



safe work australia

National Hazard Exposure Worker Surveillance

Chemical exposure and the provision of chemical exposure control measures in Australian workplaces



March 2012

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ISBN 978-0-642-33337-7 [PDF]

ISBN 978-0-642-33338-4 [RTF]

Foreword

The Australian Safety and Compensation Council (ASCC) (now Safe Work Australia) requested the development of the National Hazard Exposure Worker Surveillance (NHEWS) survey to examine the nature and extent of Australian workers' exposure to selected occupational disease-causing hazards. The survey also collected information from workers about the controls that were provided in workplaces to eliminate or reduce these hazards. The results of the NHEWS survey will be used to identify where workplace exposures exist that may contribute to the onset of one or more of the eight priority occupational diseases identified by the National Occupational Health and Safety Commission (NOHSC) in 2004. These diseases are: occupational cancer, respiratory diseases, noise-induced hearing loss, musculoskeletal disorders, mental disorders, cardiovascular disease, infectious and parasitic diseases and contact dermatitis.

The NHEWS survey was developed by the ASCC in collaboration with Australian work health and safety regulators and a panel of experts. These included Dr Tim Driscoll, Associate Professor Anthony LaMontagne, Associate Professor Wendy Macdonald, Dr Rosemary Nixon, Professor Malcolm Sim and Dr Warwick Williams. The NHEWS survey was the first national survey on exposure to workplace hazards in Australia.

In 2008, Sweeney Research was commissioned to conduct the NHEWS survey using computer assisted telephone interviews (CATI). The data, collected from 4500 workers, forms a national data set of occupational exposures across all Australian industries. The survey was conducted in two stages. The first stage (n=1900) focussed on the five national priority industries as determined by NOHSC in 2003 and 2005. These industries were selected to focus the work under the National Occupational Health and Safety Strategy 2002-2012 relating to reducing high incidence and high severity risks. The priority industries are Manufacturing; Transport and storage, Construction; Health and community services and Agriculture, forestry and fishing. The second stage (n = 2600) placed no restrictions on industry.

An initial report on the results of the NHEWS survey can be found on the Safe Work Australia website. It contains a descriptive overview of the prevalence of exposure to the nine studied occupational hazards within industries and the provision of the various hazard control measures.

This report focuses on Australian workers' skin exposure to chemicals and the control measures that are provided in workplaces to mitigate these exposures.

This report has three main objectives:

- to describe patterns of occupational exposure to chemicals, as reported by NHEWS participants, in terms of the demographic, employment and workplace characteristics
- to describe patterns of chemical control measures provided in workplaces with reference to demographic, employment and workplace characteristics, and
- to provide researchers with directions for future research in this field.

Information from these first two research objectives will inform the development of work health and safety policy and workplace interventions and it is hoped that this will contribute to the reduction and better management of workplace exposure to chemicals.

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Summary

The purpose of the National Hazard Exposure Worker Surveillance (NHEWS) Survey was to inform the development of workplace exposure prevention and control initiatives that will ultimately lead to a reduction in occupational disease. Workers may be exposed to chemicals through inhalation, ingestion or dermal (skin) contact.

This report provides a profile of the occupational and demographic characteristics of workers who reported dermal (or skin) exposure to chemicals at work, as well as the types of controls with which respondents reported they were provided in the workplace. These analyses enable the identification of groups of workers at risk of high dermal exposure and the extent to which appropriate exposure mitigation measures are present in the workplace. This information will contribute to the development of appropriately targeted work health and safety policy and practice interventions. These initiatives might ultimately lead to a reduction in occupational contact dermatitis.

Sampling methodology and research limitations

Information was collected by the NHEWS survey in 2008 across all major industry groups, although the sampling strategy focused particularly on five national priority industry groups: Manufacturing; Construction; Agriculture, forestry and fishing; Transport and storage; and Health and community services. The sampling strategy was such that workers in the five priority industries were over-sampled relative to their true population distribution. Workers in a number of the industry groups other than the non-priority industries, such as Accommodation, cafes and restaurants, are known to be at high risk of dermal exposure to chemicals including detergents and bleaches. Therefore this report includes all of the industry groups.

