of that person.

Two thousand, four hundred and ninety-one respondents completed a JSM. Twenty-two of these modules included questions related to lead exposures such as soldering and welding, working with metals, glazing and plumbing. Three hundred and seven respondents were assessed to have probable exposure and 126 respondents were assessed to have possible exposure to lead in their current occupation.

Statistical Analysis

All statistical analyses were conducted using SAS version 9.3 and Excel. Confidence intervals for proportions were also calculated using an on-line tool (Lowry 2013). Only those persons designated as having probable work-related exposure to lead were included in the main analysis. Assessments were extrapolated with reference to the 2011 Census (Australian Bureau of Statistics 2011b) to calculate an estimate of the number of Australian workers currently exposed to lead in the course of their work. These extrapolations were stratified by gender and conducted separately by occupational group and industry in order to account for potential differences in exposure. The results are presented in text, figures and tables. The main body of the report has primarily text and figures. Most of the tables are included in Appendix 3. Confidence intervals are not included in the figures and text for ease of understanding but, where appropriate, are included in the tables.

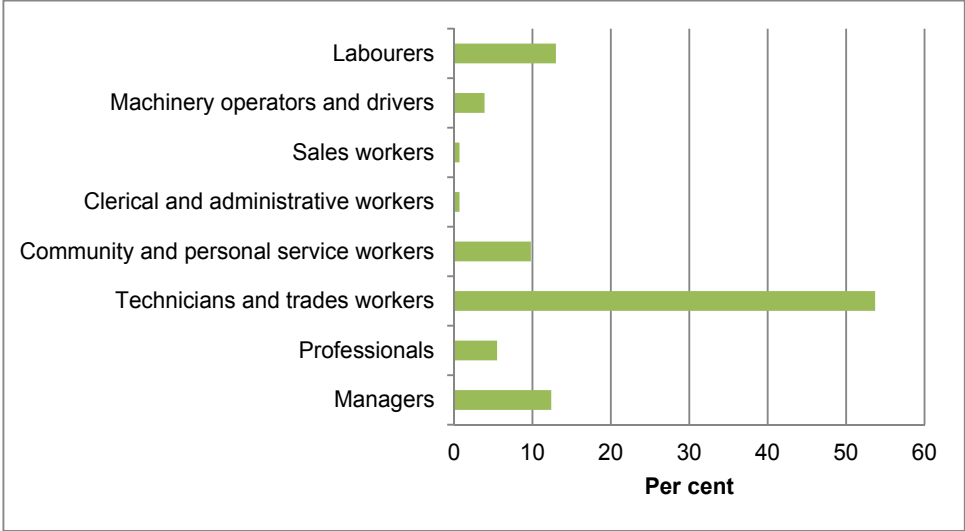
RESULTS: Information on exposure and control measures from the Australian Workplace Exposure Study

Overall results

Within the sample of 4993 respondents whose data was analysed, 307 (6.1%) had probable exposure to lead. Another 126 respondents had possible exposure but they are not considered further in this analysis. Overall, 295 (10.7%) males and 12 (0.5%) females in the AWES sample were assessed as probably being exposed to lead. The level of exposure was deemed to be high for 133 (43.3%), medium for 109 (35.5%) and low for 65 (21.2%) for those exposed.

Just over half (165: 53.7%) of the exposed respondents worked in technical occupations, 40 (13.1%) worked as labourers and 38 (12.4%) worked as managers (Figure 1)¹.

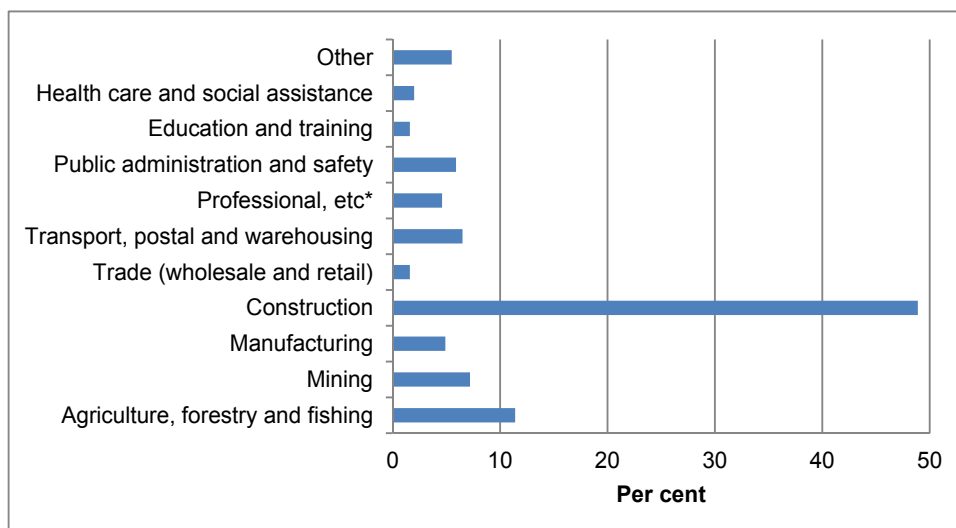
Figure 1: Occupation of all respondents exposed to lead—per cent



Construction was the industry of employment of almost half the exposed respondents (150, 48.9%), with Agriculture, forestry and fishing (11.4%) and Mining (7.2%) the next highest-represented industries (Figure 2).

