THE AUSTRALIAN WORK EXPOSURES STUDY (AWES):
CARCINOGEN EXPOSURES IN THE MANUFACTURING INDUSTRY

Report

May 2016

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This report was prepared by Ms Ellie Darcey (BSc), Dr Renee Carey (BA(Hons), PhD), Associate Professor Alison Reid (BSc(Hons), MSc, PhD) and Professor Lin Fritschi (MBBS, PhD, FAFPHM) of the Curtin University School of Public Health, Bentley, Western Australia, with the assistance of Professor Tim Driscoll (BSc(Med), MBBS, MOHS, PhD, FAFOEM, FAFPHM) of the School of Public Health from the University of Sydney.

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PREFACE

The Australian Work Health and Safety Strategy 2012-2022 (the Strategy) describes the manufacturing industry as a priority industry for prevention activities 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 collected information from respondents about their activities in the workplace and the controls used when performing those activities. This information was then used to estimate possible and probable exposures among respondents to 38 agents classified by the International Agency for Research on Cancer (IARC) as known or suspected carcinogens.

This report, prepared in collaboration with Safe Work Australia, uses AWES data to:

- estimate carcinogenic exposures within the manufacturing industry;
- identify the main circumstances of those exposures; and
- describe the reported use of workplace controls and protective measures designed to decrease those exposures.

This report describes those exposures that occur during typical work activities carried out by AWES respondents who were categorised as working in the manufacturing industry and does not specifically focus on high risk workers.

SUMMARY

Why has this research been done?

The aim of this research is to improve our understanding about potential exposure to 38 known or suspected carcinogens likely to be used in Australian workplaces.

While most workers will not develop cancer as a result of work-related exposures, those exposed to known or suspected carcinogens are at greater risk.

Who did we study?

A random, population-based sample of 5528 Australian workers participated in the Australian Work Exposures Study (AWES). Workers answered questions about the tasks they completed and the controls that were used at work. Based on their responses to those questions, the likelihood of exposure to 38 carcinogens was estimated.

This report focuses on the 281 AWES respondents who were categorised as working in the manufacturing industry.

The AWES provides reasonably representative information about potential exposures from relatively common activities. However, the results presented in this report should not be considered an exhaustive list of potential exposures to carcinogens in the manufacturing industry.

What did we find?

Approximately two-thirds (67 per cent) of manufacturing workers in this study were estimated to have a probable exposure to at least one carcinogen.

The most common carcinogens to which AWES manufacturing workers were probably exposed were diesel engine exhaust (20 per cent), chromium VI (19 per cent), environmental tobacco smoke (17 per cent), nickel (16 per cent), solar ultraviolet (UV) radiation (15 per cent) and wood dust (14 per cent).

The main circumstances or tasks associated with probable exposure included welding, working in areas where others smoked, working in areas where diesel engines were running and working outdoors.

The reported use of controls to prevent or minimise exposures varied considerably by task and circumstance. For example, about half (47 per cent) of those workers who soldered were considered to be adequately protected but ventilation systems or respiratory protective equipment were used by all workers when using power tools.

What do the findings suggest?

Existing work health and safety (WHS) guidance provides information about potential health effects and how exposures might occur and be prevented. However, the results from this study suggest that the use of controls could be improved when a number of common tasks are carried out.

What can be done?

As a first step, preventative actions should be focused on the most common carcinogen exposures and those for which options for preventing or minimising exposures are well known. In manufacturing, this suggests a focus on reducing exposures to diesel engine exhausts, reducing the use of trichloroethylene as a degreaser, and encouraging more frequent use of ventilation systems and respiratory protective equipment for tasks like welding, soldering or wood work.

Existing WHS information could be specifically tailored to provide clear, concise and consistent information about potential sources of exposures and controls that are appropriate for the manufacturing industry.

Key results could be validated through additional and more direct exposure measurement studies. The AWES exposure estimates are based on inferences made from information provided by respondents about the manner in which they perform tasks at work, using rules developed by Australian occupational hygienists. Respondents were not directly asked about their exposure to known or suspected carcinogens.

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Background

The manufacturing industry has been identified as a priority industry for prevention activities under the Australian Work Health and Safety Strategy 2012–2022 (the Strategy). Under the Strategy, better understanding of current hazardous exposures and the effectiveness of controls is a research priority. Given the varied nature of their work, workers in the manufacturing industry are potentially exposed to a wide variety of carcinogenic (cancer-causing) agents. However, little is known about the prevalence of exposure to these carcinogens or the tasks which may lead to exposures within the Australian manufacturing industry.

The Australian Work Exposures Study (AWES) was a national survey conducted between 2011 and 2013 that investigated work-related exposures to 38 known or suspected carcinogens among Australian workers. This data set provides an opportunity to gain a better understanding of the extent and circumstances of exposure to carcinogens among manufacturing workers.

The aim of this report was to examine the prevalence of exposure to carcinogens among manufacturing workers, to identify the main circumstances of those exposures, and to describe the use of workplace controls designed to decrease those exposures. This report describes those exposures that occur during typical work activities carried out by AWES respondents who were categorised as working in the manufacturing industry and does not specifically focus on high risk workers.

Approach

The information presented in this report comes from analyses of data from AWES. This study involved computer-assisted telephone interviews of approximately 5500 Australian workers. Similar to expert assessment methods, workers answered questions about the tasks they completed and the controls that were used at work. Based on their responses to those questions, the likelihood of exposure to 38 carcinogens (and exposure levels) was estimated. As AWES was a large scale survey attempting to estimate exposure to multiple agents in multiple workplaces, the online application OccIDEAS (Fritschi, Friesen et al. 2009)(Fritschi, Friesen et al. 2009)was used to estimate exposures, using algorithms are based on determinants of exposure identified in the published literature and supplemented by expert knowledge. All assessments were subsequently reviewed by AWES researchers and the adequacy of control measures reported by respondents was assessed by hygienists. For this report data on tasks that could result in worker exposures in the manufacturing industry were extracted and examined. Tasks completed by nine or more respondents were examined in greater detail.

Key findings

A total of 281 of 5528 respondents who completed the AWES survey, were categorised as being employed in the manufacturing industry. Of these, 189 (67%) had a probable exposure to at least one carcinogen. There were a total of 13 carcinogens to which more than nine or more manufacturing workers were probably exposed. The most prevalent exposures were:

- diesel engine exhaust (DEE; 20% exposed)
- chromium VI (19%)
- environmental tobacco smoke (ETS; 17%)
- nickel (16%)
- solar ultraviolet radiation (Solar UV; 15%), and
- wood dust (14%).

Workers could be exposed to these carcinogens in a variety of ways. The main tasks associated with probable exposure included:

- welding (artificial UV, chromium VI, nickel, and polycyclic aromatic hydrocarbons other than vehicle exhaust [other PAHs])
- working in areas where others smoked (ETS exposure)
- working in areas where diesel engines were running (DEE exposure), and
- working outside (Solar UV exposure).

These findings help confirm what is generally known or suspected about typical exposures to carcinogens in manufacturing.

The reported use of control measures was, on the whole, limited in manufacturing workers. Where information on controls was collected, the reported use of controls was considered adequate only 54% of the time. The least consistent use of controls was reported for UV protective measures, with only seven per cent of workers being adequately protected. This was followed by soldering, with 47% adequately protected. The only consistent use of control measures was the use of ventilation systems or respiratory protective equipment (RPE) while using powered tools (used by all workers).

Limitations

AWES is a national population-based study which is able to capture exposures across a wide range of workers and provide representative information on relatively common activities. However, this methodology is unable to provide information on tasks specific to a particular manufacturing occupation which are less common or are undertaken by a relatively small number of people. Such information would require a targeted research project to be undertaken. The AWES study used a telephone survey to collect data and thus was subject to time constraints. A compromise was needed between covering the essential questions and including questions that are important but not required for the primary purpose of the study. This meant that a limited number of specific questions could be asked about any particular circumstance. In addition, the questions asked on control use were limited to those circumstances that would affect the exposure assessment.

Exposure assessments were qualitative and refer to task or activity based exposure levels. This means that they do not necessarily correlate to exposure standards, and are not an assessment of the time-weighted average exposure of that person. The probability of any increased risk of work-related cancer in exposed workers will depend on the type of cancer and the level, duration and frequency of exposure.

Potential implications

Approximately 67% of AWES respondents categorised as working in the manufacturing industry were estimated to be exposed to at least one carcinogen when performing relatively common activities at work. While most of these workers will not develop cancer as a result of work-related exposures, they are at greater risk. Quantifying those risks is not straightforward and as a result, information is not readily available. Reviewing and assessing existing literature to derive such estimates was beyond the scope of this report.

The agents explored in the AWES study are classified by the International Agency for Research on Cancer (IARC) as known or probable human carcinogens and, as for all hazardous workplace chemicals, risks to health and safety (or exposures) must be eliminated so far as reasonably practicable. However, this is not possible for some exposures. In these cases, the hierarchy of controls must be used to minimise risks so far as is reasonably practicable—i.e. by substituting hazards (chemicals or work processes used) with something that poses less risk, isolating hazards from workers and other in the workplace, or by using or introducing engineering controls. Where risks still remain, administrative policies must be implemented, so far as is reasonably practicable, before personal protective equipment (PPE) is provided. In practice, a combination of controls might be used to minimise exposure because a single control measure might not be sufficient.

Noting the AWES concentrated on common tasks rather than specific, high risk activities, the focus for additional preventative action should be based on a balance between the exposures with a high prevalence and the exposure circumstances for which there are proven control measures and that are most amenable to control. For the manufacturing industry, this suggests:

- using new generation diesel engines (lower emissions technology), regular maintenance of existing diesel-powered vehicles and equipment, installation and maintenance of filter systems (trap particulate matter), and implementing work practices that minimise the time spent by workers near operating diesel engines
- widespread adoption (enactment of relevant anti-smoking legislation in those jurisdictions yet to do so) and enforcement of workplace smoking bans
- regularly using local exhaust ventilation (or carrying out activities in well-ventilated areas) and the use of RPE where workers are likely to be exposed to wood dust and formaldehyde, and
- regularly using local exhaust ventilation (or carrying out activities in well-ventilated areas) and the use of RPE designed for welding or soldering tasks.

Although there is considerable information available in the literature about the health effects, exposures and control of the carcinogens found in the manufacturing industry, this information is not organized in a way which is readily accessible—in form and content—for the manufacturing industry. There is a need for clear, concise and consistent information on the circumstances and control of exposures that is specifically tailored to the manufacturing industry.

Further research

The AWES provides information on current exposures to carcinogens within the manufacturing industry. Measuring specific carcinogen exposures in the workplace may be of potential use in validating the AWES data. There was no scope to complete this task as part of the AWES study.

