

# THE AUSTRALIAN WORK EXPOSURE STUDY (AWES): CARCINOGEN EXPOSURE IN THE AGRICULTURE INDUSTRY



Report

May 2016

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**SAFE WORK AUSTRALIA**

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

MAY 2016

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# PREFACE

The Australian Work Health and Safety Strategy 2012-2022 (the Strategy) describes the agricultural 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 agricultural industry
- identify the main circumstances of those exposures, and
- describe the reported use of workplace controls and protective measures designed to decrease those exposures.

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

# SUMMARY

## Why has this research been done?

The aim of this research is to improve our understanding of workers' 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 Exposure 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 156 AWES respondents who were categorised as working in the agricultural industry.

The AWES provides reasonably representative information about potential carcinogen exposures from relatively common activities. However, the small number of respondents from the agricultural industry means the results presented in this report should be used with caution. In addition, the results presented in this report should not be considered an exhaustive list of potential exposures to carcinogens in the agricultural industry.

## What did we find?

Most agricultural industry workers in this study (99 per cent) were estimated to have a probable exposure to at least one carcinogen.

The most common carcinogens to which workers were probably exposed were solar ultraviolet (UV) radiation (99 per cent), diesel engine exhaust (94 per cent), benzene (82 per cent), polycyclic aromatic hydrocarbons (76 per cent) and wood dust (71 per cent).

The main circumstances or tasks associated with probable exposure included working outside, using diesel powered equipment, refuelling petrol powered equipment, repairing motors and other farming equipment and cutting wood.

The reported use of controls to prevent or minimise exposures varied considerably by task and circumstance. For example, the controls used by outdoor workers exposed to solar UV radiation were considered adequate about 10 per cent of the time while most workers (89 per cent) who ploughed fields reported using vehicles with enclosed cabins to prevent exposures to dusts which can contain crystalline silica.

## 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 agriculture, this suggests a focus on reducing exposures to diesel engine exhausts and solar UV radiation, and encouraging more frequent use of ventilation systems and respiratory protective equipment for tasks like welding or soldering.

Existing WHS information could be specifically tailored to provide clear, concise and consistent information about potential sources of exposure and controls that are appropriate for the agricultural 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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# EXECUTIVE SUMMARY

## Background

The agricultural 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. While workers in the agricultural industry are known to be exposed to a wide variety of carcinogenic (cancer causing) agents, much of the research has tended to focus on pesticide exposures. Little is known about the prevalence of exposure to other carcinogens nor the tasks which may lead to these exposures within the Australian agricultural 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 agricultural workers.

The aim of this report was to estimate the prevalence of exposure to carcinogens among agricultural 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 agricultural 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) was used to estimate exposures, using algorithms 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 agricultural industry were extracted and examined. Tasks completed by nine or more respondents were examined in greater detail.

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## Key findings

A total of 156 of 5528 respondents who completed the AWES survey were categorised as being employed in the agricultural industry. Of these, 155 (99%) were estimated to have a probable exposure to at least one carcinogen. There were a total of 10 carcinogens to which nine or more agricultural workers were probably exposed. The most prevalent exposures were:

- solar ultraviolet radiation (solar UV; 99% exposed)
- diesel engine exhaust (DEE; 94%)
- benzene (82%)
- polycyclic aromatic hydrocarbons other than vehicle exhaust (other PAHs; 76%), and
- wood dust (71%).

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

- working outside (solar UV exposure)
- using diesel powered equipment (DEE exposure)
- refuelling petrol powered equipment (benzene exposure)
- repairing power motors and other farming equipment (DEE & other PAHs exposure), and
- cutting wood (wood dust exposure).

These findings help confirm what is generally known or suspected about typical exposures to carcinogens in agriculture, with the potential exception of refuelling tasks.

The reported use of control measures was, on the whole, limited in agricultural workers. Where information on controls was collected, the reported use of controls to prevent or minimise exposures was considered adequate only 37% of the time. The least consistent use of controls was reported for solar UV radiation exposures, with only 10% of workers assessed as being adequately protected. The use of an enclosed cab while ploughing was the control most reported by agricultural workers (89%).

## 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 farming 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 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

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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.

Exposure estimates have not been validated against measured exposures and they should not be used to comment on 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—that is current exposures will not provide information to help understand the causes of current cancer cases. Information about current exposures more appropriately enables work health and safety policies and practices to be revised or developed in a timely manner to prevent future cancer cases.

## Potential implications

Approximately 99% of AWES respondents categorised as working in the agricultural industry were estimated to be probably 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 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 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 agricultural industry, this suggests:

- using new generation diesel engines (lower emissions technology) and “cleaner” fuels, 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
- increasing the use of all sun protection measures—working in

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- the shade, wearing protective clothing that covers up arms and legs, wearing a hat and using sunscreen
  - promoting and encouraging the uptake of recommendations made by work health and safety (WHS) regulators and other government agencies about the safe use of chemicals, such as the National Industrial Chemicals Notification and Assessment Scheme (NICNAS) recommendations on the use of trichloroethylene for degreasing tasks
  - regularly using local exhaust ventilation (or carrying out activities in well-ventilated areas) and respiratory protective equipment (RPE) designed for welding or soldering tasks, and
  - regularly using local exhaust ventilation (or carrying out activities in well-ventilated areas) and 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 agricultural industry, this information is not organized in a way which is readily accessible—in both form and content—for the agricultural industry. There is a need for clear, concise and consistent information on the circumstances and control of exposures that is specifically tailored to the agricultural industry and possibly additional information for specific high risk agricultural sub-sectors.

## Further research

The AWES provides information on current exposures to carcinogens within the agricultural 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.

The work presented in this report could also be complemented by the collection of additional information about the use of controls 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 agricultural workers can be estimated. A method of predicting future cases of cancer due to current exposures has been used to help understand the potential burden of work-related cancer in the UK. This method could be used with Australian exposure data for example, AWES data, to predict the number and type of future work-related cancers in Australia and to help identify work health and safety intervention priorities.

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# BACKGROUND

## Introduction

The Agricultural 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. Whilst workers in the agricultural industry are potentially exposed to a wide variety of carcinogenic (cancer causing) agents (Blair & Freeman 2009), much of the research has tended to focus on exposure to pesticides. Little is known about the prevalence of exposure to other carcinogens, nor the tasks which may lead to these exposures, within the Australian agricultural industry.

Data from the recent Australian Work Exposures Study (AWES) provides an opportunity to gain a better understanding of the extent and circumstances of exposure to carcinogens among workers in the Australian agricultural industry.

The aim of this report was to use AWES data to estimate the prevalence of exposure to carcinogens within the Australian agricultural industry, to identify the main circumstances of those exposures, and to describe the use of workplace controls designed to prevent or minimise those exposures. This is followed by a consideration of the policy implications of these results for exposure prevention.