1. Tables providing data on which Figures are based are in Appendix 3.

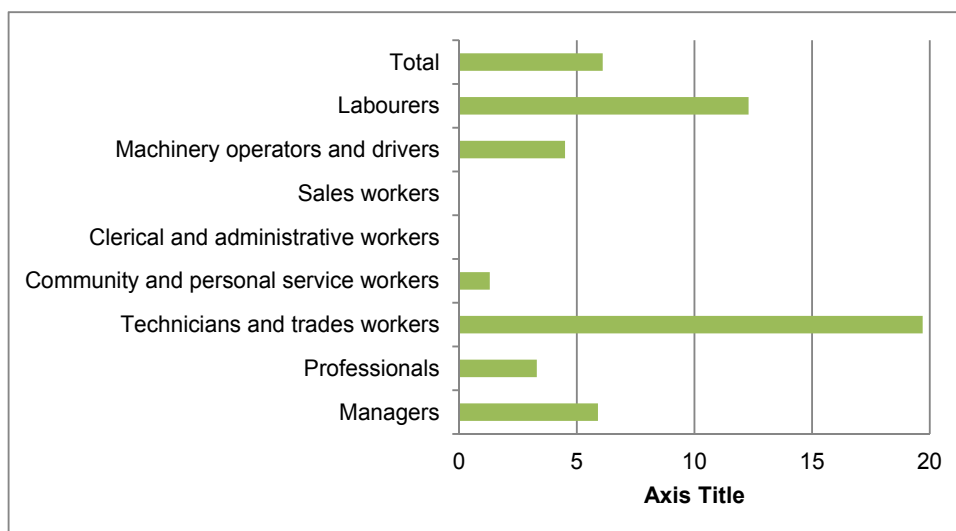
Figure 2: Industry of all respondents exposed to lead—per cent



* Professional, scientific and technical services

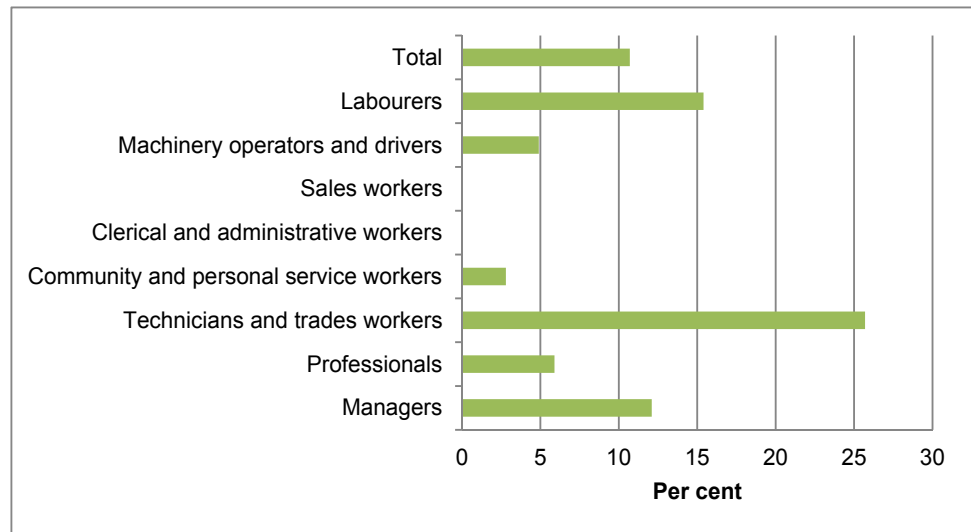
The proportion of respondents within a given occupation or industry who were exposed to lead was estimated by dividing the number of exposed respondents in a given occupation or industry by the total number of AWES respondents within that occupation or industry. Occupations with the highest proportion of members exposed were technicians and trades workers (19.7%) and labourers (12.3%)—this was true overall and for males (Figures 3 and 4).

Figure 3: Proportion of respondents in each occupation exposed to lead—per cent



Note: Proportions are not shown for clerical and administrative workers or for sales workers because there were less than five respondents in each category.

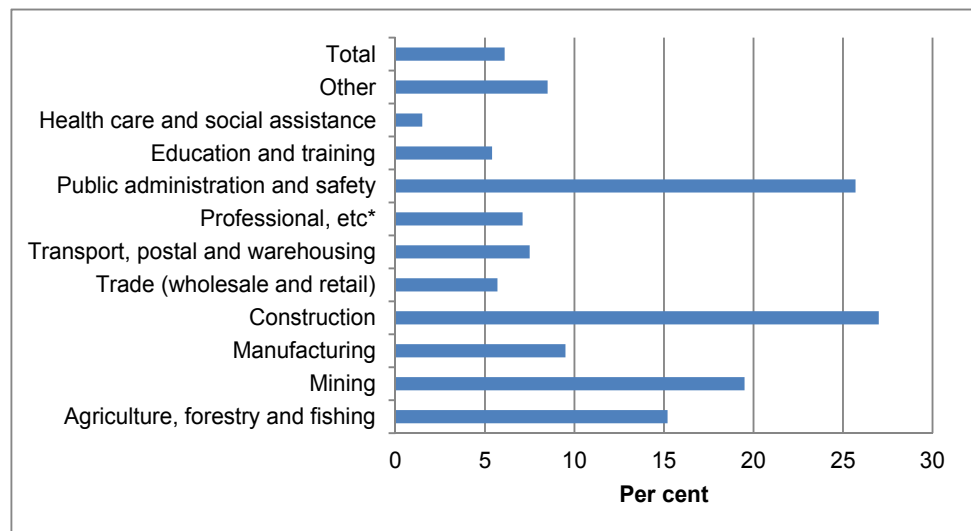
Figure 4: Proportion of male respondents in each occupation exposed to lead—per cent



Note: Proportions are not shown for clerical and administrative workers or for sales workers because there were less than five respondents in each category.