The work presented in this report could also be complemented by the collection of additional information about the use of control measures to prevent exposures where AWES respondents were estimated to have probable carcinogenic exposures. Further research could also help understand why appropriate control measures are not being used and how to use this knowledge to improve current measures and workplace practice.

The potential burden of these exposures in terms of future cancer risk in manufacturing workers can be estimated. A method of predicting future cases of cancer due to current exposures has been used to help understand the burden of work-related cancer in the UK. Thus method could be used with Australian exposure data for example, AWES data, to predict the effect on the number and type of future cancer cases. This will help in determining the most effective policies to protect health.

BACKGROUND

Introduction

The manufacturing industry has been identified as a priority industry for prevention activities under the Australian Work Health and Safety Strategy 2012–2022 (the Strategy). Under the Strategy, an improved understanding of current hazardous exposures and the effectiveness of controls is a research priority. Given the huge variety of manufactured products produced and the variety of processes used to manufacture them, Australian manufacturing workers are potentially exposed to a wide variety of carcinogenic (cancer-causing) agents. However, little is known about the prevalence of exposure to occupational carcinogens, nor the tasks which may lead to these exposures, among workers in the Australian manufacturing industry.

Data from the Australian Work Exposures Study (AWES) provides an opportunity to gain a better understanding of the extent and circumstances of exposure to carcinogens among Australian manufacturing workers. The main part of this report uses AWES data to estimate the prevalence of exposure to carcinogens within the Australian manufacturing industry, to identify the main circumstances of those exposures, and to describe the use of workplace controls designed to decrease those exposures. This is followed by a consideration of the policy implications of these results in terms of exposure prevention.

This report presents information on estimated exposures to carcinogens among AWES respondents categorised as working in the manufacturing industry.

This report presents information on estimated exposures to carcinogens among AWES respondents characterised as working in the manufacturing industry. Exposure estimates have not been validated against measured exposures, and they should they not be used to comment on the current cases of work-related cancer. Occupational cancers are caused by past exposures and often there can be a period of many decades between exposure to a carcinogen and subsequent disease incidence. Information about current exposures enables work health and safety policies and practices to be revised or developed in a timely manner to prevent future cancer cases.

The Australian manufacturing industry

The manufacturing industry added a gross value of $111 billion and contributed 9% to Australia's gross domestic product (GDP) in 2009–10 (ABS 2012).

In 2010–11, the manufacturing industry employed 9% of all people employed in Australia. Within manufacturing the largest employers were food product manufacturing (203 900), machinery and equipment manufacturing (116 800) and primary metal and metal product manufacturing (92 900) (ABS 2012).

Cancer in the manufacturing industry

A study conducted in the Nordic countries found that workers in the manufacturing industry had significant excess incidence of some cancers. These included oesophageal, sinonasal, lung and bladder cancer (Pukkala et al. 2009).

Industry exposure to carcinogens

The manufacturing industry is very diverse, and consequently workers are potentially exposed to a wide variety of carcinogens with the exposures largely dependent on the products manufactured and the manufacturing processes employed (Victorian Trades Hall Council OHS Unit 2014).

Previously collected information on exposure and control measures in Australia

Workers in the manufacturing industry were found to be exposed to many potential carcinogens like some dusts, gases, vapours, smoke or fumes, skin contact with chemicals, and direct sunlight.

The National Hazard Exposure Worker Surveillance (NHEWS) survey, a study of Australian workers designed to examine the frequency of exposure to a range of hazards, was conducted in 2008 (Safe Work Australia 2009). Workers in the manufacturing industry were found to be exposed to many potential carcinogens like some dusts, gases, vapours, smoke or fumes, skin contact with chemicals, and direct sunlight. NHEWS respondents often provided multiple responses to questions about the provision of controls, with some of the most commonly provided being masks, ventilation systems, gloves and protective clothing.

Just over half (53%) of the manufacturing workers in NHEWS reported exposure to dust. The main dust types to which manufacturing workers were exposed were metal dust (23%), wood dust (14%), environmental dust (11%) and grinding dust (10%). Seventy per cent of the manufacturing workers were provided with masks, which was the most common reported control provided to prevent dust exposure. Other common controls were ventilation systems (61%), reduced exposure time (42%) and provided respirators (41%).

About two fifths (39%) of manufacturing workers in NHEWS were found to have an exposure to gases, vapours, smoke or fumes. Combustion or welding gases (50%), solvent vapours (22%), fuel vapours (16%) and chemical gases (13%) were the most common types of gases, vapours, smoke or fumes to which manufacturing workers were exposed. The most common control provided to prevent exposure was ventilation systems and 69% of manufacturing workers reported the provision of this control. Other common controls provided were masks (64%), respirators (46%) and reduced exposure time (46%).

Chemical substance exposure was also common among manufacturing workers in NHEWS with 36% exposed. Solvents, paints and glues (51%), cleaning products (36%) and fuels (12%) were the most common chemical substances to which manufacturing workers were exposed. Controls were commonly used for chemical substances, with the provision of gloves (88%), washing facilities (87%) and protective clothing (78%) the most commonly reported.

About one quarter (24%) of manufacturing workers in NHEWS reported some level of exposure to sunlight and the most common control measures provided were protective clothing (64%), hats (62%), sunglasses (59%) and sunscreen (58%).

Previously collected information on exposure and control measures in other countries

Exposures to carcinogens in the manufacturing industry have been reported in studies from other countries. For example, a British study found that common exposures in the manufacturing industry included solar radiation, silica, diesel engine exhaust (DEE), environmental tobacco smoke (ETS) and wood dust (Hutchings & Rushton 2012).

CAREX Canada is a Canadian surveillance project that estimates the number of Canadians exposed to carcinogens in workplace and community environments, including exposures in specific manufacturing industries. In printing, the most common exposures included benzene (31%), chromium VI (10%) and trichloroethylene (<5%). Architectural and structural manufacturers were commonly exposed to chromium VI (7%), lead (15%), artificial UV (15%) and nickel (11%). Nickel was also common among motor vehicle parts manufacturers (7%). Wood dust exposure was common among furniture and kitchen cabinet manufacturers and other wood manufacturers, with 29% and 43% exposed respectively. These two manufacturing areas were also exposed to formaldehyde, with 21% of furniture and kitchen cabinet manufacturers and 18% of other wood product manufacturers exposed. Less than 5% of metal manufacturers, plastic product manufacturers and cut and sew clothing manufacturers were exposed to trichloroethylene. Thirty per cent of cement and concrete product manufacturers were exposed to crystalline silica. CAREX Canada also reported that 21% of the manufacturing industry workers were working regular night or rotating shifts (CAREX Canada 2013).

Cancers caused by workplace carcinogens

The IARC recently completed a review on the cancer sites associated with carcinogenic agents (IARC 2015). Some common carcinogens associated with the manufacturing industry and related cancer sites are outlined in Table 1 below.

Table 1: List of carcinogens common in the manufacturing industry and their associated cancer sites

Carcinogens	Cancer sites with sufficient evidence in humans	Cancer sites with limited evidence in humans
Benzene	Leukaemia (acute non-lymphocytic)	Leukaemia (acute lymphocytic, chronic lymphocytic, multiple myeloma, non-Hodgkin lymphoma)
Chromium (VI) compounds	Lung	Nasal cavity and paranasal sinus
Engine exhaust, diesel	Lung	Urinary bladder
Formaldehyde	Leukaemia (particularly myeloid), nasopharynx	Nasal cavity and paranasal sinus
Lead compounds, inorganic		Stomach
Nickel compounds	Lung; nasal cavity and paranasal sinus	
Shift work that involves circadian disruption		Breast
Silica dust, crystalline (in the form of quartz or crystobalite)	Lung	
Solar radiation	Skin (basal cell carcinoma, squamous cell carcinoma, melanoma)	Eye (squamous cell carcinoma, melanoma); lip
Tobacco smoke, second-hand	Lung	Larynx; pharynx
Trichloroethylene	Kidney	Liver and biliary tract; non-Hodgkin lymphoma
Wood dust	Nasal cavity and paranasal sinus; nasopharynx	

Note: The IARC did not differentiate between types of wood when classifying “wood dust” as carcinogenic so all types of wood dust were included in the AWES.

Sources: Cogliano et al. 2011 and IARC 2015

Information on exposure and control measures in Australia

There are a range of exposure control measures that are used or have been recommended for use to control carcinogenic exposures in the manufacturing industry. These cover all aspects of the hierarchy of control measures—elimination, substitution, isolation, engineering controls, administrative approaches and personal protective equipment (PPE). The specific measures used for a particular hazard depend on aspects such as the nature of the hazard, the tasks in which the exposure may occur and consideration of what is reasonably practicable. In many cases, exposures are likely to occur by inhalation of airborne contaminants. For inhalation exposures which cannot be eliminated, the hierarchy of controls must be used to minimise risks (exposures) so far as is reasonably practicable—by substituting hazards (chemicals or work processes used) with something that poses less risk, isolating hazards from workers and others in the workplace, or by using or introducing engineering such as local and area ventilation. Where risks still remain, administrative policies—designed to reduce the amount of time performing tasks or working in areas where exposures may occur—must be implemented, so far as is reasonably practicable, before PPE, including respiratory protective equipment (RPE) such as air-supplied helmets or face masks, is provided. These control measures are considered in more depth later in this report in relation to specific carcinogens.

METHODS

The analysis presented in this report is based on data from the AWES (Carey et al. 2014), supplemented with data from the Australian Work Exposures Study-Western Australia (AWES-WA). Both were telephone-based surveys investigating current occupational exposure to 38 known or suspected carcinogens among Australian workers. These carcinogens had been previously prioritized as being those most relevant to Australian working conditions (Fernandez et al. 2012).

Selection of carcinogens

The 38 carcinogens had been prioritised in 2012 as being those most relevant to Australian working conditions (Fernandez et al. 2012).

The selection process began by collating all agents classified by the IARC as either: carcinogenic to humans (Group 1) or probably carcinogenic to humans (Group 2A). While several classifications of carcinogens are available, the IARC classification was chosen because it had been used by several other similar studies (Kauppinen et al. 2000; Rushton et al. 2012). From the initial list the following were excluded:

- exposure circumstances, for example working as a painter
- agents for which exposure is not primarily occupational, such as dietary, pharmaceutical, or infectious agents, and
- those not used in Australia, for example banned substances or those not on the Australian Inventory of Chemical Substances (NICNAS 2015).

The AWES sample

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

Data from this study were combined with data from the AWES-WA. This study collected information on a further 505 Western Australian residents using the AWES methodology.

In total, 22,590 households were telephoned. No response was obtained from 3033 households, while 12,081 were ineligible and 1948 refused to participate. A total of 5528 interviews were completed, resulting in a response rate (excluding ineligible households) of 53%.