This report presents information on estimated exposures to carcinogens among AWES respondents categorised as working in the agricultural industry. Exposure estimates have not been validated against measured exposures, and they should 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 agricultural industry

The Australian agricultural industry is a very important Australian industry. In 2009, Australian farms produced 93% of the total volume of food consumed in Australia and in 2010-11 the value of production across farms was \$46 billion, which amounts to 2.4% of Australia's Gross Domestic Product (ABS 2012).

Over 306 700 people are employed in the agricultural industry. A majority are involved in specialised beef cattle farming, mixed grain-sheep or grain-beef cattle farming, other grain growing or specialized sheep farming (ABS 2011a).

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## Cancer in agricultural industry

Many studies show that there are some cancers to which farmers have an excess risk, such as non-Hodgkin lymphoma, myeloma, leukaemia and cancers of the lip, skin, stomach, prostate and brain (Blair & Freeman 2009). This suggests that there may be some carcinogenic agents which farmers are exposed to that increase the incidence of these cancers.

## Industry exposure to carcinogens

Workers in the agricultural industry typically have a high variation in day-to-day tasks, and therefore are potentially exposed to a diverse range of occupational carcinogens (Coble et al. 2002). These potential exposures may include fuels and engine exhausts, paints and solvents, metals, dusts, and welding fumes, as well as pesticides (Blair & Zahm 1995, Coble et al. 2002).

### Previously collected information on exposure and control measures in Australia

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 (e.g. gases, dusts, fumes and vapours), was conducted in 2008 (Safe Work Australia 2009). Workers in the agricultural industry were found to be exposed to potential carcinogens like some dusts, gases, vapours, smoke or fumes, skin contact with chemicals, and direct sunlight, however the definition of agriculture used in this study also included those working in forestry and fishing. 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.

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**Just over half (53%) of the agricultural workers in NHEWS reported exposure to dust.**

Just over half (53%) of the agricultural workers in NHEWS reported exposure to dust. The main dust types agriculture workers were found to be exposed were to environmental dust (42%), dirt or road dust (32%), crop dust (17%) and wood dust (10%). A large proportion (58%) of the agriculture workers were provided with masks, which was the most common reported control provided to prevent dust exposure.

Chemical substance exposure was also common among agricultural workers in NHEWS with 48% reporting exposure. Cleaning products (41%), gardening chemicals (39%), general chemicals (14%) and solvents, paints and glues (10%) were the most common chemical substances to which these agricultural workers reported exposure. Controls were commonly provided for chemical substances, with gloves (86%), washing facilities (83%) and protective clothing (72%) the most commonly reported.

Approximately one fifth (21%) of the agricultural workers in NHEWS reported exposure to gases, vapours, smoke or fumes. Combustion or welding gases (49%), fuel vapours (24%) and chemical gases (10%) were the most common types of gases, vapours, smoke or fumes to which agricultural workers reported exposures. The most common control used to prevent exposure was the reduction of time spent in places where the exposure occurred; 75% of the agricultural workers reported using this control. Other common controls provided were masks (60%), respirators (40%) and ventilation systems (40%).

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Some level of exposure to sunlight was reported by many agricultural workers in NHEWS (74%) and the most common control measures provided were hats (78%), sunscreen (69%) and covered clothing (68%).

### **Previously collected information on exposure and control measures in other countries**

Prevalence of exposure to carcinogens in the agricultural industry has been reported in studies from other countries. Coble and colleagues used questions based on reported farming tasks to estimate the prevalence of exposure to diesel exhaust fumes (93%), metals (68%), grain dusts (65%), solvents (25%) and other hazards, including pesticides, in farmers in the USA (Coble et al. 2002).

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 industries. The CAREX Canada study found that 69% of those employed in farming were exposed to solar radiation in Canada (Peters et al. 2012), while a British study found that workers in the farming industry were exposed to dioxins, non-arsenical pesticides and solar radiation (Rushton et al. 2010).

## **Cancers caused by workplace carcinogens**

The International Agency for Research on Cancer (IARC) recently completed a review on the cancer sites associated with carcinogenic agents (IARC 2015). Some common carcinogens associated with the agricultural industry and related cancer sites are outlined in Table 1.

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

<b>Carcinogens</b>	<b>Cancer sites with sufficient evidence in humans</b>	<b>Cancer sites with limited evidence in humans</b>
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
Lead compounds, inorganic		Stomach
Nickel compounds	Lung; nasal cavity and paranasal sinus	
Silica dust, crystalline (in the form of quartz or cristobalite)	Lung	
Solar radiation	Skin (basal cell carcinoma, squamous cell carcinoma, melanoma)	Eye (squamous cell carcinoma, melanoma); lip
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: Coglianò et al. 2011, IARC 2015

## Information on control measures

**The specific measures used for a particular hazard depend on the nature of the hazard, the task in which the exposure may occur and consideration of what is reasonably practicable.**

There are a range of exposure control measures that are used or have been recommended to control carcinogenic exposures in the agricultural 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 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 tasks or activities which were identified as resulting in probable exposures to carcinogens.



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# METHODS

The analysis presented in this report uses 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.

## 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 in 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 ABS (ABS 2011b). 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 studies 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 a specific industry. In some industries the number of participants may be small but should reflect the general working population in that industry.

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## 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 welding stainless steel using oxyacetylene processes would be assigned a high level exposure (i.e. control measures likely to be needed) if welding occurred inside and neither an air-supplied welding helmet nor a ventilation system was used.

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 (Australian Mesothelioma Registry 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 workers identifying and assessing their own exposures, that is, the approach used in surveys such as NHEWS (Teschke et al. 2002, Safe Work Australia 2009).

## 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 (Socio-Economic Indexes for Areas Index of Relative Socio-economic Disadvantage; ABS 2008) and remoteness (ABS 2011c).

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 respondents 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.

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**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**

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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 2006a) and the Australian and New Zealand Standard Industrial Classification (ANZSIC) (ABS 2006b). The analysis presented in this report is restricted to 156 AWES respondents who were categorised as working in the agricultural industry (ANZSIC code 'A01').

The agricultural industry ANZSIC code 'A01' includes the following subgroups:

- Nursery and Floriculture Production
- Mushroom and Vegetable Growing
- Fruit and Tree Nut Growing
- Sheep, Beef Cattle and Grain Farming
- Other Crop Growing
- Dairy Cattle Farming
- Poultry Farming
- Deer Farming, and
- Other Livestock Farming.

These groupings included various occupations which were categorised into four occupation groups, based on their four-digit ANZSCO codes:

- Mixed crop and livestock farmers and farmworkers (1214, 8416)
- Crop farmers and farmworkers (1212, 8412)
- Livestock farmers and farmworkers (1213, 8415), and
- Other (3622, 3624, 8311, 8414).

## AWES agricultural worker demographic information

The AWES agricultural workers were predominantly male (n=114, 73%). Just over half (51%) of the respondents were in the 35-54 years age group, and 64% had high school or less as their highest education level. Over half (54%) were of low to middle socioeconomic status and were most commonly lived in outer regional areas (43%). A comparison with overall Australian agricultural workers can be found in Table A1.