Industries with the highest proportion of persons exposed were Construction (27.0%), Public administration and safety—i.e. fire fighters²—(25.7%), Mining (19.5%) and Agriculture, forestry and fishing (15.2%). The industries with the highest prevalence of exposure were similar for men (Figures 5 and 6).

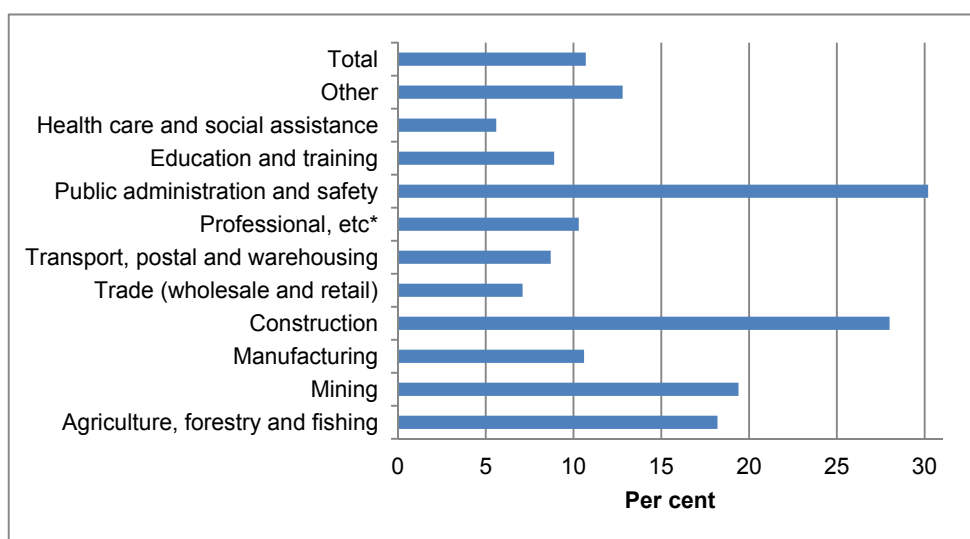
Figure 5: Proportion of respondents in each industry exposed to lead—per cent



* Professional, scientific and technical services

2. This industry classification includes Australian Defence Force personnel, and public order, safety, and regulatory services staff such as fire fighters.

Figure 6: Proportion of male respondents in each industry exposed to lead— per cent



* Professional, scientific and technical services

The prevalence of exposure to lead in the Australian workforce

Using 2011 Census data (Australian Bureau of Statistics 2011b) and the estimated proportions of AWES respondents exposed in each major occupation and industry group, stratified by gender, the numbers of exposed Australian workers in each major occupation and industry group and overall were estimated and are presented in Tables 1 and 2. Estimates are only provided for groups with at least five exposed persons in the study population.

These estimates suggest about 660 000 Australian workers, or 6.6% of the workforce, are probably exposed to lead when undertaking relatively common activities at work. The estimated exposure occurs predominantly in men. Approximately 631 000 men or 11.8% of the male workforce and approximately 29 000 women or 0.6% of the female workforce are estimated to be exposed.

Table 1: Estimated number of Australian workers exposed to lead—by occupation

Occupation ¹	Male ²	95% CI ³	Total	95% CI
Managers	100 820	73 000–137 000	102 182	74 000–140 000
Professionals	58 208	34 000–96 000	67 134	41 000–110 000
Technicians and trades workers	311 957	272 000–355 000	315 029	273 000–361 000
Community and personal service workers	8 437	6000–12 000	9 511	6000–14 000
Clerical and administrative workers	-	-	-	-
Sales workers	-	-	-	-
Machinery operators and drivers	29 229	16 000–52 000	29 229	16 000–52 000
Labourers	94 192	68 00–127 000	108 933	80 000–146 000
Total⁴	631 390	568 000–704 000	660 564	591 000–741 000

Notes:

1. Estimates are not provided for occupation groups for which there were less than five exposed respondents.
2. Separate data are not presented for females because there were too few exposed female respondents to allow occupation-specific estimates. The overall estimate of exposed women based on occupation was 29 174 (95% confidence interval 15 701 – 52 518).
3. 95% confidence interval.
4. The total is greater than the sum of the columns because estimates are not included in the table for those occupations with insufficient subjects and because an occupation could not be assigned to one respondent.