The AWES were population-based surveys, where participants were randomly selected from the working age population. Thus, participants were recruited from a wide range of occupations and industries rather than being selected from specific industries. In some industries the number of participants may be small but should reflect the general working population in that industry.

Exposure assessment methods

The online application OccIDEAS (Fritschi et al. 2009) was used to categorize people as to whether they were exposed to the 38 carcinogens. This application is based on the expert assessment method in which questions about tasks are asked of the worker, and experts infer the worker's exposure from that information (Siemiatycki et al. 1981). The innovative feature of OccIDEAS is that it uses algorithms to automatically assign exposure. The algorithms are based on determinants of exposure identified in the published literature and supplemented by expert knowledge. For example, a worker who reported that he welded stainless steel using oxyacetylene processes would be assigned high level exposure if he welded inside with neither an air-supplied welding helmet nor a ventilation system.

The OccIDEAS approach provides an estimate of exposure rather than an actual measurement.

The OccIDEAS approach provides an estimate of exposure rather than an actual measurement. However it can be used in large scale surveys such as AWES in which there is no possibility of measuring exposure to multiple agents in multiple workplaces. OccIDEAS is being used in several studies around the world including AsiaLymph (National Cancer Institute 2015) and the Australian Mesothelioma Registry (AMR 2015).

The OccIDEAS approach relies on the worker reporting their tasks accurately. While this may not always be the case, it is usually better than relying on the worker identifying and assessing their own exposure—that is, the approach used in surveys such as NHEWS (Safe Work Australia 2009; Teschke et al. 2002).

Data Collection

Interviews were conducted between October 2011 and September 2013 by trained interviewers using computer-assisted telephone interviews. All respondents provided oral informed consent before providing any information.

Demographic information collected included age, gender, postcode of residence, country of birth, year of arrival in Australia, language spoken at home, and highest level of education. Postcode information was used to determine respondents' socioeconomic status (ABS 2008) and remoteness (ABS 2011b).

A simple screening question was then used to classify each respondent's main job as either exposed or unexposed to any of the 38 carcinogens. Those whose job fitted into one of 13 predetermined categories of unexposed jobs, for example white-collar professional or customer service workers, were categorised as unexposed and no further questions were asked. A total of 2783 were classified as unexposed at this point.

Basic job information, including job title, main tasks completed, industry, and frequency of work in terms of hours per week and weeks per year, was collected from the remaining 2745 respondents. This information was then used to assign respondents to one of 57 job specific modules (JSMs) in OccIDEAS. Specific JSMs were completed by 2649 respondents. For the remaining 116 respondents open-ended questions were used to collect information about the respondent's day-to-day job tasks. Each complete interview took approximately 15 minutes.

Job coding

Following the interviews, each of the jobs was coded according to the Australian and New Zealand Standard Classification of Occupations (ANZSCO) (ABS 2006b) and the Australian and New Zealand Standard Industrial Classification (ANZSIC) (ABS 2006a). The analysis presented in this report is restricted to those 281 AWES respondents who were categorised as working in the manufacturing industry (ANZSIC code 'C').

The manufacturing industry ANZSIC code 'C' includes the following subgroups;

- Furniture and Other Manufacturing
- Machinery and Equipment Manufacturing
- Transport Equipment Manufacturing
- Fabricated Metal Product Manufacturing
- Primary Metal and Metal Product Manufacturing
- Non-Metallic Mineral Product Manufacturing
- Polymer Product and Rubber Product Manufacturing
- Basic Chemical and Chemical Product Manufacturing
- Petroleum and Coal Product Manufacturing
- Printing (including the Reproduction of Recorded Media)
- Pulp, Paper and Converted Paper Product Manufacturing
- Wood Product Manufacturing
- Textile, Leather, Clothing and Footwear Manufacturing
- Beverage and Tobacco Product Manufacturing, and
- Food Product Manufacturing
- AWES manufacturing worker demographic information

AWES manufacturing worker demographic information

The AWES manufacturing workers were predominantly male (n=249, 89%), aged 35–54 years (60%) and most (87%) had a trade certificate or diploma or less as their highest education level. Over half (n=163; 58%) lived in major cities. Other demographic information and a comparison to all manufacturing workers can be found in Table A1.

The sample of AWES manufacturing workers was made up of six occupational groups: managers (11%), professionals (5%), technicians and trade workers (49%), clerical and administrative workers (1%), machinery operators and drivers (10%), and labourers (23%).

Exposure Assessment

OccIDEAS was used to provide an automatic assessment of the probability ('none', 'possible', 'probable') and level ('unknown', 'low', 'medium', 'high') of exposure to each of the 38 carcinogens. These assessments were based on predetermined rules which had been developed on the basis of findings reported in the scientific literature, including, exposure measurements where relevant, and expert opinion. Rules were attached to and triggered by specific answers within the JSMs, and took into account the tasks completed, materials used and the use of exposure control measures, where available. All automatic assessments were reviewed by project staff for consistency.

Possible exposures were assigned if the information suggests there was a chance that the person could be exposed but there was not enough information available to accurately estimate whether they are exposed or not. Probable exposures were assigned where it was likely that the person was exposed. Assigned exposure levels provide an estimate of exposure for specific tasks taking into account task-related factors including the adequacy of workplace controls which could eliminate or reduce exposures, based on information reported by respondents—they are not an assessment of the time-weighted average exposure of that person and they do not necessarily correlate to exposure standards. Thus, a low level of exposure was defined as 'present but not likely to require further control measures'; high exposure as 'control measures are likely to be needed'; and medium as a level between these values (Figure 1) (Fritschi et al. 2012). This information is designed to highlight circumstances where the use of controls can be improved rather than attempt to estimate the risk of cancer arising from specific tasks.

Figure 1: Automatic assessment definitions for OccIDEAS

OccIDEAS was used to provide an automatic assessment of:

probability

- ***none***
- ***possible**—'the information suggests there is a chance that the person could be exposed but there is not enough information available to correctly determine whether they are exposed or not', or*
- ***probable**—'it is likely that this person is exposed', and*

level

- ***unknown***
- ***low**—'present but not likely to require further control measures*
- ***high**—'control measures are likely to be needed', or*
- ***medium**—level between these values.*

Statistical Analysis

All statistical analyses were conducted using Stata 13 and Microsoft Excel. Descriptive statistics were used to summarise the demographic distribution of the sample. The sample distribution was then compared with the demographic distribution in the Australian working population employed in the manufacturing industry according to Census 2011 data (ABS 2011a) using Chi-square goodness of fit test.

Overall prevalence of exposure was defined as the proportion of workers assessed as having probable exposure to at least one of the priority carcinogens in their current job, regardless of frequency, duration, or level of exposure. A dichotomous measure of exposed or not exposed was used. Prevalence of exposure to individual carcinogens was similarly defined as the proportion of workers assessed as having probable exposure to that carcinogen. Further analyses were restricted to those carcinogens to which more than nine workers were probably exposed. Pairwise correlation was used to assess co-exposures among carcinogens.

Confidence intervals are not included in this report because calculations would have been very difficult to undertake accurately given the multi-stage sampling methods used, and more error is likely to arise from selection and measurement issues than from the statistical uncertainty implied by confidence intervals and probability values. Including some form of uncertainty statistic would make the report less readable while providing little additional useful information for general audiences.

Task based Analysis

Task-based analyses were restricted to those carcinogens with nine or more workers assessed as being exposed. For each such carcinogen, a list of potential circumstances leading to exposure was compiled, and the number of workers completing each task counted. Only those tasks completed by nine or more workers were subject to further analysis. For each relevant task, the number of workers completing the task was cross-tabulated with the exposure level assigned.

Where available, the use of controls, including personal protective equipment, was also considered for each task. A cross-tabulation was used to compare the number of respondents completing each task with the number who reported using the controls included in the JSMs.

RESULTS: Information on exposure and control measures from the Australian Work Exposures Study

Overall results

A total of 202 (72%) of the AWES manufacturing workers were estimated (or deemed) to have a possible or probable exposure to at least one of the carcinogens. The number of workers who had a probable exposure to at least one carcinogen was 189 (67%).

There were 29 carcinogens to which at least one of the manufacturing workers was estimated to be either probably or possibly exposed (Table 2). Respondents considered 'possibly exposed' are not considered in further data analyses.

Table 2: AWES manufacturing workers estimated to have probable or possible exposure to carcinogens—by carcinogen (number and per cent)

Carcinogen	Probable exposure n (%)	Possible exposure n (%)	Total n (%)
Chromium VI*	**52 (19%)**	**21 (7%)**	**73 (26%)**
Diesel Engine Exhaust*	**57 (20%)**	**1 (0%)**	**58 (21%)**
Nickel*	**44 (16%)**	**5 (2%)**	**49 (17%)**
Environmental Tobacco Smoke*	**48 (17%)**	**0 (0%)**	**48 (17%)**
Wood Dust*	**40 (14%)**	**4 (1%)**	**44 (16%)**
Artificial Ultraviolet Radiation*	**25 (9%)**	**19 (7%)**	**44 (16%)**
Solar Ultraviolet Radiation *	**42 (15%)**	**0 (0%)**	**42 (15%)**
Lead*	**26 (9%)**	**14 (5%)**	**40 (14%)**
Other PAHS*	**30 (11%)**	**0 (0%)**	**30 (11%)**
Formaldehyde*	**23 (8%)**	**6 (2%)**	**29 (10%)**
Shift work*	**26 (9%)**	**0 (0%)**	**26 (9%)**
Asbestos	6 (2%)	16 (6%)	22 (8%)
Crystalline Silica*	**14 (5%)**	**2 (1%)**	**16 (6%)**
Trichloroethylene*	**12 (4%)**	**0 (0%)**	**12 (4%)**
Nitrosamine	6 (2%)	2 (1%)	8 (3%)
Cadmium	5 (2%)	3 (1%)	8 (3%)
Benzene	5 (2%)	2 (1%)	7 (2%)
Arsenic	6 (2%)	0 (0%)	6 (2%)
Ionizing Radiation	6 (2%)	0 (0%)	6 (2%)
Acid mists	2 (1%)	3 (1%)	5 (2%)
Styrene	0 (0%)	5 (2%)	5 (2%)
Vinyl Chloride	1 (0%)	3 (1%)	4 (1%)
Perchloroethylene	0 (0%)	4 (1%)	4 (1%)
Ethylene Oxide	3 (1%)	0 (0%)	3 (1%)

Carcinogen	Probable exposure n (%)	Possible exposure n (%)	Total n (%)
Butadiene	0 (0%)	3 (1%)	3 (1%)
PCBS	0 (0%)	3 (1%)	3 (1%)
MOCA	0 (0%)	2 (1%)	2 (1%)
Cobalt	0 (0%)	1 (0%)	1 (0%)
Leather	1 (0%)	0 (0%)	1 (0%)

Notes:

Those carcinogens listed in bold and have an * are those to which nine or more workers were exposed and will be the only carcinogens included in further analysis.