The sample of AWES agriculture workers was made up of four distinct groups: those who worked as mixed crop and livestock farmers and farmworkers (46%); those who worked as crop farmers and farmworkers (28%); those who worked as livestock farmers and farm workers (21%); and a group of other workers that included garden and nursery labourers (5%).

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## Exposure Assessment

These assessments were based on predetermined rules which had been developed on the basis of scientific literature, including exposure measurements where relevant, and expert 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 scientific literature, including exposure measurements where relevant, and expert assessment. 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 this information was available. All automatic assessments were reviewed by project staff for consistency.

Possible exposures were assigned if the information suggests there was a chance the respondent could be exposed but not enough information was available to accurately estimate whether they were 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 in 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.*

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## 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 agricultural industry according to Census 2011 data (ABS 2011b) 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 PPE 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 controls included in JSMs.

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

## Overall results

A total of 155 (99%) of the AWES agricultural 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 remained at 155 (99%).

There were 15 carcinogens to which at least one of the agricultural 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 agricultural 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 (%)
<b>Solar UV*</b>	<b>154 (99%)</b>	<b>0 (0%)</b>	<b>154 (99%)</b>
<b>DEE*</b>	<b>147 (94%)</b>	<b>0 (0%)</b>	<b>147 (94%)</b>
<b>Benzene*</b>	<b>128 (82%)</b>	<b>0 (0%)</b>	<b>128 (82%)</b>
<b>Other PAHS*</b>	<b>118 (76%)</b>	<b>0 (0%)</b>	<b>118 (76%)</b>
<b>Wood Dust*</b>	<b>110 (71%)</b>	<b>0 (0%)</b>	<b>110 (71%)</b>
<b>Chromium VI*</b>	<b>22 (14%)</b>	<b>61 (39%)</b>	<b>83 (53%)</b>
Artificial UV	0 (0%)	63 (40%)	63 (40%)
<b>Lead*</b>	<b>39 (25%)</b>	<b>19 (12%)</b>	<b>58 (37%)</b>
<b>Crystalline Silica*</b>	<b>45 (29%)</b>	<b>0 (0%)</b>	<b>45 (29%)</b>
Nitrosamine	0 (0%)	34 (22%)	34 (22%)
<b>Nickel*</b>	<b>12 (8%)</b>	<b>13 (8%)</b>	<b>25 (16%)</b>
<b>Trichloroethylene*</b>	<b>12 (8%)</b>	<b>0 (0%)</b>	<b>12 (8%)</b>
Cadmium	2 (1%)	10 (6%)	12 (8%)
Perchloroethylene	0 (0%)	1 (1%)	1 (1%)
Shift work	1 (1%)	0 (0%)	1 (1%)

Notes:

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

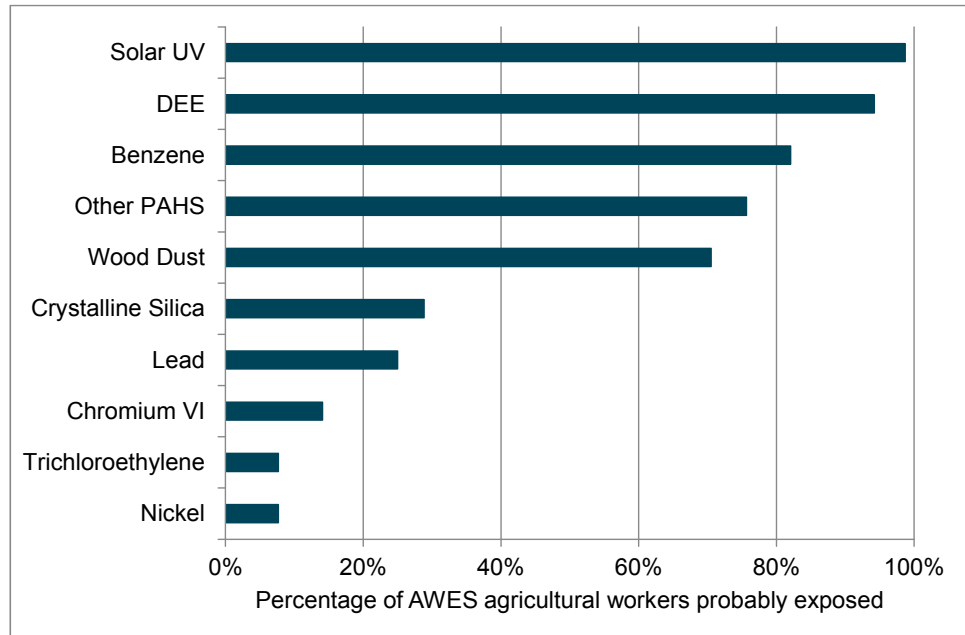
DEE—diesel engine exhaust

Other PAHs—polycyclic aromatic hydrocarbons (PAHs) other than vehicle exhaust

UV—ultraviolet

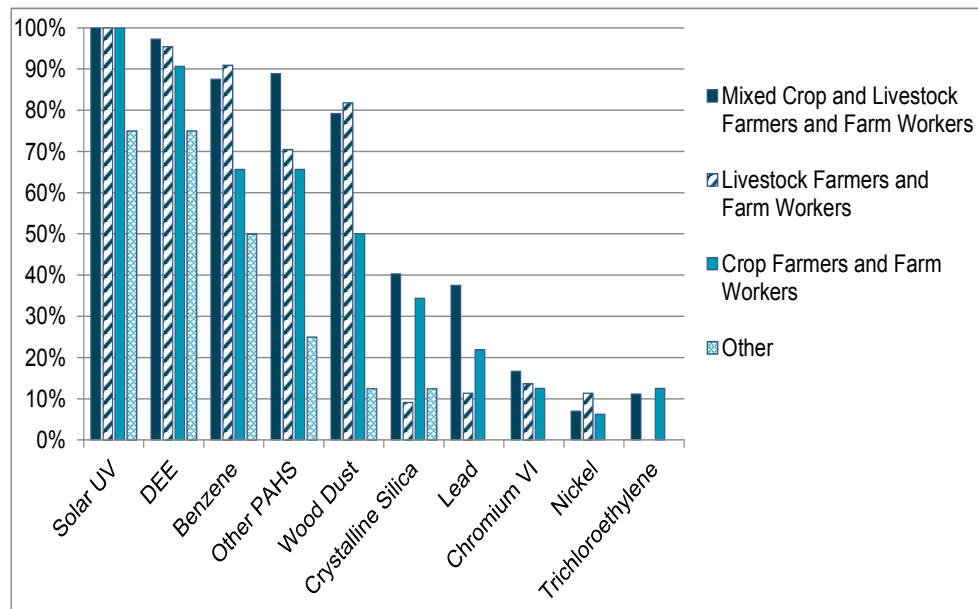
There were 10 carcinogens to which nine or more agricultural workers were probably exposed. The carcinogens that had the highest probable exposure prevalence were solar ultraviolet radiation (solar UV; 99%), diesel engine exhaust (DEE; 94%), benzene (82%), polycyclic aromatic hydrocarbons other than vehicle exhausts (other PAHs; 76%) and wood dust (71%) (Figure 2).