Table 2: Estimated number of Australian workers exposed to lead—by industry

Industry ¹	Male ²	95% CI ³	Total	95% CI
Agriculture, forestry and fishing	31 768	23 000 – 44 000	35 862	27 000–51 000
Mining	28 304	18 000–42 000	34 463	23 000–50 000
Manufacturing	71 066	42 000–115 000	71 066	51 000–139 000
Construction	201 054	174 000–230 000	206 041	194 000–257 000
Trade (wholesale and retail)	-	-	74 212	31 000–196 000
Accommodation and food services	-	-	-	-
Transport, postal and warehousing	32 144	20 000–48 000	32 144	23 000–55 000
Professional, scientific and technical services	41 830	23 000–72 000	49 774	30 000–86 000
Public administration and safety—i.e. fire fighters ⁴	112 393	70 000–166 000	149 761	112 000–261 000
Education and training	-	-	33 398	16 000–103 000
Health care and social assistance	13 756	6 000–30 000	13 756	7000–40 000
Total	604 481	544 000–749 000	700 477	627 000–879 000

Notes:

1. Estimates are not provided for industry groups for which there were less than five exposed respondents.
2. Separate data are not presented for females because there were too few exposed female respondents to allow industry-specific estimates. The overall estimate of exposed women based on industry was 95 996 (95% confidence interval 51 664 – 172 807).
3. 95% confidence interval. The data have been rounded to the nearest thousand.
4. This industry classification includes Australian Defence Force personnel, and public order, safety, and regulatory services staff such as fire fighters.
5. The total is greater than the sum of the columns because estimates are not included in the table for those industries with insufficient subjects and because the industry was not known for six subjects.

Circumstances of exposure

The assessed lead exposure occurred in a variety of circumstances. The main exposure circumstances are summarised in Table 3. These were, in decreasing order, soldering; painting; general plumbing; cleaning up or sifting through the remains of a fire; handling lead flashing; repairing engine radiators; using or cleaning an indoor firing range; machining brass, bronze, lead-plated metal or leaded alloys; mining lead ores or other ores containing lead; and welding leaded steel. Some subjects were exposed when performing more than one task and some less common exposure circumstances are not included in Table 3.

Table 3: Main circumstances resulting in exposure to lead

Exposure circumstance	High	Medium	Low	Total
Soldering	95	82	-	177
Painting	19	23	5	47
Plumbing - general	-	-	42	42
Fire fighting	-	4	16	20
Handling lead flashing	-	-	16	16
Radiator repair	13	-	-	13
Firing range	1	11	-	12
Machining	-	8	3	11
Mining	6	2	1	9
Welding leaded steel	6	2	-	8

Note: This table does not include all exposed respondents and respondents could be exposed through more than one activity.

The main circumstances resulting in assessed **high** exposures were:

- soldering in enclosed areas or mainly indoors without appropriate use of a hood or helmet
- painting old houses, ships or bridges using a power sander or burning off paint without use of a suitable respirator
- repairing engine radiators
- welding leaded steel in confined spaces or mainly indoors without appropriate use of a hood or helmet, and
- mining lead ores or other ores containing lead.

The main circumstances resulting in assessed **medium** exposures were:

- soldering not in enclosed areas and with common (more than 50% of the time) use of either a hood or helmet or commonly working outdoors
- painting old houses, ships or bridges – sanding by hand or commonly using a suitable respirator when burning off paint
- machining brass, bronze, lead-plated metal or leaded alloys without use of appropriate ventilation
- instructing in or firing guns in an indoor firing range, and
- cleaning up or sifting through the remains of a fire without commonly using appropriate breathing apparatus.

The main circumstances resulting in assessed **low** exposures were:

- general plumbing work
- handling lead flashing
- cleaning up or sifting through the remains of a fire commonly

using appropriate breathing apparatus or fighting house and residential fires

- painting old houses, ships or bridges – sanding by hand and commonly using a suitable respirator, and
- machining brass, bronze, lead-plated metal or leaded alloys with use of appropriate ventilation.

Each of the main tasks involving lead exposure is considered in more detail below. Those which may be classified as lead processes are also identified.

Soldering

There were 177 respondents who were exposed to lead through soldering work. The main industry of employment of the exposed respondents was Construction (53%), Agriculture, forestry and fishing (20%), Transport, postal and warehousing (9%) and Manufacturing (6%). The main occupation of the exposed respondents was vehicle worker (23%), plumber (17%), farmer (16%), electrical worker (15%) and metal worker (14%).

Ninety-five of these exposed respondents were deemed to have high exposures on the basis of working in enclosed areas (54), or commonly using none of a helmet, booth or outdoors work (41). The remaining 82 exposed respondents were deemed to have medium exposures because they usually used a helmet (18) or commonly used a hood (15) or commonly worked outdoors when soldering (45), or both (4).

Painting

There were 47 respondents who were exposed to lead through painting old houses, ships or bridges. One respondent used red-lead paint. The main activities likely to result in exposures when painting are preparing and sanding away old paint before painting over it or removing paint from old structures. The main industry of employment of the exposed respondents was Construction (71%) and Agriculture, forestry and fishing (19%). The main occupation of the exposed respondents was painter (48%), farmer (14%), plumber (9%) and handyperson (9%).

Nineteen of the respondents were deemed to have high exposures on the basis of working on old houses, bridges or ships using a power sander. The remaining 28 respondents were classified as having medium or low exposure because they only sanded by hand and they either did not use respiratory protection—classified as medium exposures—or they did use respiratory protection—classified as low exposures.

Some of these activities may be classifiable as lead processes depending on the amount of lead contained in paint being removed.

Plumbing and handling lead flashing

All 58 respondents undertaking plumbing work were deemed to have low exposure to lead, whether or not they handled lead flashing as part of their work (as 16 did) or were only identified as being involved in general plumbing tasks. Fifty-two (90%) respondents undertaking plumbing work were employed in the Construction industry, and the main occupations of the exposed respondents were plumber (43%), electrical worker (9%), manager (10%), handyperson (9%) and engineer (10%).