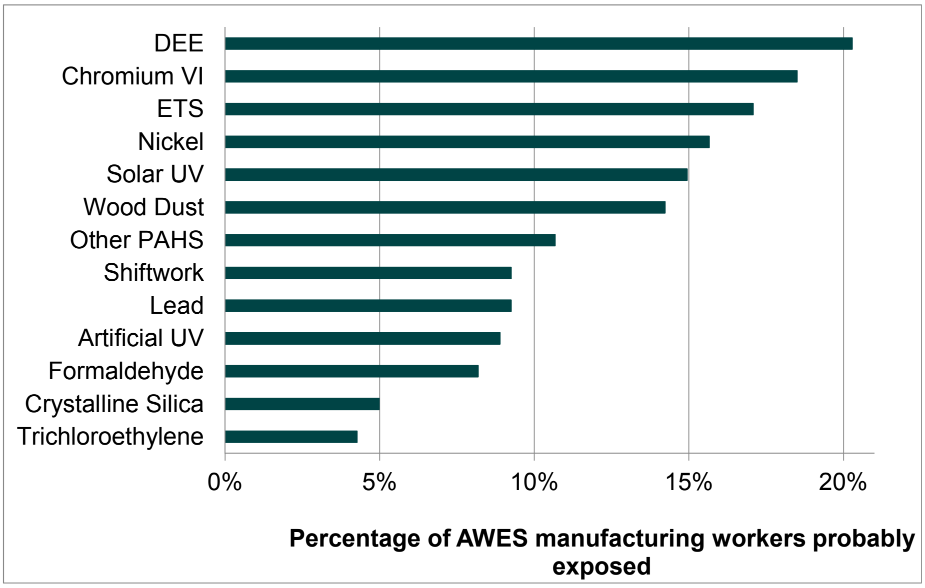
'Other PAHs' are polycyclic aromatic hydrocarbons (PAHs) other than vehicle exhaust.

'PCBS' are polychlorinated biphenyls.

'MOCA' is 4,4'-methylenebis(2-chloroaniline)

There were 13 carcinogens to which nine or more manufacturing workers were probably exposed. The carcinogens that had the highest prevalence of probable exposure in the manufacturing industry were diesel engine exhaust (DEE; 20%), chromium VI (19%), environmental tobacco smoke (ETS; 17%) and nickel (16%) (Figure 2).

Figure 2: Percentage of AWES manufacturing workers probably exposed to each carcinogen



Exposure Combinations

Co-exposure to the carcinogens was examined in a correlation matrix (Table A2). Most correlations were low. However, co-exposure to chromium VI and nickel was common. These are both exposures that are associated with welding and it is not surprising they tend to occur together. Exposures to artificial UV, lead and other PAHs which can be associated with welding tasks were also found to co-occur with chromium VI and nickel.

Wood dust and formaldehyde were also found to co-occur. Sanding chipboard is a common task that results in exposure to both wood dust and formaldehyde, which is a likely explanation for their correlation.

The rest of this chapter separately considers each of the carcinogens to which nine or more workers were deemed to have probable exposure. These are listed in alphabetical order, consistent with the Model WHS Regulations (Schedule 10) (Safe Work Australia 2014) and Safe Work Australia guidance for health monitoring (Safe Work Australia 2013b).

Artificial Ultraviolet Radiation (Artificial UV)

Twenty-five (9%) workers were deemed to have a probable exposure to artificial UV radiation. Of those exposed, 14 (56%) were assigned a medium level exposure and 11 (44%) a low level exposure.

Almost all (96%) of these workers were technicians and trade.

Circumstances of exposure

Supervising welders and working in areas with other welders present were the most common circumstances that led to a probable exposure. Medium level exposures were assigned to workers who supervised other welders (n=11; 44%) (Table 3).

Table 3: Main circumstances resulting in probable exposure to artificial UV

Exposure circumstance	High (n)	Medium (n)	Low (n)	Total (n)
Other welders in areas where worked	-	5	14	19
Supervising other welders	-	11	-	11

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

The exposure level for those who worked with other welders around them was dependent on the number of welders they worked with.

The exposure level for those who worked with other welders around them was dependent on the number of welders they worked with. A medium level was assigned if workers reported working with more than six other welders (n=5; 20%) and a low level was assigned if workers reported working with between one and six others (n=14; 56%) (Table 3).

The use of controls

Information on the use of controls was not collected for tasks associated with probable exposure to artificial UV.

Chromium VI

Fifty-two (19%) workers were deemed to have a probable exposure to chromium VI. Of those exposed, 29 (56%) were assigned a high level exposure, 6 (12%) a medium level exposure and 16 (31%) a low level exposure. An exposure level could not be assigned (was unknown) for one worker.

Most (n=44; 85%) of these workers were technicians or trades workers.

Circumstances of exposure

Welding stainless and chromium-plated steel and machining stainless steel were the most common tasks that led to a probable exposure to chromium VI.

Welding stainless and chromium-plated steel and machining stainless steel were the most common tasks that led to a probable exposure to chromium VI. Welding stainless steel or chromium-plated steel using ordinary, plasma arc, braze or oxyacetylene processes were assigned high or medium level exposures depending on whether or not an air-supplied welding helmet was worn, the amount of time spent welding outside, or if a ventilation system was in place (welding booth, exhaust hood or local exhaust ventilation). Twenty-four respondents completed welding tasks, with 11 being assigned a high level exposure and 13 a medium level exposure. Welding using metal inert gas (MIG), submerged arc or tungsten inert gas (TIG) processes resulted in either a medium or low level exposure based on the use of controls. Of those respondents who used MIG, submerged arc or TIG processes to weld stainless steel or chromium-plated steel, 12 (41%) respondents were not considered to have used adequate controls and were assigned a medium level exposure. The remaining respondents (n=17; 59%) were assigned a low level exposure because they were considered to have used adequate controls (Table 4).

Table 4: Main circumstances resulting in probable exposure to chromium VI

Exposure circumstance	High (n)	Medium (n)	Low (n)	Total (n)
Welds stainless or chromium-plated steel				32
• using ordinary, plasma, braze or oxyacetylene welding	11	13	-	24
• using MIG, submerged or TIG welding	-	12	17	29
Grind stainless steel welds	29	-	-	29
Welds stainless or chromium-plated steel in confined space	8	-	-	8
Machining stainless steel	-	6	14	20

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

Twenty-nine workers ground stainless steel welds and this task was assigned a probable high level exposure (Table 4).

Twenty workers machined stainless steel and were assigned either a medium or low level exposure depending on whether or not the area they worked in was ventilated (fan in window or doorway, open windows or doors, ventilated room). Six (30%) workers machined metal in areas that were not ventilated and 14 (70%) in areas that were (Table 4).

The use of controls

Use of controls was reported for welding and machining tasks. For welding, the controls included the use of an air-supplied welding helmet, the amount of time the respondent welded outdoors, and the amount of time spent welding where a ventilation system was in place (welding booth, exhaust hood or local exhaust ventilation) (Table 5).

Table 5: The reported use of controls when performing tasks with probable exposure to chromium VI

Exposure Circumstance	Air-supplied welding helmet (n)	Working outdoors (n)	Ventilated area or ventilation system (n)	Other RPE (n)	None (n)	Unknown (n)
Welds stainless steel or chromium-plated steel	10	1*	8*	N/A	14	0
Machining stainless steel	N/A	0	14	5	1	4

* More than half the time

Note: This table does not include all exposed workers and workers may have used more than one control.

Information collected on the use of controls for machining stainless steel was limited to time spent welding in areas that were ventilated (fan in window or doorway, open windows or doors, ventilated room) (Table 5).

Information was not collected on the use of controls when grinding welds.

The exposure assessment was adjusted if controls were considered adequate

For welding tasks, the exposure assessment was adjusted if controls were considered adequate because the worker welded where a ventilation system was in place more than half the time, welded more than half the time outdoors, or wore an air-supplied welding helmet. Forty-four per cent of workers who welded stainless steel or chromium-plated steel did not use adequate protection to reduce exposures (Table 6.)

Table 6: The adequate use of controls when performing tasks with probable exposure to chromium VI

Exposure circumstance	Adequate (n)	Inadequate (n)	Unknown (n)	Total (n)
Welds stainless or chromium-plated steel	18	14	0	32
Machining stainless steel	14	2	4	20
Total	**32**	**16**	**4**	**52**

Note: Workers who reported always or usually using ventilation systems, working in ventilated areas or wearing RPE during relevant work activities were grouped as ‘yes’. Those workers who reported sometimes or never using ventilation systems, working in ventilated areas or wearing RPE during relevant work activities were grouped as ‘no’.

For machining tasks, working in ventilated areas reduced the exposure assessment from a medium to a low level. Thirty per cent of the workers did not work in ventilated areas or information about the use of controls was not collected from them, thus the assessed level of exposure was not adjusted (Table 6).

Crystalline Silica

Fourteen (5%) workers were deemed to have a probable exposure to crystalline silica. Of those exposed, nine (64%) were assigned a high level exposure, one (7%) a medium level exposure and four (29%) a low level exposure.

These workers were technicians and trade workers (43%), labourers (21%), professionals (14%) and managers (14%).

Circumstances of exposure

Circumstances that led to probable exposure to crystalline silica included working with concrete, making ceramic products, and working on construction sites. Higher levels of exposure were assigned to respondents mixing and grinding concrete or handling raw ceramic materials. Low exposures were assigned to workers who worked on construction sites but were not undertaking tasks related to higher exposures (i.e. background levels). Less than nine workers completed each of these tasks and so no further analysis was undertaken.

The use of controls

Information on the use of controls was not collected for tasks associated with probable exposure to crystalline silica.

Diesel Engine Exhaust (DEE)

Fifty-seven (20%) workers were deemed to have a probable exposure to DEE. Of those exposed, the majority (n=36; 63%) were assigned a medium level exposure, 17 (30%) a low level exposure and four (7%) were assigned a high level exposure.

These workers were technicians and trade workers (33%), machinery operators and drivers (21%), labourers (18%) and managers (16%).

Circumstances of exposure

The most common circumstance that led to a probable exposure to DEE was working in areas where diesel vehicle engines were running.

The most common circumstance that led to a probable exposure to DEE was working in areas where diesel vehicle engines were running. The location (whether indoors, outdoors, or both), distance from the vehicle (less than 20 metres, 20–50 metres, more than 50 metres) and being able to smell exhaust fumes were all factors that influenced exposure assessments. Higher exposure levels were assigned to those workers who worked indoors, closer to vehicles, and could smell exhaust fumes. Seven workers reported working indoors and less than 50 metres away from a running diesel vehicle; however, only four workers reported smelling exhaust fumes and were assigned high level exposures, and the other workers were assigned medium level exposures. Eight (47%) of the 17 workers who worked in outdoor areas were assigned medium level exposures as they worked less than 20 metres away from a running diesel vehicle and reported smelling exhaust fumes. The other nine workers worked greater than 20 metres away or reported not smelling exhaust and so incurred a low level exposure. Of those who worked both indoors and outdoors, 23 (85%) were assigned a medium level exposure and four (15%) a low. Medium level was assigned if the worker reported working less than 20 metres away from the running diesel vehicle or if they worked between

20–50 metres away and could smell exhaust (Table 7).