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



Mixed crop and livestock workers were estimated to have more probable exposures to carcinogens than the other types of agricultural workers (Figure 3). The least number of probable exposures were seen in the group 'other workers'.

**Figure 3: Percentage of AWES agricultural workers probably exposed to each carcinogen within occupation groups**



## 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, nickel and lead was common. These are exposures that are associated with welding and it is not surprising that they tend to occur together.

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Other PAHs, DEE and benzene were also found to co-occur. Repairing or refuelling power motors, vehicles and other equipment is a common task that incurs exposure to other PAHs, DEE and benzene, 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 the Safe Work Australia guidance for health monitoring (Safe Work Australia 2013a).

## Benzene

A large proportion of workers (n=128, 82%) were deemed to have a probable exposure to benzene. All of these were assessed as being exposed at a medium level.

Just under half (n=63; 49%) of these workers were mixed crop and livestock farmers, with a further 40 (31%) working as livestock farmers and farmworkers and 21 (16%) working as crop farmers and farmworkers.

### Circumstances of exposure

The two most common tasks leading to probable medium benzene exposure were refuelling petrol powered equipment (n=127, 99%) and degreasing using petrol at room temperature (n=19, 15%) (Table 3).

**Table 3: Main circumstances resulting in probable exposure to benzene**

Exposure circumstance	High (n)	Medium (n)	Low (n)	Total (n)
Refuel equipment with petrol	-	127	-	127
Used room temperature petrol to degrease	-	19	-	19

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 benzene.

## Chromium VI

Twenty-two (14%) workers were deemed to have a probable exposure to chromium VI. Of those exposed, 12 (55%) were assigned a high level exposure and medium and low level exposures were each assigned to five (23%) workers.

Over half (n=12; 55%) of these workers were mixed crop and livestock farmers and farmworkers, with a further six (27%) working as livestock farmers and farmworkers and four (18%) working as crop farmers and farmworkers.



**Welding stainless or chromium plated steel was the most common circumstance that led to a probable exposure to chromium VI.**

## Circumstances of exposure

Welding stainless or chromium plated steel was the most common circumstance that led to a probable exposure to chromium VI. Welding stainless steel or chromium-plated steel using ordinary, plasma arc, braze or oxyacetylene processes was 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). Eleven workers completed this task, with three (27%) being assigned a high level exposure and eight (73%) a medium level exposure. Welding using MIG, submerged arc or TIG processes was assigned medium or low level exposures based on the use of controls. Of those workers who used MIG, submerged arc or TIG processes to weld stainless steel or chromium-plated steel, three (33%) workers were not considered to use adequate controls and were assigned a medium level exposure and six (67%) were considered to use adequate controls and were assigned a low level exposure (Table 4). Twenty-three per cent of those who welded did so in a confined space however only five welded metals that probably expose workers to chromium VI.

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

Exposure circumstance	High (n)	Medium (n)	Low (n)	Total (n)
Welds stainless steel or chromium-plated steel				14
• using ordinary, plasma arc, braze or oxy-acetylene	3	8	-	11
• using MIG, submerged arc or TIG	-	3	6	9
Grinds stainless steel welds	10	-	-	10
Sanding vehicles, ships/boats or bridges	-	4	5	9

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

Ten workers ground stainless steel welds and this task was assigned a high level exposure (Table 4).

The other task resulting in a probable exposure to chromium VI was sanding metal objects such as vehicles, ships/boats and bridges. The level of exposure assigned was determined by whether or not a respirator was worn while doing the task. If a respirator was worn the task was assigned a low level exposure, if not, the task was assigned a medium level exposure (Table 4).

## The use of controls

Controls were considered for both welding and sanding tasks. For welding, the control 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 5).

For the sanding tasks, workers were asked about the use of respirators (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)	Outdoors* (n)	Ventilated area or ventilation system* (n)	Respirator (sanding) (n)	No controls (n)
Welds stainless steel or chromium-plated steel	4	5	2	N/A	4
Sanding vehicles, ships/boats or bridges	N/A	N/A	N/A	5	4

\* More than half the time

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

For welding tasks, the exposure assessment was adjusted if the controls used were considered adequate. Control measures considered included the use of an air-supplied welding helmet, welding more than half the time (always or usually) outdoors, or welding where a ventilation system was in place for more than half the time. Twenty-nine per cent of respondents who welded stainless steel or chromium-plated steel were not considered to use adequate controls to reduce their exposures (Table 6).

**Table 6: The assessed adequacy of controls when performing tasks with probable exposure to chromium VI**

Exposure circumstance	Adequate use of controls		Total (n)
	Yes (n)	No (n)	
Welds stainless steel or chromium-plated steel	10	4	14
Sanding vehicles, ships/boats or bridges	5	4	9
Total	15	8	23

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'.

No information was collected on controls used when grinding welds.

The use of a respirator was considered an adequate control to reduce exposures when sanding from a medium to a low level. Forty-four per cent of workers did not wear a respirator and their exposure was not adjusted (Table 6).

## Crystalline Silica

Forty-five (29%) workers were deemed to have a probable exposure to crystalline silica. A vast majority (89%) were assigned a medium level exposure, with the remaining 11% being assigned a high level exposure.

Almost two-thirds (n=29; 64%) of these workers were mixed crop and livestock farmers and farmworkers and about one quarter (24%) were crop

farmers and farmworkers.

### Circumstances of exposure

The only task undertaken that led to a probable exposure to crystalline silica was ploughing, harrowing or otherwise disturbing soil. All workers probably exposed to crystalline silica completed this task, however the assigned level of exposure varied depending on the use of vehicles with an enclosed cab. Five (11%) workers did not work in an enclosed cab and were assigned a high exposure. The rest (40; 89%) were assigned a medium exposure (Table 7).

**Table 7: Main circumstances resulting in probable exposure to crystalline silica**

Exposure circumstance	High (n)	Medium (n)	Low (n)	Total (n)
Plough, harrow, or otherwise disturb soil	5	40	-	45

### The use of controls

The use of a vehicle with an enclosed cab was considered adequate to reduce the crystalline silica exposure to a medium level exposure. Most (89%) workers used this control. Ensuring that air conditioning filters are regularly cleaned, changed and inspected would lower the exposure further, but workers were not asked about inspection or maintenance procedures.

## Diesel Engine Exhaust (DEE)

Most workers (n=147, 94%) were deemed to have a probable exposure to DEE. Of those exposed, 146 (99%) were assigned a medium level and one (1%) a low level.