Fire fighting

Twenty fire-fighters were deemed to have exposure to lead, four with medium exposures and 16 with low exposures. The medium exposures involved overhaul, clean up, or sifting through the remains of a fire without using breathing apparatus at any time. If breathing apparatus was used during this activity, the exposure was deemed to be low. Exposure was also deemed to be low if respondents were fighting a residential or house fire (with or without breathing apparatus)—two respondents were deemed to have low exposure on this basis. The main industry of employment of the exposed respondents was Public administration and safety (40%), Health care and social assistance (20%) and Professional, scientific and technical services (15%). All the exposed respondents were emergency service workers.

Radiator repair

Thirteen respondents were exposed to lead through radiator repair work. All were deemed to have high exposure. The main industry of employment of the exposed respondents was Construction (46%) and Transport, postal and warehousing (23%). The main occupation of the exposed respondents was vehicle worker (42%) heavy vehicle driver (15%) and machine operator (15%). There was no available information on the use of exposure controls by these workers.

Some radiator repairs may be classifiable as a lead process if they may cause exposure to lead dust or lead fumes.

Indoor firing range

Twelve respondents were exposed to lead through working at an indoor firing range. Six (50%) of the exposed respondents worked for the police service and six worked in the military.

One exposed respondent was deemed to have high exposure as he cleaned a firing range as part of his duties and the remaining 11 were deemed to have medium exposure as they worked as an instructor or fired guns at a range.

Some of these activities may be classifiable as lead processes.

Machining

Eleven respondents were exposed to lead through machining lead plated metals or alloys containing lead. The metals involved were brass (8), lead (1), and both (2). The main industry of employment of the exposed respondents was Construction (55%) and Manufacturing (18%). The main occupation of the exposed respondents was metal worker (46%), electrical worker (18%) and engineer (18%).

Eight of the exposed respondents were deemed to have medium exposure on the basis of machining without the use of ventilation. The other three exposed respondents were deemed to have low exposure because they used ventilation when working.

Some of these activities may be classifiable as lead processes depending on the amount of lead contained in the alloys and the type of workplace.

Mining

Nine respondents were exposed to lead through mining activities. The metals being mined were lead and nickel (4), nickel (4) and uranium (1) and the mines were below ground (4), above ground (4) or both (1). All the exposed respondents worked in the Mining industry. The main occupation of the exposed respondents was miner (44%).

The level of exposure was determined by what the exposed respondents did and where they worked on the mine site. Six of the exposed respondents were deemed to have high exposure because they worked in an area that was dusty from the crusher (5) or at the mine face of an underground mine (1). Two more were deemed to have medium exposure because they worked in an open mine and the remaining respondent was deemed to have low exposure because they worked in the mine workshop.

Welding leaded steel

Eight respondents were exposed to lead due to welding leaded steel³. The main industry of employment of the exposed respondents was Construction (50%) and Agriculture, forestry and fishing (25%). The main occupation of the exposed respondents was vehicle worker (38%) and metal worker (25%).

Six of the exposed respondents were deemed to have high exposure on the basis of working in enclosed areas (3), or because they did not use a helmet, booth or did not work outdoors (3). The remaining two exposed respondents were deemed to have medium exposure because they commonly welded outdoors.

3. The AWES respondents were asked 'What are the main types of metals you weld?' and possible responses included 'lead-plated or leaded steel'. This response is simply described as leaded steel in this report.

DISCUSSION AND INTERPRETATION OF THE STUDY FINDINGS

Exposures

The main lead exposure circumstances identified in the AWES project were soldering, painting (old houses in particular), plumbing, fire clean-up and fire fighting, handling lead flashing, engine radiator repair, working at a gun firing range, machining metals containing lead, mining lead ore and ore contaminated with lead, and welding leaded steel. Soldering and painting were particularly common activities that entailed probable exposure.

The AWES project did not identify persons working in the 'traditional' high risk lead industries, such as smelting and refining, lead battery manufacture and recycling, and lead chemical manufacturing. This is because AWES is not a study of the lead industry but is a population-based study that attempts to identify if exposures to lead occur in the course of general work activities. These are two very different areas, although clearly with some overlap. Lead battery workers, for example, were not included in the analysis because there were no battery workers in the AWES sample, reflecting their relatively low numbers in the working population. This is an unavoidable aspect of any population-based survey.

Studies such as AWES are not designed to provide detailed information about exposure circumstances in a specific industry sector known to have lead exposure. That information can be obtained much more efficiently from a small study designed specifically to provide such information. Instead, AWES indicates that lead exposure is common in a range of occupations and industries and is not confined to the traditional industries where lead exposure is probably most intense. This may be an important consideration in work health and safety policy development aimed at protecting workers from adverse health effects, including cancer, from exposures to lead.

Based on AWES results and national employment data, it is estimated that about 660 000 workers—approximately 6% to 7% of the Australian workforce—are likely to be exposed to lead at least some of the time in their current job.

The exposure prevalence in this study was much higher than the 1.1% exposure prevalence estimation determined by the CAREX study (Finnish Institute of Occupational Health 1998) for some European countries. Exposure prevalence was also much higher in the current study than in CAREX for specific industries. The UK cancer burden study by Rushton and co-workers (Brown et al. 2012; Rushton et al. 2012) estimated an overall lead exposure prevalence of 4.2% for men and 2.0% for women. As mentioned earlier this was the proportion of the working cohort that was 'ever' exposed in the 10 to 50 year relevant exposure period. The point prevalence, which is essentially what AWES estimates, would be considerably less. Note these three studies included all lead identified exposures, not only those required to be considered for regulatory purposes.