Table 7: Main circumstances resulting in probable exposure to DEE

Exposure circumstance	High (n)	Medium (n)	Low (n)	Total (n)
Diesel vehicles with engine running in areas worked				53
• indoor areas	4	3	-	7
• outdoor areas	-	8	9	17
• both indoor and outdoor areas	-	23	4	27

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

The use of controls

Information on the use of controls was not collected for tasks associated with probable exposure to DEE.

Environmental Tobacco Smoke (ETS)

Forty-eight (17%) workers were deemed to have a probable exposure to ETS. Of those exposed, a majority (n=35; 73%) were assigned a low level exposure and 13 (27%) a high level exposure.

Thirty-seven (77%) of these workers were technicians or trades workers.

Circumstances of exposure

Exposure level for ETS was dependent on where (whether indoors, outdoors, or at the entrance to the building) workers were exposed to other people smoking whilst at work. A high exposure level was assigned where smoking was reported in indoor areas (n=13), while a low exposure level was assigned where smoking was reported near the entrance to the building (n=26) or in outdoor work areas (n=29) (Table 8).

Table 8: Main circumstances resulting in exposure to ETS

Exposure circumstance	High (n)	Medium (n)	Low (n)	Total (n)
People smoking in indoor areas that respondents worked in	13	-	-	13
People smoking near entrances to buildings that respondents worked in	-	-	26	26
People smoking in outdoor areas that respondents worked in	-	-	29	29

Note: Workers could be exposed through more than one activity.

The use of controls

22 (28%) of the workers reported that people smoked in areas subject to smoking bans.

All workers were asked about smoking bans in workplaces. Seventy-nine of the manufacturing workers reported that smoking bans were in place in their workplace. Of these, 38 had indoor smoking bans, six outdoor bans, 18 entrance bans and 43 total work site bans. However, 22 (28%) of the workers reported that people smoked in areas subject to smoking bans.

Formaldehyde

Twenty-three (8%) workers were deemed to have a probable exposure to formaldehyde. Of those exposed, most (n=17, 74%) were assigned a medium level exposure and six (26%) a low level exposure.

Most (82%) of these workers were technicians and trade workers (83%), with the remaining exposed working as labourers (9%) and machinery operators and drivers (9%).

Circumstances of exposure

The most common task resulting in exposure to formaldehyde was the use of power tools on particle board, pressed wood or plywood. Seventeen (74%) workers completed this task and were assigned a medium level exposure.

The use of controls

Of those workers who reported using power tools while working with particle board or plywood, 13 (76%) reported usually using a simple half face paper mask, 16 (94%) used ventilation systems (probably mainly local exhaust ventilation) and 12 (71%) used both paper masks and ventilation systems (Table 9). Regardless of whether controls were used or not, exposures were not adjusted because the hygienists did not consider the controls used were adequate to minimise all exposures.

Table 9: The reported use of controls when performing tasks with probable exposure to formaldehyde

Exposure circumstance	Half-face paper mask (n)	Ventilation (n)	Both (n)	None (n)
Use power tools on particle board, pressed wood or plywood	13	16	12	0

Note: This table doesn't include all exposed workers and workers may have used more than one control.

Lead

Twenty-six (9%) workers were deemed to have a probable exposure to lead. Of those exposed, over half (n=14; 54%) were assigned a high level exposure, 10 (38%) a medium level exposure and two (8%) a low level exposure.

Most (n=21, 81%) of these workers were technicians or trades workers, 3 (12%) were professionals and 2 (8%) were labourers.

Circumstances of exposure

The most common task that led to a probable exposure to lead was soldering. Five of those who soldered did so in a confined space and were assigned a high level exposure. High level exposure was also assigned to those workers who soldered and who were not considered to have used adequate controls. Medium exposure level was assigned to nine workers who did not solder in a confined space and whose use of controls was considered adequate (Table 10). Welding lead-plated steel also resulted in exposures to lead. However, only two workers reported this task and it was not analysed further.

Table 10: Main circumstances resulting in probable exposure to lead

Exposure circumstance	High (n)	Medium (n)	Low (n)	Total (n)
Soldering	10	9	-	19
Machining brass	-	4	6	10

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

Machining brass was another task resulting in exposure to lead. Medium level exposure was assigned if the worker machined brass but the exposure level was adjusted if the task was completed in a ventilated area (fan in window or doorway, open windows or doors, ventilated room) (Table 10).

The use of controls

Use of controls was reported for soldering and machining tasks. For soldering, the controls included the use of an air-supplied welding helmet, the amount of time the respondent soldered outdoors, and time spent soldering where a ventilation system was in place (welding booth, exhaust hood or local exhaust ventilation) (Table 11).

Table 11: The reported use of controls when performing tasks with probable exposure to lead

Exposure Circumstance	Air-supplied welding helmet (n)	Outdoors (n)	Air-supplied welding helmet (n)	Other RPE (n)	Air-supplied welding helmet (n)	Unknown (n)
Solders	4	3*	6*	N/A	7	0
Machining brass	N/A	0	6	1	2	2

* More than half the time

Note: This table does not include all exposed respondents and respondents may have used more than one control.

Information collected on the use of controls for machining brass was limited to time spent working in areas that were ventilated (fan in window or doorway, open windows or doors, ventilated room) (Table 11).

For soldering tasks, the assessed exposure was adjusted if controls were considered adequate because the worker soldered where a ventilation system was in place for more than half the time, soldered more than half the time outdoors or wore an air-supplied helmet. About two thirds of workers (62%) were considered to have used adequate controls to reduce their exposures (Table 12).

Table 12: The adequate use of controls when performing tasks with probable exposure to lead

Exposure circumstance	Adequate (n)	Inadequate (n)	Unknown (n)	Total (n)
Soldering	12	7	-	19
Machining brass	6	2	2	10
Total	18	9	2	29

Note: Workers who reported always or usually using ventilation systems, working in ventilated areas or wearing RPE during relevant work activities were grouped as 'yes'. Those workers who reported sometimes or never using ventilation systems, working in ventilated areas or wearing RPE during relevant work activities were grouped as 'no'.

For machining tasks, working in ventilated areas reduced the assigned exposure level from a medium to a low level exposure. Exposures were not adjusted for 40% of workers who did not work in ventilated areas or did not provide information on ventilation (Table 12).

Nickel

Forty-four (16%) workers were deemed to have a probable exposure to nickel. Of those exposed, 29 (66%) were assigned a high level exposure, four (9%) a medium level exposure and 11 (25%) a low level exposure.

Almost all (91%) of these workers were technicians and trades workers.

Circumstances of exposure

A large proportion (73%) of those workers who were deemed to have a probable exposure to nickel welded stainless steel or nickel alloy.

A large proportion (73%) of those workers who were deemed to have a probable exposure to nickel welded stainless steel or nickel alloy. Welding stainless steel or nickel alloy using ordinary, plasma arc, braze or oxyacetylene processes was assigned a high or medium level exposure depending on whether or not an air-supplied welding helmet was worn, the amount of time spent welding outside, or if a ventilation system was in place (welding booth, exhaust hood or local exhaust ventilation). Twenty-four workers completed this task with 11 being assigned a high level exposure and 13 a medium level exposure. Welding stainless steel or nickel alloy using MIG, submerged arc or TIG processes was assigned either a medium or low level exposure based on the use of controls. Of those respondents that used MIG, submerged arc or TIG processes to weld stainless steel or nickel alloy, 17 (59%) were considered to use adequate controls and were assigned a low level exposure and 12 (41%) workers were not considered to use adequate controls and were assigned a medium level exposure (Table 13). Welding in confined spaces was assessed as a high exposure.

Two thirds of workers (n=29, 66%) ground stainless steel welds and this task was assigned a high level exposure (Table 13).

Twenty workers machined stainless steel or nickel alloy were assigned either a medium or low level exposure depending on whether or not the area they worked in was ventilated (fan in window or doorway, open windows or doors, ventilated room). (Table 13).

Table 13: Main circumstances resulting in probable exposure to nickel

Exposure circumstance	High (n)	Medium (n)	Low (n)	Total (n)
Grinds stainless steel welds	29	-	-	29
Welds stainless steel or nickel alloy				32
• using ordinary, plasma arc, braze or oxy-acetylene	11	13	-	24
• using MIG, submerged arc or TIG	-	12	17	29
Welds stainless steel or nickel alloy in a confined space	8	-	-	8
Machine stainless steel or nickel alloy	-	6	14	20

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

The use of controls

Use of controls was reported for welding and machining tasks. For welding, the controls included the use of an air-supplied welding helmet, the amount of time the respondent welded outdoors, and the amount of time spent welding where a ventilation system was in place (e.g. welding booth, exhaust hood or local exhaust ventilation) (Table 14).

Table 14: The reported use of controls when performing tasks with probable exposure to chromium VI

Exposure Circumstance	Air-supplied welding helmet (n)	Outdoors (n)	Air-supplied welding helmet (n)	Other RPE (n)	Air-supplied welding helmet (n)	Unknown (n)
Welds stainless steel or nickel alloy	10	1*	8*	N/A	14	0
Machining stainless steel or nickel alloy	N/A	0	14	5	1	4

* More than half the time

Note: This table does not include all exposed workers and workers may have used more than one control.

Information on the use of controls for machining stainless steel or nickel alloy was limited to time spent welding in areas that were ventilated (e.g. fan in window or doorway, open windows or doors, ventilated room) (Table 14).

No information was collected on controls used when grinding welds.

For welding tasks, the exposure assessment was adjusted if controls were considered adequate because the worker welded where a ventilation system was in place for more than half the time, welded more than half the time outdoors, or wore an air-supplied welding helmet. Forty-four per cent of workers who welded stainless steel or nickel alloy did not use adequate protection to reduce exposures (Table 15).

Table 15: The adequate use of controls when performing tasks with probable exposure to nickel

Exposure circumstance	Adequate (n)	Inadequate (n)	Unknown (n)	Total (n)
Welds stainless steel or nickel alloy	18	14	0	32
Machining stainless steel or nickel alloy	14	2	4	20
Total	32	16	4	52

Note: Workers who reported always or usually using ventilation systems or wearing respiratory protection during relevant work activities were grouped as 'yes'. Those workers who reported sometimes or never using ventilation systems/areas or wearing respiratory protection during relevant work activities were grouped as 'no'.