Based on the limitations of the study sample it is important to note that the NHEWS survey cannot be considered to be representative of the Australian population. This means that the overall generalisability to the Australian working population is limited. Another important consideration with the NHEWS survey is that the described exposure data is self-reported and may be affected by bias arising from inaccurate recall and reporting of dermal exposure of the individual study participants. This bias may vary with different chemical exposures, industries and worker characteristics (such as education level, seniority or area of expertise). For example, more senior workers, workers with highly specialised training or workers in sectors with particular dermal exposures may tend to report more accurately. Also, workers may be expected to report more accurately on exposures which are most obvious to them rather than more cryptic exposures or exposures more peripheral to the central tasks of their job. It was outside the scope of the NHEWS survey to perform objective dermal exposure assessment.

Main findings

Reported chemical exposures

Overall 37% (95% Confidence Interval [95% CI]: 36 - 39%) of workers who participated in the NHEWS survey reported that they had skin contact with chemicals at work in the week preceding the survey. A higher percentage of males reported dermal chemical exposure than females.

When the chemicals nominated by the NHEWS respondents were systematically classified, the most commonly reported chemical classes were *Detergents, Organic solvents, Disinfectants, Bases and alkalis, Paints, varnishes and inks, Cement and lime* and *Non-bituminous hydrocarbon fuels*.

There were a number of factors that were associated with a higher risk of dermal exposure to the seven most commonly reported classes of chemicals:

- Gender - female workers were more likely than male workers to report dermal exposure to *Bases and alkalis*, *Detergents* and *Disinfectants*. Males were more likely to report *Non-bituminous hydrocarbon fuels*, *Paints, varnishes and inks*, and *Cement and lime*. There was no difference between males and females for exposure to *Organic solvents*, however there may have been differences by the types of solvents, for example alcohol hand rubs were predominantly reported by workers in the Health and community services industry, an industry which has a large proportion of female workers.
- Age - workers in the youngest age group were more likely to be exposed to *Detergents* than workers in any other age group. Workers in the 25-34 and the 35-44 year old age groups were less likely to be exposed to *Disinfectants* compared to the youngest age group.
- Occupational skill level - workers in the lowest occupational skill level jobs were more likely to report dermal exposure to *Bases and alkalis*, *Detergents* and *Disinfectants* than higher-skilled workers. The likelihood of reporting dermal exposure to *Cement and lime* was also elevated in the lowest occupational skill level group, skill level five, which includes unskilled labourers. The second highest likelihood of reporting dermal exposure to *Cement and lime* was recorded by workers in skill level three, a group that includes qualified trades jobs. Skill level three workers were also most likely to report dermal exposure to *Non-bituminous hydrocarbon fuels*, *Organic solvents* and *Paints, varnishes and inks*. Skill level five workers also had increased likelihoods of reporting of these dermal exposures compared to the highest skilled workers.

The provision of dermal chemical exposure control measures in the workplace

The provision of control measures to stop dermal exposure to chemicals, or to minimise problems when someone does have dermal exposure to chemicals, was reported less frequently by certain groups of respondents. Compared to workers in workplaces with 200 or more employees, workers in smaller workplaces were less likely to report the provision of all types of control measures: gloves, protective clothing, labelling and warning signs, washing facilities, and training in the safe use of chemicals.

Only 61% of workers who reported exposure to chemicals also reported that their employers provided chemical safety training.

Compared to workers in permanent or contract positions, workers who described their work arrangement as casual or temporary were less likely to report the provision of labelling and warning signs and were also less likely to report the provision of chemical safety training.