The industries with the highest identified prevalence of exposure in CAREX were electricity, gas and water; manufacturing; construction; mining; and transport and storage. The UK cancer burden study identified the main industries with inorganic lead exposure as being lead battery work, demolition, and work in some manufacturing sub-sectors. In comparison, the industries identified in AWES as having the highest prevalence were Construction, Public administration and safety, Mining and Agriculture, forestry and fishing. The traditional lead-exposed industries were not well represented in AWES for the reasons discussed above. The main industries involving lead exposure identified by IARC and based on a range of published studies were “lead smelting and refining industries, battery manufacturing plants, steel welding or cutting operations, construction, painting and printing industries, firing ranges, vehicle radiator-repair shops and other industries requiring flame soldering of lead solder, and gasoline stations and garages” (International Agency for Research on Cancer 2006). Many of these are similar to the main industries identified in the AWES project. This may not be surprising because the exposure classification rules built into the AWES database are based on much of the same published literature that IARC would have used for its assessments.

Some of the differences in the overall prevalence estimates between these studies may reflect the different industry profiles in the countries in which the studies were based. The studies also used quite different methods. AWES was the only study that surveyed workers about the tasks they actually performed at work and took into account the use or non-use of control measures. CAREX estimates were based on workplace measures taken and on expert opinion. The UK Burden study used a similar approach, and relied heavily on CAREX estimates, but probably had better local exposure information at a broad industry level. The definition of exposure in the three studies also appears to have been different but it is difficult to make a direct comparison. The higher exposure prevalence estimated for the Australian working population by AWES suggests estimates might be based on lower levels of exposure or a lower probability of exposure than those used in the other studies. The level of exposure in the AWES project was based on exposure while undertaking the relevant task and was not intended to necessarily relate to an assessment of the time-weighted average exposure of that person. That was probably the case for the CAREX and UK studies. Levels of exposure assessed by the AWES project were not designed to be consistent with the lead regulations but to be relevant to suspected carcinogenic outcomes. The methods used in the AWES project suggest it is more likely to provide a nationally representative estimate of exposure than are the other two studies.

Use of control measures

The analysis of AWES data showed inconsistent use of control measures in circumstances that entailed potential exposure to lead. The main control measures used related to decreasing the chance of inhalation and included soldering or welding hoods, face masks or half-face respirators, outdoor work or area ventilation such as dilution or local exhaust ventilation. The study did not include specific questions on the provision of washing facilities or wipe-downs of dusty areas which might prevent ingestion of lead dust through hand-mouth transfers.

Soldering was found to be the most common form of exposure to lead and the use of appropriate exposure control measures, such as wearing an air-supplied helmet, was uncommon. This is a particular concern because high internal lead exposures can occur as a result of inhaling lead fumes.

While some tasks or activities may be considered lead risk work, the AWES project did not collect information about blood lead level testing. This is because the project was attempting to assess the actual exposure of workers and the direct control measures in place. Measures like administrative controls or health monitoring are also important but the AWES project did not collect this information. Activities such as mining, smelting, soldering with poor exposure control, repairing engine radiators and manufacturing involving lead batteries can potentially involve high lead exposures. It is likely that workers employed in tasks that explicitly involved potentially high and common lead exposure would undergo blood testing to monitor blood lead levels.

Gaps, strengths and weaknesses

This report uses data from the AWES project because there are few other relevant Australian data sources that include information on work practices and exposure estimates. The AWES project provides population-based information on current workplace exposures to a range of definite and probable carcinogens when relatively common workplace activities are carried out. It also provides evidence on which to base estimates of future burden arising from current exposures and on which to base estimates of future avoidable burden if exposures are better controlled. This information can be used for prioritising work to decrease exposures to lead. However, like any such survey, it has some limitations.

Data were collected through a telephone survey, with attendant time restraints in terms of maintaining the respondent's cooperation. In practical terms, telephone-based surveys involve a compromise between covering the essential questions and including questions that are important but not required for the primary purpose of the study. As the AWES covered a range of potential exposures a limited number of specific questions could be asked about any particular exposure. There were similar issues with the NHEWS project.

The sample was selected to be representative of the workforce, and the occupation and industry within the workforce, of each state and territory and therefore of the national workforce. The final sample on whom the results are based may not have been fully representative of the workforce due to people declining to be interviewed or being ineligible, but it was known that most of the general characteristics were similar between the final included sample and the general Australian population of working age. The primary study results of prevalence of exposure in the Australian workforce are based on the prevalence of exposure in the occupations that had the possibility of being exposed. This provided information on the prevalence of exposure to each carcinogen of interest in each occupation. This information was extrapolated to the Australian workforce, taking into account (that is, weighting by) the occupational distribution. If there is error in these prevalence estimates it will have come primarily because certain specific occupations in a broader occupation group were not accurately represented in the sample because a higher proportion of their members

declined to be included or were ineligible—e.g. because they did not speak English—and/or because those who participated did not accurately report their exposure.