For machining tasks, working in ventilated areas reduced the exposure assessment from a medium to a low level. Thirty per cent of the workers did not work in ventilated areas or information about the use of controls was not collected from them, thus the assessed level of exposure was not adjusted (Table 15).

Other Polycyclic Aromatic Hydrocarbons (PAHs)

Thirty (11%) workers were deemed to have a probable exposure to other PAHs—that is, PAHs from sources other than vehicle exhausts. Of those exposed, 21 (70%) were assigned a low level exposure, 4 (13%) a medium level exposure and 5 (17%) a high level exposure.

Most of these workers were technicians and trade workers (67%), however professionals (13%), machinery operators and drivers (13%) and labourers (7%) were also deemed to have a probable exposure to other PAHs.

Circumstances of exposure

Welding surfaces coated in oil or paint was the most common (n=15, 50%) task resulting in exposure to other PAHs.

The use of controls

The controls reported by workers who welded coated surfaces included the use of an air-supplied welding helmet, the amount of time the respondent welded outdoors, and the amount of time spent welding where a ventilation system was in place (welding booth, exhaust hood or local exhaust ventilation) (Table 16). Regardless of whether controls were used or not, exposures were not adjusted because the tasks were already considered by hygienists to result in low level exposures.

Table 16: The reported use of controls when performing tasks with probable exposure to other PAHS

Exposure Circumstance	Air-supplied welding helmet (n)	Outdoors* (n)	Ventilated area* (n)	None (n)
Weld surfaces with a coating	6	1	1	7

* More than half the time

Note: This table does not include all exposed workers and workers may have used more than one control.

Shift work

Twenty-six (9%) workers were deemed to have a probable exposure to shift work. Exposure level was not assessed for this carcinogen.

Thirteen (50%) of these workers were labourers, five (19%) were technicians and trades workers and five (19%) were managers.

Circumstances of exposure

Working either between midnight and 5 am (graveyard shift) or starting work between 5 am and 7 am were the most common circumstances that led to probable shift work exposures. Exposure was only assigned where workers reported working two or more shifts in a row. Of the 26 workers who reported working between midnight and 5 am, 23 (88%) were assigned a shift work exposure and of the 31 workers who started work between 5 am and 7 am, 15 (48%) were assigned a probable exposure (Table 17). A number of other factors also determined whether the worker was exposed, including but not limited to lighting conditions while trying to sleep, the number of hours slept between shifts, and the quality of sleep.

Table 17: Main circumstances resulting in probable exposure to shift work

Exposure circumstance	Probable exposure (n)	No exposure (n)	Total (n)
Work between midnight and 5 am	23	3	26
Works a shift that starts between 5 am and 7 am	15	16	31

Note: Workers could be exposed through more than one activity.

The use of controls

Information on the use of controls was not collected for tasks associated with probable exposure to shift work.

Solar Ultraviolet Radiation (Solar UV)

Forty-two (15%) workers were deemed to have a probable exposure to solar UV. Of those exposed, 14 (33%) were assigned a high level exposure, 17 (40%) a medium level exposure and 11 (26%) a low level exposure.

Twenty-one (50%) of these workers were technicians and trade workers, 7 (16%) were labourers, 6 (14%) were machinery operators and drivers and 4 (10%) were professionals.

Circumstances of exposure

Manufacturing workers were exposed to solar UV through outdoor work, with the time spent working outside and the use of controls determining the level of exposure. Fifteen workers (36%) reported spending greater than four hours each day working outside, 18 (43%) spent between one and four hours working outdoors, and nine (21%) spent less than one hour each day working outside (Table 18).

Table 18: Main circumstances resulting in probable exposure to solar UV

Exposure circumstance	High (n)	Medium (n)	Low (n)	Total (n)
Outside greater than four hours	14	1	-	15
Outside between one and four hours	-	16	2	18
Outside less than one hour	-	-	9	9

The use of controls and protective equipment

Information was collected on the use of four methods for preventing UV exposures–using sunscreen, wearing a hat, wearing protective clothing (covering up arms and legs), and working in the shade. Controls were considered adequate if all four methods were used for more than half the time spent outdoors. Only seven per cent of respondents who spent four or more hours a day outside were considered to have used adequate controls based on this definition; similarly 11% of those who spent between one and four hours were considered to have used adequate controls. Wearing protective clothing (81%) and a hat (67%) were the most common forms of UV protection used by workers when working outside (Table 19).

Table 19: The reported use of controls when performing tasks with probable exposure to Solar UV

Length of daily exposure	Sunscreen (n)	Hat (n)	Covered Clothing (n)	Shade (n)	All (n)
Outside greater than four hours	4	13	12	6	1
Outside between one and four hours	5	11	17	8	2
Outside less than one hour	3	4	5	4	0
Total	12	28	34	18	3

Trichloroethylene

Twelve (4%) workers were deemed to have a probable trichloroethylene exposure. Of those exposed, 11 (92%) were assigned a medium level exposure and one (8%) a high level exposure.

Ten (83%) of these workers were technicians and trade workers.

Circumstances of exposure

The most common task that resulted in exposure to trichloroethylene was degreasing. The level of exposure was dependent on the temperature at which the worker completed the task. Eleven (92%) workers completed the task at room temperature and were assigned a medium level exposure, and one (8%) worker used a degreaser at both room temperature and while heated and was assigned a high exposure. Information was also collected about the degreasing process. Six (55%) workers reported degreasing by spraying parts, four (36%) by hand painting parts and two (18%) used a dip tank.

Six (55%) workers reported degreasing by spraying parts

The use of controls and protective equipment

Information on the use of controls was not collected for tasks associated with probable exposure to trichloroethylene.

Wood Dust

Forty (14%) workers were assigned a probable exposure to wood dust. IARC did not differentiate between types of wood when classifying "wood dust" as carcinogenic so all types of wood dust were included in the AWES. Of those exposed, 24 (60%) were assigned a high level exposure, 8 (20%) a medium level and 5 (12.5%) a low level exposure.

These workers were mostly technicians and trade workers (70%) and labourers (15%).

Circumstances of exposure

There were a number of common tasks that led to probable exposures to wood dust. Nineteen (48%) workers used a powered sander and 10 (25%) a hand sander to sand wood and these tasks were assigned high and medium level exposures respectively. Ten (25%) workers used compressed air to clean up wood dust and were assigned a high level exposure. Workers who used power tools when doing carpentry work were assigned high or medium exposure levels depending on whether or not a ventilation system was used to remove wood dust or if half-face paper masks or half-face rubber masks were worn. Twenty-one (53%) workers used power tools, nine (23%) on hard wood, seven (18%) on soft wood and 17 (43%) on particle board. All workers who used power tools were assigned a medium level exposure based on the use of controls. Sixteen (40%) workers used hand tools to do carpentry work and these tasks were assigned low level exposure. Finishing carpentry such as cabinetry was also considered to have led to a probable exposure to wood dust. Low exposures were assigned for all 16 (40%) workers undertaking this task (Table 20).

Sixteen (40%) workers used hand tools to do carpentry work and these tasks were assigned low level exposure.

Table 20: Main circumstances resulting in probable exposure to wood dust

Exposure circumstance	High (n)	Medium (n)	Low (n)	Total (n)
Using a powered sander	19	-	-	19
Using a hand sander	-	10	-	10
Using compressed air to clean up wood dust	10	-	-	10
Using power tools				21
• hard wood	-	9	-	9
• soft wood	-	7	-	7
• particle board	-	17	-	17
Using hand tools	-	-	16	16
Finishing carpentry—e.g. cabinetry	-	-	16	16

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

The use of controls and protective equipment

Information on the use of controls was only collected for those workers who used power tools. Controls included working in an area with a ventilation system in place to remove wood dust or wearing a simple half-face paper mask or a half-face rubber mask. Most workers (n=20; 95%) who used power tools reported a ventilation system was in place, 16 workers wore a simple half-face paper mask and 15 workers used both types of control (Table 21). The use of these controls was considered adequate to prevent high exposures.

Table 21: The reported use of controls when performing tasks with probable exposure to wood dust

Exposure circumstance	Half-face paper mask (n)	Ventilation (n)	Both (n)	None (n)
Use power tools	16	20	15	0

Note: This table doesn't include all exposed workers and workers may have used more than one control.

DISCUSSION AND INTERPRETATION OF THE STUDY FINDINGS

Exposures and controls

The most common exposures were to DEE, chromium VI, ETS and nickel.

The AWES found that 67% of the respondents who were categorised as working in manufacturing were deemed to have a probable exposure to at least one carcinogen included in the study. The most common exposures were to DEE, chromium VI, ETS and nickel. There are few other studies that explore the prevalence of carcinogen exposure in the manufacturing industry as a whole. CAREX EU and CAREX Canada both used a job exposure matrix (JEM) approach and assigned exposure based on industry and occupation (Kauppinen et al. 2000; Peters et al. 2015).

CAREX EU found a much lower prevalence of carcinogen exposure in the manufacturing industry, with about 29% exposed (Kauppinen et al. 2000). CAREX Canada found that the most common exposures in the manufacturing industry were shift work, wood dust and benzene (Peters et al. 2015). This differs to the AWES findings where the most common probable exposures were DEE, chromium VI and ETS, however both wood dust and shift work were still common in Australia with 14% and 9% exposed respectively in the AWES. Benzene exposure was not common among Australian respondents with only 2% exposed. A difference in the type of manufacturing undertaken in the countries, as well as different exposure assessment methods are likely to be the main reasons for the differences in most common exposures seen.

The Australian NHEWS study collected self-report data to estimate the prevalence and nature of exposures to priority occupational disease causing hazards. However, it used self-reported exposures which have been found to lead to significant misclassification when compared with expert assessment (ASCC 2008b). It found the most common exposures in the manufacturing industry were solvents or paints and glues, combustion or welding gases and direct sunlight. However, as NHEWS assessed categories of hazard rather than specific exposures it is hard to assess the significance of any similarities and differences between the two studies.

Diesel Engine Exhaust (DEE)

The AWES found 20% of respondents who worked in manufacturing were deemed to have probable exposure to DEE. The exposure circumstances were quite broad with the main tasks involving work near diesel powered vehicles rather than fixed plant or equipment. Exposure assessment was based on the proximity of diesel powered vehicles, the ventilation (including working outside) and whether or not the worker reported having smelt diesel exhaust. Diesel exhaust can be smelt at levels of about 5 ppm (Fiedler et al. 2004).

Guidance material is provided by Safe Work Australia on the health monitoring of PAHs, which includes diesel emissions and more recently, specific guidance on DEE has been developed to provide information about potential controls to eliminate or reduce DEE exposure (Safe Work Australia 2015).