Some of the groups of workers who were most likely to report dermal exposure to particular chemical classes were also more likely to report they were provided with none of the surveyed controls. For example, workers from the smallest workplaces (less than five employees) were more likely than workers from larger workplaces to report exposure to *Paints, varnishes and inks* and *Cement and lime*. Relative to the largest workplaces, these same workers were also almost five times more likely to report they were provided with none of the surveyed controls.

Policy implications

From the raw verbatim data collected from the NHEWS survey participants, it is evident that a number of workers who reported working in occupations known to have high dermal exposure to chemicals did not report exposure to these chemicals. Understanding the underlying reasons for and the distribution of under-reporting of dermal chemical exposure may indicate areas for policy intervention and targeted worker education.

The extent to which workers reported that they were provided with training in the safe use of chemicals is an issue that warrants further investigation, particularly with the reported lack of training for temporary and casual employees. Further research with a view to intervention is

warranted, particularly given the apparent trend towards increasing casual employment and labour hire in the workforce.

Targeted interventions to reduce dermal exposure to chemicals within specific workplace contexts may be required, particularly in smaller workplaces. Policy and intervention targeting workers in sectors of high dermal exposure risk, such as workers in small businesses and the *Construction* industry, is likely to be beneficial.

Further research

Evaluation of the NHEWS survey self-reported dermal exposure data through comparison with the results of formal exposure assessment methods would be a worthwhile avenue of research. This could be undertaken in a variety of ways and would enable quantification of the extent of reporting bias (such as under-reporting) and patterns of reporting bias. For example, closer examination of the raw NHEWS data and comparison with objective occupational data, such as exposure assessment using a Job Exposure Matrix, would provide useful information about probable dermal exposures that have been under-reported and patterns of under-reporting.

Further research investigating the types of small businesses that are less likely to provide dermal exposure control measures and the factors that influence the management of chemical exposure risk would also be a useful extension of the NHEWS program. Future intervention research might focus on the development of tailored interventions that will be acceptable and successful within the small business context.

A number of the industries with high dermal exposures for chemicals are not national priority industries. Future surveys exploring dermal exposure to chemicals would benefit from a sampling strategy more representative of the Australian workforce.

Future hazard exposure surveys should concentrate on assessing workplace exposure to particular chemicals of interest in specific industries or settings, or amongst high risk workers. For example exposure to *Cement and lime* amongst casual employees in the Construction industry.

Dermal chemical exposure is one of the principal causes of occupational contact dermatitis. While this report details characteristics of dermal chemical exposure and the provision of control measures in the workplace, the NHEWS survey did not collect information on health outcomes such as occupational contact dermatitis. Parallel studies to identify industries and workplace settings associated with elevated rates of diagnosis and compensation claims for occupational contact dermatitis would complement the NHEWS survey findings and extend its interpretation.

Background and research objectives

Background

Many chemicals commonly handled in both workplaces and homes may have deleterious effects on human health. These health effects can be either short or long latency effects. Long latency health effects are those where there is a long interval, usually years to decades, between the exposure and the consequent health outcome. Shorter latency effects are more immediate results of the exposure in question. Short latency effects include poisoning, burns to skin or eyes as well as irritation and allergic reactions to the skin, eyes or other mucus membranes. Longer latency effects can include cancers, reproductive and cumulative neurotoxic effects. Attribution of longer latency effects to particular exposures is often problematic given the temporal separation of the cause and effect. Like most toxicological effects, the health effects of dermal chemical exposure are influenced by the intensity of exposure (dosage or concentration of the exposure), and the frequency and duration of exposure (how often the individual was exposed and for how long), in addition to the toxicological nature of the chemical substance in question (Benke et al. 1997).

Whilst we acknowledge the range and importance of these multiple health effects, the questions asked of the NHEWS survey participants were developed with the intention of collecting information about dermal (skin-related) health effects of exposure to chemicals (ASCC 2008). It is also recognised that self-reported data as a source of occupational exposure information are less useful for conditions of long latency such as cancer, as the worker is seldom knowledgeable about the chemicals that might have led or lead to the development of disease (Brooke et al. 2005). Self-reported data are also associated with the problems of recall bias, particularly when the health effect in question has a long latency.