Just under half (n=70; 48%) of these workers were mixed crop and livestock farmers and farmworkers, with a further 42 (29%) working as livestock farmers and farmworkers and 29 (20%) working as crop farmers and farmworkers.

### Circumstances of exposure

Using diesel powered equipment and repairing power motors and other equipment were two common tasks that led to a probable DEE exposure at a medium level. Most workers (n=143, 97%) used diesel powered equipment and 88 (60%) repaired power motors or other equipment (Table 8).

**Table 8: Main circumstances resulting in probable exposure to diesel engine exhaust**

Exposure circumstance	High (n)	Medium (n)	Low (n)	Total (n)
Using diesel powered equipment	-	143	-	143
Repairing power motors or other equipment	-	88	-	88

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.

## Lead

Thirty-nine (25%) workers were deemed to have a probable exposure to lead. Of these, 15 (38%) were assigned a high level exposure and 24 (62%) a medium level exposure.

More than two-thirds (n=27; 69%) were mixed crop and livestock farmers and farmworkers, seven (18%) were crop farmers and farmworkers and five (13%) were livestock farmers and farmworkers.

## Circumstances of exposure

Soldering was the most common task that led to a probable exposure to lead. All of the workers who were probably exposed to lead reported soldering. If the worker soldered in a confined space (n=10; 26%) or if the controls used by workers while soldering were not considered adequate (n=9; 23%) they were assigned a high level exposure. All other soldering exposures were assigned a medium exposure level (n=24; 62%). Welding lead-plated steel also led to probable lead exposure, however only two workers reported this task and their responses were not analysed further.

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**Soldering was the most common task that led to a probable exposure to lead.**

## The use of controls

Information on controls collected for those who soldered included the use of an air-supplied welding helmet, the amount of time the respondent soldered outdoors or the time spent soldering where a ventilation system was in place (welding booth, exhaust hood or local exhaust ventilation). The assigned exposure level was adjusted if controls used during soldering tasks were considered adequate—i.e. if the respondent wore a helmet or soldered outside or where a ventilated system was in place for more than half the time. Adequate protection was used by 30 (77%) workers (Table 9).

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

Exposure Circumstance	Air-supplied welding helmet (n)	Outdoors*	Ventilation system* (n)	None (n)
Soldering	7	21	4	9

\* More than half the time

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

## Nickel

Twelve (8%) workers were deemed to have a probable exposure to nickel. Of those exposed, almost all (n=11; 92%) were assigned a high level exposure—just one respondent (8%) was assigned a low level exposure.

Five (42%) of these workers were mixed crop and livestock farmers and farmworkers, five (42%) were livestock farmers and farmworkers and two (17%) were crop farmers and farmworkers.

## Circumstances of exposure

All 12 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). Nine workers completed this task with two (22%) being assigned a high level exposure and seven (78%) a medium level exposure. Welding using MIG, submerged arc or TIG processes resulted in either a medium or low exposure based on the use of controls. Of those that used MIG, submerged arc or TIG processes to weld stainless steel or nickel alloy, two (25%) workers were not considered to use adequate controls and were assigned a medium level exposure and six (75%) were considered to use adequate controls and were assigned a low level exposure. Twenty-three per cent of all workers who welded did so in a confined space but only two workers welded metals that probably expose workers to nickel and this task was not analysed further (Table 10).

Ten (83%) respondents ground stainless steel welds and this task was assigned a high level exposure (Table 10).

**Table 10: Main circumstances resulting in probable exposure to nickel**

Exposure circumstance	High (n)	Medium (n)	Low (n)	Total (n)
Welds stainless steel or nickel alloy				12
• using ordinary, plasma arc, braze or oxy-acetylene	2	7	-	9
• using MIG, submerged arc or TIG	-	2	6	8
Grinds stainless steel welds	10	-	-	10

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 controls was collected for those who welded stainless steel or nickel alloy. 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 11).

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

Exposure Circumstance	Air-supplied welding helmet (n)	Outdoors* (n)	Ventilation system* (n)	None (n)
Welds stainless steel or nickel alloy	3	5	2	3

\*More than half the time

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

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Seventy-five per cent of workers who welded stainless steel or nickel alloy used adequate protection to reduce exposures.

No information was collected on controls used when grinding welds.

For welding tasks, the exposure assessment was adjusted if controls were considered adequate—that is if the worker wore an air-supplied welding helmet, welded more than half the time outdoors, or welded where a ventilation system was in place for more than half the time. Seventy-five per cent of workers who welded stainless steel or nickel alloy used adequate protection to reduce exposures.

## Other Polycyclic Aromatic Hydrocarbons (PAHs)

Most workers (n=118, 76%) were deemed to have a probable exposure to other PAHs such as benzo[a]pyrene, coal-tar pitch, soots, and mineral oils. Of those exposed, 80 (68%) were assigned a high level exposure and the remaining 38 (32%) respondents were assigned a medium level exposure.

Over half of these workers were mixed crop and livestock farmers and farmworkers (n=64; 54%), 31 (26%) were livestock farmers and farmworkers, 21 (18%) were crop farmers and farmworkers.

### Circumstances of exposure

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More than half of the exposed respondents (n=67, 57%) burnt waste in the open and the 18 (15%) respondents used and incinerator.

Burning waste, cleaning out ash, and repairing power motors and other equipment were the three most common tasks resulting in a probable exposure to other PAHs. The method by which waste was burnt resulted in different exposure levels being assigned—a high level exposure was assigned if waste was burnt in the open and a medium level exposure was assigned if in an incinerator; was used. More than half of the exposed respondents (n=67, 57%) burnt waste in the open and 18 (15%) respondents used an incinerator (Table 12).

**Table 12: Main circumstances resulting in probable exposure to other polycyclic aromatic hydrocarbons**

Exposure circumstance	High (n)	Medium (n)	Low (n)	Total (n)
Burn waste in the open	67	-	-	67
Burn waste in an incinerator	-	18	-	18
Cleaning out ash	31	-	-	31
Repairing power motors and other equipment	-	88	-	88

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

Thirty-one (26%) workers removed ash after burning wastes and were assigned a high exposure (Table 12).

Eighty-eight (75%) workers repaired power motors and other equipment and were assigned a medium exposure (Table 12).

### The use of controls

Information on the use of controls was only collected from respondents who burnt waste. Exposure assessment was adjusted from a high to a medium level exposure if an incinerator was used.

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## Solar Ultraviolet Radiation (Solar UV)

Almost all workers (n=154, 99%) were deemed to have a probable exposure to solar UV. Of those exposed, 121 (79%) were assigned a high level exposure, 29 (19%) a medium level exposure and four (3%) a low level exposure.

### Circumstances of exposure

Agricultural 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. Most workers (n=135, 88%) reported spending greater than four hours each day working outside, 17 (11%) spent between one and four hours working outside, and just two (1%) spent less than one hour each day working outside (Table 13).