Several organisations have also developed factsheets and guidance on reducing exposure to diesel exhaust emissions in industries other than manufacturing (Department of Defence 2012; Department of Mines and Petroleum 2013; WorkCover NSW 2015). Though the fact sheets are general or target other industries, the suggested controls are broadly applicable to the manufacturing industry. Controls suggested included monitoring levels, substituting vehicles with ones that have safer engines, using particle filters, scheduling regular maintenance of the equipment, installing ventilation systems and minimising the amount of time spent around the emissions (WorkCover NSW 2015). The US Occupational Safety and Health Administration (OSHA) released an information sheet that outlines potential engineering controls that can reduce exposure to DEE; for example, performing routine maintenance on diesel engines, installing engine exhaust filters and using cleaner burning engines. It also suggests some administrative controls; for example, restricting the amount of diesel powered equipment in an area and prohibiting or restricting unnecessary machine idling (OSHA 2013). While some guidance recommends the use of cleaner fuels, changes made to the Australian diesel fuel quality standard in 2009 mean diesel is supplied as ultra-low sulphur diesel (ULSD) fuel.

Environmental Tobacco Smoke

Seventeen per cent of AWES respondents who worked in manufacturing were deemed to have a probable exposure to ETS. The 'Guidance Note on the Elimination of Environmental Tobacco Smoke in the Workplace' recommended smoking be prohibited in all workplaces (National Occupational Health and Safety Commission 2003). Smoking legislation differs by state but smoking in enclosed workplaces is consistently banned and currently Queensland, Tasmania, Northern Territory and New South Wales prohibit smoking directly outside a building. Of all AWES manufacturing workers, 5% reported being exposed to ETS in indoor work areas, 10% in outdoor work areas and 9% at entrances to work buildings. In NHEWS only 1% of respondents reported being exposed to tobacco or cigarette smoke (Safe Work Australia 2009).

Welding, soldering and machining (artificial UV, chromium VI, lead, nickel and other PAHs)

Probable exposures to artificial UV, chromium VI, lead, nickel and other PAHs were deemed to have resulted from welding soldering or machining tasks. Nine per cent of AWES respondents who worked in manufacturing were probably exposed to artificial UV produced from welding. Common circumstances that resulted in probable exposure included supervising other welders and working in areas with other welders. The Safe Work Australia Welding Processes Code of Practice (Welding Code) highlights this risk of radiation exposure posed to other workers in the workplace or passers-by (Safe Work Australia 2012).

Nine per cent of AWES respondents who worked in manufacturing were probably exposed to artificial UV produced from welding.

AWES respondents who worked in manufacturing were probably exposed to chromium VI (19%), lead (9%) and nickel (16%) which are identified as carcinogenic welding (and soldering) by-products in the Welding Code. Eleven per cent of AWES manufacturing workers were probably exposed to other PAHs and the most common task was welding surfaces with a coating such as a paint or oil. Guidance material is provided by Safe Work Australia on the health monitoring of PAHs.

The material lists a number of potential workplace exposure circumstances but none of those mentioned were common in the AWES manufacturing sample.

The Welding Code outlines recommended control measures to prevent exposures to these carcinogens. Specifically, recommendations for preventing exposures to artificial UV radiation include installing screens or partitions, using warning signs when welding activities are being undertaken, providing appropriate PPE including filter shades for goggles and face shields, and ensuring protective clothing (gloves and long sleeves) is worn to cover exposed skin. To prevent exposures to airborne contaminants such as chromium VI, nickel, lead and other PAHS, the Welding Code recommends substitution (using a less hazardous chemical where possible), as well as carrying out tasks in isolated booths, installing ventilation systems and providing appropriate respiratory protection. In confined spaces the Welding Code recommends the use of air-supplied respirators. The AWES study asked questions about the amount of time spent welding where ventilation systems were in place where work was undertaken and whether or not workers wore an air-supplied welding helmet while welding. Approximately 44% of workers who were probably exposed to chromium VI and nickel, 46% who were probably exposed to other PAHs and 53% of those who were probably exposed to lead were not considered to have used adequate controls based on their responses to these questions.

Shift work

CAREX Canada found that 21% of manufacturing workers undertook shift work. This is higher than the proportion (9%) found in the AWES but exposure assessments differed between the two studies. CAREX Canada assessed individuals as exposed if they worked regular night or rotating shifts. The AWES was more specific in defining and assessing shift work exposures, assigning exposures to workers who reported working between the hours of midnight and 5 am or to those whose shift started between 5 am and 7 am. There are currently no recommendations for shift work, however, there is also some uncertainty about the risks posed by shift work.

Solar UV

The AWES found that 15% of respondents who worked in manufacturing were deemed to have probable exposure to solar UV. The NHEWS survey found a similar exposure prevalence of 13% in the manufacturing industry when looking at NHEWS respondents who spent one or more hours a day in direct sunlight (Safe Work Australia 2009).

Safe Work Australia has released a set of guidelines for the management of solar UV exposure (Safe Work Australia 2013a). Potential control measures identified in the guidelines include working in shaded areas, eliminating or reducing reflective nature of surfaces, window tinting or glass, changing work schedules to limit time spent outdoors when UV is highest and the use of PPE. The guidelines state that combining control measures is the most effective way of reducing exposure. The AWES asked questions on the amount of time spent outdoors, in shaded areas and the use of three types of PPE (wearing sunscreen, a hat or protective clothing). Working in the shade and wearing sunscreen were reported by 43% and 29% of exposed workers respectively, indicating these controls are not well used.

Overall, only 7% of respondents were considered to have used adequate controls to prevent exposures.

Trichloroethylene

The AWES found that four per cent of respondents who worked in manufacturing were probably exposed to trichloroethylene when using solvents for degreasing tasks.

The AWES found that four per cent of respondents who worked in manufacturing were probably exposed to trichloroethylene when using solvents for degreasing tasks. CAREX Canada found that workers in some manufacturing sectors were exposed to trichloroethylene; including workers in metal manufacturing, printing, plastic product manufacturing and cut and sew clothing manufacturing (CAREX Canada 2013).

NICNAS has a trichloroethylene safety factsheet which provides recommendations on the safe use of the solvent (NICNAS 2013). It recommends that where possible a safer product or process should be substituted, that trichloroethylene should be phased out for cold cleaning and that trichloroethylene should not be used as a spray or aerosol. It also suggests using a ventilation system when trichloroethylene is being mixed or used and to avoid skin contact by wearing long sleeved shirts and trousers and suitable gloves, such as viton gloves. Of those AWES manufacturing workers who used trichloroethylene to degrease parts, 55% reported spraying the parts. Information on the use of ventilation or PPE was not collected for degreasing tasks.

Wood Dust and Formaldehyde

The AWES found that 14% and 8% of respondents categorised as working in manufacturing were probably exposed to wood dust and formaldehyde respectively. NHEWS found 14% of manufacturing workers were exposed to wood dust. CAREX Canada, which examined specific subgroups of manufacturing workers, found that furniture and cabinet manufacturing (29%) and other wood product manufacturing (43%) were two specific areas in which wood dust exposure was common. Subgroups found to have common formaldehyde exposure were household and institutional furniture and kitchen cabinet manufacturing (21%) and other wood product manufacturing (18%) (CAREX Canada 2013).

AWES manufacturing workers were probably exposed to wood dust when sanding wood, using compressed air to clean wood dust and using power or hand tools on wood or particle board.

AWES manufacturing workers were probably exposed to wood dust when sanding wood, using compressed air to clean wood dust and using power or hand tools on wood or particle board. Using power and hand tools on particle board also resulted in probable exposure to formaldehyde. Seven per cent of AWES manufacturing workers were probably exposed to both wood dust and formaldehyde.

A report released by the Australian Safety and Compensation Council (ASCC; now Safe Work Australia) 'makes best practice exposure control suggestions for wood dust and formaldehyde (ASCC 2008a). Controls suggested for wood dust included local exhaust ventilation, vacuum cleaning methods rather than using compressed air or sweeping, isolation of dusty processes, external exhaust, separate enclosed work areas, and provision of overhead filtered air supply or air fed masks for non-mobile workers. Similar advice was given by the UK HSE, with the additional advice that both RPE and LEV should be used for particularly dusty tasks such as sanding (HSE 2012; 2014). The AWES collected information on the use of ventilation systems and RPE when manufacturing workers used power tools. Overall, the reported use of these controls by workers was high—all but one worker (95%) reported that a ventilation system was in place and 71% reported using ventilation and face masks.

The ASCC report does not give detailed recommendations for the control of formaldehyde for manufacturing workers (ASCC 2008a). The Institut de recherche Robert-Sauvé en santé et en sécurité du travail (IRRST) has developed specific guidance for preventing exposures to formaldehyde in these circumstances (Goyer et al. 2006). The IRRST recommendations include using local exhaust ventilation, general ventilation and RPE appropriate for different levels of exposure. The AWES found high reported use of ventilation with 94% of those probably exposed reporting some form of ventilation in place. However, the most commonly reported form of RPE used was a simple half face paper mask (76%) which may not be considered adequate for preventing formaldehyde exposures. Although formaldehyde exposure levels emanating from particle boards and plywood appear to have decreased in the last decade (EWPAA 2015), particularly if products meeting Australian low-emissions standards are used for fabrication purposes, the AWES method assumes formaldehyde exposures can occur when working with particle board and plywood.

Gaps, strength and weaknesses

Data for this report was taken primarily from the AWES project as there are few other relevant data sources that include information on work tasks and exposures. The AWES project provides population-based information on current Australian workplace exposure to a range of definite and probable carcinogens while completing relatively common workplace tasks or in certain workplace circumstances. The population based nature of the AWES project makes it unique internationally in that information is obtained not only from regulators, nor from large companies with in-house work health and safety expertise, but rather from all workers in the sector, including small and medium size enterprises. The data should be representative of exposures and exposure circumstances in the manufacturing industry in Australia. However, like any such survey, it is has some limitations.

The AWES used a telephone survey to collect the data, which introduces problems with respondent's willingness to cooperate when interviews are too long. In order to minimize the time of the interview so that the required sample size could be reached, there had to be compromise between covering the essential questions and including questions that are important but not required for the primary purpose of the study. The AWES covered a range of potential exposures across a wide range of industry sub-sectors and so a limited number of specific questions could be asked about any particular circumstance in a sub-sector. This is particularly relevant in the manufacturing industry where there is such a large variety of sub-sectors. There were similar issues with the NHEWS project.

The AWES covered a range of potential exposures across a wide range of industry sub-sectors and so a limited number of specific questions could be asked about any particular circumstance in a sub-sector.