Allergic and irritant occupational contact dermatitis, associated with skin exposure to chemicals, is a significant and widespread problem in Australian workplaces. Previous studies have reported associations between exposure of the skin to chemicals at work and the development of both irritant and allergic contact dermatitis (Nixon & Frowen 1991; Nixon & Moyle 2004; Nixon et al. 2005; Nixon & Williams 2007). Allergic and irritant occupational contact dermatitis are comparatively short latency conditions and therefore self-reported data may be more informative in this context because of the temporal proximity of the exposure to the potential disease outcome. For these reasons the present report analyses the self-reported chemical exposures and protective measures data from the NHEWS survey primarily in the contextual framework of allergic and irritant occupational contact dermatitis.

Contact dermatitis is the most common occupational skin disease in westernised industrial countries (approximately 90-95% of all occupational skin disease) (Lushniak 1995). A recent analysis found occupational skin disease, which includes occupational contact dermatitis, was the second most common work-related problem presenting to general practitioners in Australia (Hendrie & Driscoll 2003). Occupational contact dermatitis is a skin problem usually affecting the hands, although other sites may be affected or become involved later (Rietschel et al. 2002). There are two main types of contact dermatitis. Irritant contact dermatitis is caused by acute dermal exposure to strongly acidic or alkaline substances, or by the cumulative effect of ongoing dermal exposure to substances such as soap and water. Allergic contact dermatitis is caused by sensitisers contacting the skin and eliciting a Type IV immune response (typically delayed, 4-24 hours following contact), and is detected by patch testing (Nixon & Frowen 2005). Diagnosis of occupational contact dermatitis requires assessment by an occupational dermatologist, using a specific set of diagnostic criteria (Mathias 1989), along with patch testing, and if required, radioallergosorbent (RAST) tests or prick testing.

There are many inconsistencies in the terminology utilised for occupational contact dermatitis. Some authors use the term "hand eczema" or "hand dermatitis" to encompass all skin conditions affecting the hands, while others prefer "hand eczema" for endogenous

disease, and “hand dermatitis” for exogenous disease, some of which may be occupational in origin. The definition of occupational contact dermatitis may also vary, sometimes because of different legal requirements necessary for a successful workers' compensation claim. For the purpose of the present report, “occupational contact dermatitis” is understood as exogenous skin disease associated with occupational chemical exposures.

Available statistics for occupational contact dermatitis are generally considered to underestimate disease prevalence and incidence (Keegel et al. 2005; Keegel et al. 2007; Rosen & Freeman 1992). There are many underlying reasons for this. Medical practitioners do not always ask about workplace exposures and thus do not recognise the contribution of the workplace to the disease (Holness 2004). Even if an occupational relationship is suspected, many workers affected by occupational contact dermatitis do not claim workers' compensation or even seek medical advice, and their access to both varies widely throughout the world. Relevant insurance bodies may not accept some claims even if the dermatitis does arise from work exposures. Meeting an expense threshold, or minimum period away from work, or the existence of permanent impairment may be required for a successful claim in some jurisdictions. Best international estimates of incidence and prevalence rates of occupational contact dermatitis, obtained from reporting schemes using medical practitioners as voluntary reporters, range between 1.3 per 10 000 workers in the UK to 15 per 10 000 workers in the Netherlands (Keegel et al. 2009). An Australian reporting scheme using general practitioners and dermatologists as reporters found an incidence rate of 2.2 (95% Confidence Interval [95% CI], 1.3-3.2) per 10 000 workers and a one year period prevalence rate of 3.5 (95% CI, 2.4-4.8) per 10 000 workers (Keegel et al. 2005).