The study relied on self-report data which is likely to introduce some error into the exposure assessment. However, the exposure assessment relied on subjects describing their current job tasks, guided by the questions in the relevant job-specific modules, rather than the workers having to recognise and recall specific exposures. This makes it less likely that exposure will be missed and less likely that specific exposures will be erroneously reported (Parks et al. 2004).

As a population-based study AWES can only be expected to provide representative exposure information on relatively common activities. Information will be lacking on most industry sub-sectors, specific occupations and specific tasks which are less common or which are undertaken by a relatively small number of people. This is why workers undertaking tasks that would usually be viewed as having a high risk of significant lead exposure such as manufacturing or recycling lead-acid batteries, but which do not comprise a significant proportion of the workforce, were not found in the study sample. If detailed information is required about a specific sector of the workforce or a specific activity targeted, specific research projects need to be undertaken.

As noted previously, exposure assessments were qualitative and referred to:

- exposure levels relevant to suspected carcinogenic outcomes—i.e. they do not necessarily correlate to airborne exposure standards or to blood lead removal levels, and
- the level of exposure while undertaking the relevant task—i.e. they are not an assessment of the time-weighted average exposure of that person.

While there may not be close quantitative correlation between exposure levels assessed in this study and blood-lead levels or airborne exposure levels, exposures may be qualitatively similar in many instances.

The AWES project provided some information on the use of control measures but the information that was collected on the use of controls was somewhat limited. The questions asked in AWES were aimed primarily to allow assessment of the fact of exposure and, if possible, the level of exposure. As noted earlier, they did not include specific questions on the provision or use of washing facilities or wipe-downs of dusty areas which might prevent ingestion of lead dust through hand-mouth transfers.

Non-response is also an issue for any survey such as that used for AWES. This raises the possibility that those who did participate had a different prevalence of exposure and different approach to the use of exposure control measures than those who did not participate. Since there is no employment information available on non-participants it is not possible to assess this potential problem in detail.

There is some disagreement between the overall numbers estimated using occupation compared to those using industry (Tables 1 and 2). This is because the number of exposed respondents was low in some gender-specific, occupation-specific and industry-specific groups, meaning the

estimate for that group had considerable uncertainty. The overall estimate based on occupation is likely to be more accurate. The confidence intervals around the estimates for women were wide because of the low number of exposed female subjects in the study.

Despite these limitations the AWES project has provided a considerable amount of data on exposure circumstances and the use (and non-use) of control measures.

Policy implications

This study estimates approximately 6.6% of the Australian workforce is likely to be exposed to lead mostly in the form of inorganic lead, when performing relatively common activities at work. This is higher than results of some other studies. As noted the differences probably reflect differences in the methodology used in the various studies, with the AWES using a task-based assessment process.

The probability of any increased risk of work-related cancer will depend on the type of cancer, the type of lead a worker is exposed to and the level, duration and frequency of exposure. The current mandatory reporting of blood lead levels for workers who perform lead risk work are unlikely to provide the appropriate type or detail of information to allow an appropriate assessment, as increased cancer risk might be expected at exposure levels below those triggering action based on blood lead levels. A cautionary approach to preventing exposures is therefore warranted.

In general some of the health risks posed by exposures to lead, the tasks that might result in such exposures and the methods of preventing exposure should be well understood by employers and workers (Australian Institute of Occupational Hygienists 2009). However, the use of controls by workers in the AWES sample was generally poor. Where information on the use of controls was collected many respondents reported not using respiratory protective equipment (RPE) or reported not using any controls to prevent exposures. There is an opportunity to prevent work-related exposures to lead, and reduce the potential for work-related cancer cases, through efforts to increase the number of workplaces that eliminate the use of lead where possible or consistently use high order controls and good work practices to eliminate or reduce exposures to lead when relatively common activities are carried out. This may simply require initiatives that raise awareness or educate PCBUs and workers about using lead-free alternatives or known controls to prevent exposures to lead. In particular, efforts could be focused on lowering exposures in those activities where a significant number of workers were assessed as having high exposures in the AWES. For example:

- PCBUs should be encouraged to install soldering booths or area ventilation such as dilution or local exhaust ventilation if soldering activities are fairly common in the workplace, or where this is not practicable, to provide respiratory protective equipment and ensure that is used when workers are soldering, and
- ensuring that power sanders are fitted with dust collectors and that workers wear appropriate RPE when workers sand old structures prior to painting or repairing them.

Research opportunities

Exposures and health outcomes

The AWES project provides qualitative information on current exposures to lead based on job tasks. Quantitative measures of lead exposure in the workplace may be of use to validate the data collected in AWES and to help better understand the absolute levels of exposure to lead. There was no scope to do this as part of the AWES but this information would be useful for tasks such as sanding structures prior to painting, radiator repairs or working at firing ranges.

Exposure information may be collected using biological measures of exposure such as blood lead levels or by air monitoring activities. If quantitative data is collected, the recommended approach would be to collect information on blood-lead levels in workers who were identified as exposed to high levels of lead in the AWES. Blood lead levels reflect the amount of lead absorbed through any route of exposures—i.e. both inhalation and ingestion—and are widely used to investigate the relationships between exposures and non-carcinogenic health effects of lead. Additional research examining the relationship between occupational lead exposure and cancer occurrence would also be useful.