Error was likely introduced in the exposure assessment due to the reliance on self-report data. This is likely to be minimal as, unlike other studies that rely on the worker to recognize and recall specific exposures, the exposure assessment in the AWES study asked questions on current job tasks undertaken and the questions asked were specific to each job. This makes it less likely that exposure will be missed and 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 within the manufacturing industry. Information will be lacking on tasks that are specific to manufacturing sub-sectors which are less common or which are undertaken by a relatively small number of people. As the manufacturing industry is declining in Australia, this issue will become even more apparent. If detailed information is required about a specific sector of the industry like ceramics manufacture or a specific activity, this would require a targeted, specific research project to be undertaken.

Information on the use of control measures was collected in the AWES study. However due to the time constraints mentioned earlier the questions asked on control use were somewhat limited to those circumstances that would affect the exposure assessment. As a result of this, respiratory controls were the most commonly asked questions, as inhalation was the most common route of exposure. The time constraints also limited the collection of more specific and detailed information on control measures. As a result, often potentially relevant information (such as specific type of ventilation) was not collected.

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A common issue in survey data collection is non-response resulting in potential selection bias. In the AWES study, information is not available on those who did not participate, raising the possibility that those who participated had a different prevalence of exposure and different approach to the use of exposure control measures than those who did not participate. However, it is not possible to assess the extent of the potential selection bias.

The AWES study was able to assess exposure to individual agents, rather than broad groupings such as those used by the NHEWS study. This allows better understanding of the hazard to which workers are exposed and potential risks, for example OccIDEAS classified exposures to “silica” rather than “construction dust” reported in NHEWS. The use of a population-based approach and subsequent ability to capture exposures across a wide range of manufacturing workers are also particular strengths of this study. Further, the methodology used is useful in pinpointing areas where the control of exposure is not considered adequate.

Potential implications

The AWES estimated that approximately 67% of respondents categorised as working in the manufacturing industry were likely to be exposed to at least one carcinogen when performing relatively common activities at work. Tasks undertaken by workers in the manufacturing industry vary greatly depending on what is being manufactured and the manufacturing process used and there were 13 carcinogens to which nine or more AWES manufacturing workers were probably exposed. While most of these workers will not develop cancer as a result of work-related exposures, they are at greater risk. Quantifying those risks is not straightforward and as a result, information is not readily available. Reviewing and assessing existing literature to derive such estimates was beyond the scope of this report.

The agents explored in the AWES study are classified by the IARC as known or probable human carcinogens and, as for all hazardous workplace chemicals, risks to health and safety (or exposures) must be eliminated so far as reasonably practicable. However, this is not possible for some exposures. In these cases, the hierarchy of controls must be used to minimise risks so far as is reasonably practicable by substituting hazards (chemicals or work processes used) with something that poses less risk, isolating hazards from workers and other in the workplace, or by using engineering controls. Where risks still remain, administrative policies must be implemented, so far as is reasonably practicable, before PPE is provided. In practice, a combination of controls might be used to minimise exposure because a single control measure might not be sufficient.

Noting the AWES concentrated on common tasks rather than specific, high risk activities, the focus for additional preventative action should be based on a balance between the exposures with a high prevalence and the exposure circumstances for which there are proven control measures and that are most amenable to control. Based on the reported use of controls by AWES manufacturing workers and recommendations in existing guidance, this suggests a focus on:

- using new generation diesel engines (lower emissions technology), regular maintenance of existing diesel-powered vehicles and equipment, installation and maintenance of filter systems (trap particulate matter), and implementing work practices that minimise the time spent by workers near operating diesel engines
- widespread adoption (enactment of relevant anti-smoking legislation in those jurisdictions yet to do so) and enforcement of workplace smoking bans
- promoting and encouraging the uptake of recommendations made by WHS regulators and other government agencies about the safe use of chemicals, such as the NICNAS recommendations about not using trichloroethylene as a spray or aerosol and phasing out the use of trichloroethylene for cold cleaning
- regularly using local exhaust ventilation (or carrying out activities in well-ventilated areas) and the use of RPE designed for welding or soldering tasks, and
- regularly using local exhaust ventilation (or carrying out activities in well-ventilated areas) and the use of RPE where workers are likely to be exposed to wood dust.

Although there is considerable information available in the literature about the health effects, exposures and control of the carcinogens found in the manufacturing industry, this information is not organized in a way which is convenient for the manufacturing industry. There is a need for clear, concise and consistent information on the circumstances and control of exposures that is specifically tailored to the manufacturing industry.

Further Research

The AWES provides information on current exposures within the manufacturing industry. Measuring exposures to specific carcinogen exposures in the workplace for some of the tasks identified in this report may be of potential use in validating the data collected in AWES. There was no scope to complete this task as part of the AWES study.

The work presented in this report could also be complemented by the collection of more widespread and detailed information on the use of control measures where probable carcinogenic exposures have been identified in this report. Further research could also help understand why appropriate control measures are not being used and how to use this knowledge to improve current measures and workplace practice.

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The potential burden of these exposures in terms of future cancer risk in manufacturing workers can be estimated. A method to predict future risk of cancer based on exposures now has recently been developed based on the lifetime risk model (Rushton et al. 2012). With this model, current workers are divided into those exposed and unexposed to the carcinogen in a baseline year. The numbers of cancers in the future due to exposure are then calculated. Scenarios can then be applied to the current exposures, such as the increased use of ventilation systems, etc. The change in number of cancers can be determined to see which actions would have the most effect.

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GLOSSARY

ABS	Australian Bureau of Statistics
ANZSCO	Australian and New Zealand Standard Classification of Occupations
ANZSIC	Australian and New Zealand Standard Industrial Classification
Artificial UV	Artificial Ultraviolet Radiation
AWES	Australian Work Exposures Study
DEE	Diesel Engine Exhaust
ETS	Environmental Tobacco Smoke
EWPAA	Engineered Wood Products Association of Australasia
HSE	Health and Safety Executive
IARC	International Agency for Research on Cancer
IRSST	Institut de recherche Robert-Sauvé en santé et en sécurité du travail
JEM	Job Exposure Matrix
JSM	Job Specific Module
LEV	Local Exhaust Ventilation
MIG	Metal Inert Gas (welding)
MOCA	4,4’-Methylenebis(2-chloroaniline)
NHEWS	National Hazard Exposure Worker Surveillance (study)
NICNAS	National Industrial Chemical Notification and Assessments Scheme
OccIDEAS	An online tool to manage interviews and assess exposures
OHS	Occupational Health and Safety
OSHA	Occupational Safety and Health Administration
Other PAHs	Other Polycyclic Aromatic Hydrocarbons
PCBs	Polychlorinated biphenyls
PPE	Personal Protective Equipment
RPE	Respiratory Protective Equipment
Solar UV	Solar Ultraviolet Radiation
TIG	Tungsten Inert Gas (welding)

APPENDIX 1

Table A1: Comparison of demographic characteristics between AWES manufacturing workers probably exposed to carcinogens and all Australian manufacturing workers

Demographic Characteristic	Study population n (%)	Australian Population[a] n (%)	Chi² p-value[d]
Gender			**0.001**
Male	249 (88.6)	646 452 (74.1)	
Female	32 (11.4)	225,394 (25.9)	
Age Group			**0.008**
18-34	50 (17.8)	276 810 (31.7)	
35-54	168 (59.8)	456 543 (52.4)	
55-65	63 (22.4)	138 493 (15.9)	
State of Residence			**0.058**
New South Wales	72 (25.6)	255 930 (29.4)	
Victoria	78 (27.8)	262 477 (30.1)	
Queensland	51 (18.2)	165 456 (19.0)	
Western Australia	51 (18.2)	86 665 (9.9)	
South Australia	15 (5.3)	75 602 (8.7)	
Tasmania	11 (3.9)	18 159 (2.1)	
Australian Capital Territory	1 (0.4)	3755 (0.4)	
Northern Territory	2 (0.7)	3799 (0.4)	
Country of Birth			**0.021**
Australia	214 (76.2)	568 099 (65.2)	
Other	67 (23.8)	303 747 (34.8)	
Language Spoken at Home			**0.000**
English	274 (97.5)	671 692 (77.0)	
Other	7 (2.5)	200 154 (23.0)	
Highest education level			**1.000**
High school or less	131 (46.6)	409 582 (47.0)	
Trade certificate or diploma	113 (40.2)	346 967 (39.8)	
Bachelor degree or higher	37 (13.2)	115 297 (13.2)	
Socioeconomic status[b]			**0.278**
Fifth quintile (Highest)	46 (17.4)	184 127 (21.3)	
Fourth	67 (23.8)	199 001 (23.0)	
Third	63 (22.4)	188 185 (21.7)	
Second	70 (24.9)	153 747 (17.8)	
First quintile (Lowest)	32 (11.4)	140 422 (16.2)	
Remoteness[c]			**0.002**
Major city	163 (58.0)	638 735 (73.4)	
Inner regional	89 (31.7)	160 338 (18.4)	
Outer regional	26 (9.2)	63 867 (7.3)	
Remote/very remote	3 (1.1)	7856 (0.9)	

a. Using the ABS 2011 Census data for ANZSIC code C.
b. From Socio-Economic Index for Areas Index of Relative Socio-economic Disadvantage (SEIFA IRSD)
c. From Australian Standard Geographical Classification Accessibility/Remoteness Index of Australia (ARIA+)
d. p-value for difference between the study and Australian population for each demographic characteristic

APPENDIX 2

Table A2: Correlations between exposure combinations for AWES manufacturing workers

	Artificial UV	Chromium VI	DEE	ETS	Formaldehyde	Lead	Nickel	Other PAHS	Crystalline Silica	Solar UV	Trichloro-ethylene	Wood Dust	Shift work
Artificial UV	1.000												
Chromium VI	**0.566**	1.000											
DEE	-0.090	-0.029	1.000										
ETS	**0.317**	**0.164**	-0.102	1.000									
Formaldehyde	-0.082	-0.033	0.037	0.019	1.000								
Lead	**0.262**	**0.462**	0.037	**0.121**	-0.044	1.000							
Nickel	**0.559**	**0.878**	-0.097	**0.157**	**-0.132**	**0.493**	1.000						
Other PAHS	**0.318**	**0.215**	0.053	**0.119**	0.009	0.114	**0.190**	1.000					
Crystalline Silica	0.049	0.058	**0.218**	0.104	-0.008	**0.173**	0.001	0.073	1.000				
Solar UV	-0.071	0.004	**0.271**	**0.287**	0.111	**0.134**	-0.067	-0.080	**0.328**	1.000			
Trichloro-ethylene	0.089	**0.172**	-0.064	0.091	-0.038	**0.180**	**0.193**	0.041	0.029	0.158	1.000		
Wood Dust	**-0.140**	-0.048	0.111	-0.005	0.636	0.115	**-0.151**	-0.049	-0.103	0.049	-0.040	1.000	
Shift work	**-0.130**	**-0.134**	-0.040	**-0.145**	-0.084	-0.104	**-0.128**	0.049	-0.077	**-0.134**	-0.067	-0.066	1.000

Note: Numbers in bold are statistically significant