**Table 13: Main circumstances resulting in probable exposure to solar UV**

Exposure circumstance	High (n)	Medium (n)	Low (n)	Total (n)
Outside greater than four hours	121	14	-	135
Outside between one and four hours	-	15	2	17
Outside less than one hour	-	-	2	2

### The use of controls and protective equipment

Information was collected on the use of four methods for preventing UV exposure—using sunscreen, wearing a hat, wearing protective clothing (i.e. 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 14 (10%) workers who spent four or more hours a day outside were considered to have used adequate controls based on this definition, similarly two (12%) of those workers who spent between one and four hours were considered to have used adequate controls. Wearing a hat (90%) and protective clothing (79%) were the most common methods for preventing UV exposures used by workers when working outside (Table 14).

**Table 14: The reported use of controls when performing tasks with probable exposure to solar UV**

Length of daily exposure	Sunscreen (n)	Hat (n)	Protective Clothing (n)	Shade (n)	All controls (n)
Outside greater than four hours	47	123	108	43	14
Outside between one and four hours	8	15	13	9	2
Outside less than one hour	1	1	1	0	0
Total	56	139	122	52	16

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## Trichloroethylene

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

Two thirds (67%) of these workers were mixed crop and livestock farmers and farmworkers and the remainder (33%) were crop farmers and farmworkers.

### Circumstances of exposure

The most common task that led to a probable exposure to trichloroethylene was degreasing. All workers who were deemed to have a probable exposure completed this task and the level of exposure was dependent on the temperature at which the worker completed the task. Eleven (92%) completed the task at room temperature and were assigned a medium exposure and one (8%) used a heated degreaser and was assigned a high level exposure. Information was also collected on the process used when degreasing. Nine (75%) workers reported degreasing by spraying parts, three (25%) by hand painting parts and two (17%) used a dip tank. The method of degreasing did not affect the assigned exposure level. No information was collected on what was degreased as it was felt this was unlikely to affect exposure levels.

### The use of controls

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

## Wood Dust

One hundred and ten (71%) workers were deemed to have 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, 71 (65%) were assigned a low level exposure and 39 (35%) were assigned a medium level exposure.

Over half (52%) of these workers were mixed crop and livestock farmers and farmworkers, 33% were livestock farmers and farmworkers, and 15% were crop farmers and farmworkers.

### Circumstances of exposure

Cutting and sanding wood were the most common circumstances that led to a probable exposure to wood dust.

Almost all exposed respondents (n=106, 97%) cut wood. The exposure level assigned was dependent on what was used to cut the wood. Thirty-nine (37%) respondents used a chainsaw and 67 (61%) either used an axe or handsaw or did not specify the tool used and these tasks were assigned medium or low level exposures respectively (Table 15). Information on the type of materials cut was not gathered as it was unlikely to affect exposure assessments.

Twenty-seven (25%) workers sanded wood and the exposures levels were determined by whether or not they used a respirator to prevent exposures.



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Twenty (74%) workers were assigned a medium level exposure as they did not use a respirator, and the remaining 7 (26%) workers were assigned a low level exposure as they reported using a respirator (Table 15). Information on the type of materials sanded was not gathered as it was unlikely to affect exposure assessments.

**Table 15: Main circumstances resulting in probable exposure to wood dust**

Exposure circumstance	High (n)	Medium (n)	Low (n)	Total (n)
Cutting wood	-	39	67	106
• Chainsaw	-	39	-	39
• Axe, handsaw, or not specified	-	-	67	67
Sanding Wood	-	20	7	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 respirators was collected for those workers who sanded. If a respirator was worn the exposure assessment was adjusted from a medium level to a low level exposure. Only seven (26%) of those workers who sanded wood wore a respirator and had their exposure level adjusted.

No information on the use of controls was collected from AWES agricultural workers who reported cutting wood.

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# DISCUSSION AND INTERPRETATION OF THE STUDY FINDINGS

## Exposures and controls

In the AWES 99% of the respondents who were categorised as working in agriculture were deemed to have a probable exposure to at least one carcinogen included in the study. The most common exposures were solar UV, DEE, benzene, other PAHs and wood dust. There are few other studies that explore the prevalence of carcinogen exposure in the agricultural industry. 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 agricultural industry than the AWES, with about 40% exposed (Kauppinen et al. 2000). However, the definition of agriculture differed and exposures encountered in Australia, for example solar UV radiation, are very different from the EU. CAREX-Canada found that the most common exposures in the agricultural industry were solar UV radiation, DEE and wood dust (Peters et al. 2015). These results were similar to those found in the AWES which also found that benzene and other PAHs were common.

The Australian NHEWS survey collected self-report data to estimate the prevalence and nature of exposures to priority occupational disease causing hazards. Self-reported exposures have been found to lead to significant misclassification when compared with expert assessment (ASCC 2008b). It found the most common exposures in the agriculture, forestry and fishing industry were direct sunlight, combustion or welding gases and environmental dust. Again, the industry categories differed between the NHEWS and AWES studies and it is hard to assess the significance of any similarities and differences between the two studies as NHEWS assessed categories of hazard rather than specific exposures as in AWES.

### **Benzene**

The AWES found 82% of the respondents who worked in agriculture were deemed to have probable exposure to benzene. Safe Work Australia's guidance material on the health monitoring of benzene considers petrol evaporation as a non-work exposure circumstance (Safe Work Australia 2013a). In contrast, the AWES found that refuelling petrol equipment was the most common task leading to probable exposure to benzene in the agricultural industry. Another common task that resulted in a probable benzene exposure was the use of petrol as a degreaser. Although inhalation is the most common route of exposure, skin contact can also result in benzene entering the body (NICNAS 2013a).

There is currently limited information provided by Safe Work Australia about potential controls to eliminate or reduce benzene exposure. Work Cover NSW released a fact sheet that included information on reducing exposure to benzene from petrol emissions in the agricultural industry. Controls suggested included substituting vehicles with ones that have safer engines and cleaner fuels and administrative controls such as minimizing the amount of time spent around the emissions (WorkCover NSW 2015).

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The use of petrol as a degreaser has a high potential for skin contact. Recommendations from NICNAS suggest substituting with a degreaser that does not contain benzene and avoiding skin contact through wearing benzene-resistant gloves or other PPE (NICNAS 2013a).

### **Crystalline Silica**

The AWES found 29% of respondents who worked in agriculture were deemed to have a probable exposure to crystalline silica. The most common task that was assessed as probably exposing workers to crystalline silica was ploughing, harrowing or otherwise disturbing soil, based on studies conducted in South Africa and North Carolina which investigated exposure to respirable quartz in farming soils (Swanepoel et al. 2011). Therefore exposure was found most commonly in those who worked on crop farms (mixed crop and livestock farmers and farmworkers and crop farmers and farmworkers). Inferences about the presence of respirable silica in Australian farming soils had to be made in order to assess the exposure as similar Australian studies were not identified. The guidance material for the health monitoring of crystalline silica provides some examples of work activities that could result in crystalline silica exposure but these tasks focus on tasks undertaken in the construction, manufacturing and mining industries (Safe Work Australia 2013a). There is little information available that makes the agricultural industry aware of potential exposures and controls that could be used to reduce or eliminate silica exposure. While working in an air conditioned vehicle cabin is a useful first step, filters need to be regularly cleaned and inspected to ensure they are not damaged for effective use (HSE 2006).