The use of control measures

More detailed information on the use of control measures should be considered in those work situations highlighted in this report where probable lead exposures were assessed as being high. It would also be helpful to understand why appropriate control measures are not used where they should be. Work health and safety policy-makers and practitioners might be interested in aspects such as identifying the extent to which:

- PCBUs and workers understand the hazards and associated potential risks
- PCBUs and workers understand the need for various control measures and how they operate
- higher order controls are used
- current regulations and guidance are adequate for preventing exposures, and
- current methods for providing risk management information and assistance to PCBUs are effective.

This information would allow interventions and prioritisation of action to be based on sound evidence from Australian workplaces.

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GLOSSARY

95% CI	95% confidence interval
ABS	Australian Bureau of Statistics
ANZSCO	Australian and New Zealand Standard Classification of Occupations
Approved Criteria	Approved Criteria for Classifying Hazardous Substances [NOHSC:1008(2004)] 3rd Edition
AWES	Australia Workplace Exposure Study
CAREX	Carcinogen Exposure (study)
GHS	Globally Harmonized System for Classification and Labelling of Chemicals
HSIS	Hazardous Substances Information System
IARC	International Agency for Research on Cancer
JSM	Job-specific module
NHEWS	National Hazard Exposure Worker Surveillance (study)
OccIDEAS	An online tool to manage interviews and assess exposures
PCBU	Persons conducting a business or undertaking
WHO	World Health Organization
WHS	Work health and safety

APPENDIX 1: CLASSIFICATION OF CARCINOGENS

IARC classification of carcinogens

The following information is taken from the [IARC web site](#) describing the IARC classification.

Group 1	The agent is carcinogenic to humans.
Group 2A	The agent is probably carcinogenic to humans.
Group 2B	The agent is possibly carcinogenic to humans.
Group 3	The agent is not classifiable as to its carcinogenicity to humans.
Group 4	The agent is probably not carcinogenic to humans.

Approved Criteria Classifications

The Approved Criteria for Classifying Hazardous Substances [NOHSC:1008(2004)] (the Approved Criteria) uses the following classification categories for carcinogens:

Category 1	Substances known to be carcinogenic to man.
Category 2	Substances that should be regarded as if they are carcinogenic to man.
Category 3	Substances that cause concern for man owing to possible carcinogenic effects.

APPENDIX 2: Job-Specific Module questions and exposure coding rules for machining metals

Questions

What are the main types of metals you machine? [allow multiple]

- stainless steel
- mild steel
- brass or bronze
- cast iron
- copper
- aluminium
- titanium based alloys
- cadmium plated steel
- lead plated or leaded alloys
- nickel alloys
- other, please describe [free text]

Is there usually a ventilation system operating on the machines which you use to machine metal parts? Y/N/DK

Rules

If machining brass or bronze, or lead plated metals or leaded alloys, code to **probable** lead exposure.

Code to **medium** exposure unless ventilation system operating.

Otherwise, if ventilation system is operating, code to **low** exposure.

APPENDIX 3: Tables relevant to Figures presented in Chapter 3

Table 4: Occupations of all lead-exposed persons—numbers and percentages

Occupation	Number	Per cent
Managers	38	12.4
Professionals	17	5.5
Technicians and trades workers	165	53.7
Community and personal service workers	30	9.8
Clerical and administrative workers	2	0.7
Sales workers	2	0.7
Machinery operators and drivers	12	3.9
Labourers	40	13.0
Total	307	100.0

Note: One respondent's occupation was not known.

Table 5: Industries of all lead-exposed persons—numbers and percentages

Industry	Number	Per cent
Agriculture, forestry and fishing	35	11.4
Mining	22	7.2
Manufacturing	15	4.9
Construction	150	48.9
Trade (wholesale and retail)	5	1.6
Transport, postal and warehousing	20	6.5
Professional, scientific and technical services	14	4.6
Public administration and safety	18	5.9
Education and training	5	1.6
Health care and social assistance	6	2.0
Other	17	5.5
Total	307	100.0

Note: Industry was not known for six respondents and 11 respondents worked in industries other than those listed in the table—these respondents are classified as 'Other'.

Table 6: Proportions of respondents in each occupation who were exposed to lead—per cent

Occupation	Male	Female¹	Total
Managers	12.1	-	5.9
Professionals	5.9	-	3.3
Technicians and trades workers	25.7	-	19.7
Community and personal service workers	2.8	-	1.3
Clerical and administrative workers ²	-	-	-
Sales workers ²	-	-	-
Machinery operators and drivers	4.9	-	4.5
Labourers	15.4	-	12.3
Total	10.7	0.5	6.1

Notes:

- 1: Proportions are not shown for individual occupations for female respondents because there were less than five female respondents in each category.
- 2: Proportions are not shown for clerical and administrative workers or for sales workers because there were less than five respondents in each category

Table 7: Proportions of respondents in each industry who were exposed to lead—per cent

Industry	Male	Female	Total
Agriculture, forestry and fishing	18.2	-	15.2
Mining	19.4	-	19.5
Manufacturing	10.6	-	9.5
Construction	28.0	-	27.0
Trade (wholesale and retail)	7.1	-	5.7
Transport, postal and warehousing	8.7	-	7.5
Professional, scientific and technical services	10.3	-	7.1
Public administration and safety	30.2	-	25.7
Education and training	8.9	-	5.4
Health care and social assistance	5.6	-	1.5
Other	12.8	-	8.5
Total	10.7	0.5	6.1

Note: Proportions are not shown for individual industries for female respondents because there were less than five female respondents in each category.