### **Diesel Engine Exhaust (DEE)**

The AWES found 94% of respondents who worked in agriculture were deemed to have probable exposure to DEE. The most common task leading to probable DEE exposure was the use and repair of diesel powered equipment.

Guidance material is provided by Safe Work Australia on the health monitoring of workers exposed to 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). WorkCover NSW has produced a fact sheet that includes information on reducing exposure to DEE in the agricultural industry. Controls suggested included substituting vehicles with ones that have safer engines and cleaner fuels, scheduling regular maintenance of the equipment and minimising the amount of time spent around the emissions (WorkCover NSW 2015). The US Occupational Safety and Health Administration (OSHA) has also released an information sheet that outlines potential engineering controls that can reduce exposure to DEE, and similarly suggests performing routine maintenance on diesel engines, installing engine exhaust filters and using cleaner burning engines. They also suggest some administrative controls; for example, restricting amount of diesel powered equipment in work areas and prohibiting or restricting unnecessary 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).

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**Specific guidance on DEE has been developed to provide information about potential controls to eliminate or reduce DEE exposure (Safe Work Australia 2015)**

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**This study found that burning waste was a common agricultural task exposing agricultural workers to PAHs.**

### **Other Polycyclic Aromatic Hydrocarbons (PAHs)**

The AWES found 76% of respondents who worked in agriculture were deemed to have probable exposure to PAHs other than vehicle exhausts. Safe Work Australia guidance material on the health monitoring of PAHs provides examples of a number of potential workplace activities that might result in exposure, however none of those included were agricultural tasks. This material does, however, state that non-work sources of exposure include breathing air containing smoke from burning agricultural crops or wastes (Safe Work Australia 2013a). This study found that burning waste was a common agricultural task exposing agricultural workers to PAHs. No control measures are mentioned in the current guidelines. The AWES considered work practices such as burning waste in an incinerator, rather than out in the open, one way to reduce the exposure level.

Another common task that leads to probable exposure to other PAHs was the repair of power motors and other equipment. Other than guidance aimed at preventing or reducing exposures to vehicle exhausts, there is limited or no guidance on controls to prevent exposures to other PAHs when repairing motors. This task is likely to result in exposure through inhalation, however, it is also possible that exposure could occur through skin contact.

### **Welding or Soldering Exposures (Chromium VI, Lead and Nickel)**

Respondents who worked in agriculture were deemed to have probable exposures to chromium VI (14%), lead (25%) and nickel (8%), which are carcinogenic welding by-products described in the Safe Work Australia Model Code of Practice for Welding Processes (Welding Code) (Safe Work Australia 2012). The Welding Code is also relevant for allied tasks like soldering. To prevent exposures to these airborne contaminants, the Welding Code recommends using a less hazardous chemical where possible, as well as carrying out tasks in isolated booths, installing ventilation systems and providing appropriate RPE. In confined spaces it recommends the use of air-supplied respirators. The AWES asked questions about the amount of time spent welding outdoors or where ventilation systems were in place and whether or not respondents wore an air-supplied welding helmet while welding. Approximately 40% of respondents who had probable exposures to chromium and lead and 25% of those who had probable exposures to nickel were not considered to use adequate controls based on their responses to these questions. Welding outdoors or where ventilation systems were in place was common but air-supplied welding helmets are expensive, which may account for respondents favouring the former controls. Respondents were not asked questions about machining alloys as that task was thought to be unlikely in most agricultural jobs.

### **Solar UV**

The AWES found 99% of respondents who worked in the agriculture industry had a probable exposure to solar UV. This is a much higher prevalence than was found in the CAREX Canada study, where 69% of workers in the farming industry were exposed (Peters et al. 2012). The NHEWS study found a lower exposure prevalence of 74% in agriculture, forestry and fishing industry—the broader industry category may explain

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**Safe Work Australia has released a set of guidelines for the management of solar UV exposure.**

this difference (Safe Work Australia 2009).

Safe Work Australia has released a set of guidelines for the management of solar UV exposure. Potential control measures identified by the guidelines are working in shaded areas, eliminating or reducing the 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. It is stated in the guidelines that combining control measures is the most effective way of reducing exposure (Safe Work Australia 2013b). The AWES asked questions on the amount of time spent outdoors, time working 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 only 34% and 36% of exposed respondents respectively, indicating these controls are not well used. Overall, only 10% of respondents were considered to have used adequate controls to prevent exposures.

### **Trichloroethylene**

The AWES found eight per cent of the respondents who worked in agriculture were exposed to trichloroethylene when using solvents for degreasing tasks, particularly by those who worked on crop farms. However the sample of exposed respondents was small and it is not reasonable to draw firm conclusions.

NICNAS has a trichloroethylene safety factsheet which provides recommendations on the safe use of the solvent (NICNAS 2013b). 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 exhaust ventilation 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 respondents who used trichloroethylene to degreasing parts, 75% reported spraying the parts. No information was collected on the use of ventilation or PPE.

### **Wood Dust**

The AWES found 71% of respondents who worked in agriculture were deemed to have a probable exposure to wood dust. IARC did not differentiate between types of wood when classifying of “wood dust” so all types of wood dust were included in the AWES. The NHEWS survey found a much lower prevalence (10%) (Safe Work Australia 2009).

A report released by the Australian Safety and Compensation Council (ASCC; now Safe Work Australia) in 2008 makes suggestions for best practice control measures for wood dust (ASCC 2008a). Controls suggested included local exhaust ventilation (LEV), vacuum cleaning methods rather than 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, HSE 2014). The current study asked questions on RPE used whilst sanding but no information on LEV was collected. On the whole, RPE was not well-used during sanding tasks. Although there were

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no farmers who were assessed as being exposed to formaldehyde in the sample, the NICNAS guidance on working with particle board may also be relevant (NICNAS 2013c).

## Gaps, strengths and weaknesses

Data for this report was taken primarily from the AWES as limited other relevant data sources that include information on work tasks and exposures exist. The AWES 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 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. In general, the data collected in population-based studies should be representative of exposures and exposure circumstances. However, like any such survey, it has some limitations.

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

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 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 so a limited number of specific questions could be asked about any particular circumstance in a sub-sector. There were similar issues with the NHEWS project.

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 asked questions on current job tasks undertaken and was guided by questions in the relevant job-specific modules. 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, the AWES can only be expected to provide representative exposure information on relatively common activities within the agricultural industry. Information will be lacking on tasks that are specific to a particular occupation, or in this case farm, which are less common or which are undertaken by a relatively small number of people. If detailed information is required about a specific sector of the workforce 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. However due to the time constraints mentioned earlier, the questions asked on control use was 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,

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often potentially relevant information (such as specific type of ventilation) was not collected.

A common issue in survey data collection is non-response resulting in potential selection bias. In the AWES, 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 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 agricultural 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.

Since the development of the carcinogen list in 2012 (Fernandez et al. 2012), IARC have classified the insecticide lindane as Group 1 and the insecticides malathion, diazinon and dichlorodiphenyltrichloroethane (DDT) and the herbicide glyphosate as Group 2A (Guyton et al. 2015, Loomis et al. 2015). DDT is banned in Australia but the remaining pesticides may be used by a proportion of the study population. Although information was collected on whether insecticides or herbicides were used by the participants, the use of specific chemicals was not assessed.

## Potential implications

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**Agricultural workers generally undertake a wide variety of tasks with the potential to expose them to a number of carcinogens.**

Almost all AWES agricultural workers were likely to be exposed to at least one carcinogen when performing relatively common activities at work. Agricultural workers generally undertake a wide variety of tasks with the potential to expose them to a number of carcinogens and the AWES agricultural workers were commonly exposed to 10 carcinogens. 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 are classified by the IARC as known or probable human carcinogens and, as for all hazardous workplace chemicals, risks (or exposures) to health and safety 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 others 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,

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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 agricultural 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
- increased use of all sun protection measures—working in the shade, wearing protective clothing that covers up arms and legs, wearing a hat and using sunscreen
- 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 agricultural industry, this information is not organized in a way which is convenient for the agricultural industry. There is a need for clear, concise and consistent information on the circumstances and control of exposures that is specifically tailored to the agricultural industry. For example, some WHS regulators have developed information sheets specifically for the agricultural industry; however these could be improved by providing information for tasks associated with exposures commonly identified in this report. To have the greatest benefit information should be developed in a nationally consistent manner.

## Further Research

The AWES provides information on current exposures within the agricultural industry. Measuring exposures to specific carcinogens 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.

The work presented in this report could also be complemented by the



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collection of more widespread and detailed information on the use of control measures where probable carcinogenic exposures have been highlighted 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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**A method to predict future risk of cancer based on current exposures has recently been developed based on the lifetime risk model (Rushton et al. 2012)**

The potential burden of these exposures in terms of future cancer risk in agricultural workers can be estimated. A method to predict future risk of cancer based on current exposures 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 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

A01	Agricultural Industry
ABS	Australian Bureau of Statistics
ANZSCO	Australian and New Zealand Standard Classification of Occupations
ANZSIC	Australian and New Zealand Standard Industrial Classification
AWES	Australian Work Exposures Study
DEE	Diesel Engine Exhaust
HSE	Health and Safety Executive
IARC	International Agency for Research on Cancer
JEM	Job Exposure Matrix
JSM	Job Specific Module
LEV	Local Exhaust Ventilation
MIG	Metal Inert Gas (welding)
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
PPE	Personal Protective Equipment
RPE	Respiratory Protective Equipment
TIG	Tungsten Inert Gas (welding)
UV	Ultraviolet

# APPENDIX 1

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

Demographic Characteristic	Study population n (%)	Australian Population <sup>a</sup> n (%)	Chi <sup>2</sup> p-value <sup>d</sup>
<b>Gender</b>			<b>0.387</b>
Male	114 (73.1)	125 321 (68.6)	
Female	42 (26.9)	57,245 (31.4)	
<b>Age Group</b>			<b>0.007</b>
18-34	18 (11.5)	43 359 (23.7)	
35-54	79 (50.6)	87 010 (47.7)	
55-65	59 (37.8)	52 197 (28.6)	
<b>State of Residence</b>			<b>0.000</b>
New South Wales	29 (18.6)	50 146 (27.5)	
Victoria	54 (34.6)	42 475 (23.3)	
Queensland	26 (16.7)	41 129 (22.5)	
Western Australia	36 (23.1)	19 669 (10.8)	
South Australia	6 (3.8)	21 548 (11.8)	
Tasmania	5 (3)	6025 (3.3)	
Australian Capital Territory	0	1366 (0.7)	
Northern Territory	0	208 (0.1)	
<b>Country of Birth</b>			<b>0.014</b>
Australia	145 (92.9)	153 716 (84.2)	
Other	11 (7.1)	28 850 (15.8)	
<b>Language Spoken at Home</b>			<b>0.001</b>
English	156 (100)	164 846 (90.3)	
Other	0	17 620 (9.7)	
<b>Highest education level</b>			<b>0.000</b>
High school or less	100 (64.1)	112 401 (61.6)	
Trade certificate or diploma	27 (17.3)	53 988 (29.6)	
Bachelor degree or higher	29 (18.6)	16 177 (8.9)	
<b>Socioeconomic status<sup>b</sup></b>			<b>0.493</b>
Fifth quintile (Highest)	9 (5.8)	11 046 (6.2)	
Fourth	24 (15.4)	26 353 (14.8)	
Third	38 (24.4)	45 940 (25.8)	
Second	61 (39.1)	56 588 (31.8)	
First quintile (Lowest)	24 (15.4)	38 174 (21.4)	
<b>Remoteness<sup>c</sup></b>			<b>0.270</b>
Major city	10 (6.4)	21 075 (11.6)	
Inner regional	59 (37.8)	60 665 (33.3)	
Outer regional	67 (42.9)	74 335 (40.9)	
Remote/very remote	20 (12.8)	25 852 (14.2)	

a. Using the ABS 2011 Census data for ANZIC codes A01

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 agricultural workers

	Benzene	Chromium VI	DEE	Lead	Nickel	Other PAHS	Silica	Solar UV	Trichloro-ethylene	Wood Dust
Benzene	1.00									
Chromium VI	<b>0.1850</b>	1.00								
DEE	<b>0.2425</b>	<b>0.1574</b>	1.00							
Lead	<b>0.1638</b>	<b>0.6406</b>	0.1153	1.00						
Nickel	0.1051	<b>0.6426</b>	0.1014	<b>0.3617</b>	1.00					
Other PAHS	<b>0.3183</b>	<b>0.3072</b>	<b>0.4360</b>	<b>0.2722</b>	0.0778	1.00				
Silica	0.1503	0.0541	0.0969	<b>0.1653</b>	-0.0165	<b>0.1965</b>	1.00			
Solar UV	<b>0.2437</b>	0.1082	<b>0.2162</b>	0.0826	0.0467	<b>0.2008</b>	0.0726	1.00		
Trichloro-ethylene	0.0096	0.1332	0.0714	0.1273	0.0896	0.1078	0.1348	0.0329	1.00	
Wood Dust	<b>0.2837</b>	<b>0.1976</b>	<b>0.2620</b>	<b>0.2230</b>	0.0464	<b>0.2880</b>	0.0084	<b>0.1762</b>	0.0284	1.00

Note: Numbers in bold are statistically significant.