Contact dermatitis can have profound effects on workplace productivity and workplace costs (Burnett et al. 1998). Affected workers may require prolonged time off work and changes in workplace practices. Some workers may need to change their occupations (Burnett et al. 1998; Rosen & Freeman 1993). The worker may also accrue an ongoing financial burden as a result of treatment expenses (medical costs including topical corticosteroids) and preventative items (such as soap substitutes and moisturisers), which the employer or compensation authority do not recompense. Occupational contact dermatitis impacts on domestic activities, can necessitate social restrictions and may have detrimental psychological effects (Holness 2001).

Dermal chemical exposure

Australian workers participating in the NHEWS study reported working with a wide range of chemicals and substances. Some of these chemicals are clearly hazardous, even when handled at very low concentrations and for short periods of time, while other chemical products such as soaps or detergents may only have deleterious health effects at high concentrations or with repeated or prolonged exposure.

Information about hazardous chemicals is available from Safe Work Australia in the form of an online database called the Hazardous Substances Information System (HSIS) <http://hsis.ascc.gov.au/>. The HSIS provides information about many substances which have been classified as hazardous according to the Approved Criteria for Classifying Hazardous Substances [NOHSC:1008 (2004)] (NOHSC 2004). Some of these chemicals/substances will also have national exposure standards as declared by the Adopted National Exposure Standards for Atmospheric Contaminants in the Occupational Environment [NOHSC:1003 (1995)] (NOHSC 1995). Chemicals listed in the HSIS are subject to specific risk management provisions.

There is very little information in the published literature regarding the nature and extent of dermal exposure of Australian workers to chemicals in the workplace, either self-reported or through objective observation. Adequate information on the distribution of dermal exposures and levels of exposure in different industries or to describe dermal exposure conditions in specific contexts, such as small businesses, is required by workers, employers and policy-makers to help protect workers. An important employment-related determinant of dermal

chemical exposure risks is the manner in which specific tasks are performed by individual workers and this may vary considerably from worker to worker within the same industry, within the same occupation, and even within particular workplaces. Information about the patterns of dermal exposure to chemicals will also serve as a guide for the development and implementation of workplace interventions and information campaigns targeting reduction of potentially harmful chemical exposures, thereby reducing the potential for health effects among workers.

The NHEWS survey represents a first Australian attempt at obtaining this crucial information. Workers who participated in the survey were asked to estimate how long they spent working with chemicals on a typical working day and to identify the chemicals they worked with. The questions about exposure to chemicals are based on questions used in European Union and Swedish surveys (ASCC 2008). Self-reported exposure to chemicals from the European Working Conditions survey 2005 was used in a Swiss study as a determinant for self-reported work-related symptoms (Ariani et al. 2011; Gallup Europe 2006).

Self-reported data has a number of inherent limitations. Workers may not be aware of the chemical constituents of products they are using and may also be unaware of their properties and potential for harm. A related problem is that workers may identify different substances as “chemicals” or “exposures” for idiosyncratic reasons, possibly related to familiarity, ubiquity or popular reputation of the substance in question. Some exposures are simply more obvious than others and those that form a more central role in the core tasks of a particular operation may be better reported than those that are more peripheral. For example, a concreter may report cement exposure but may overlook sand and aggregate exposure because cement is the defining product used in this particular job. Other exposures may be less readily identified if perceived as either non-central ingredients or as items that are not seen as “chemicals” or as “exposures”. Using the same example, another possibility is that a concreter may perceive sand and aggregate (necessary ingredients in concrete) as somehow encompassed by the reported “cement” exposure, particularly since the modern concreting process often relies on ready-mixed product in which the components are less obviously separate elements. Finally, in self-report surveys, the wording of the question/s can influence respondents’ recall of different exposures. For example, respondents are more likely to recall exposures related to those provided as examples by the interviewer. The limitations of self-reported data similarly apply to exposure control measures. These limitations must be acknowledged and taken into account when interpreting the results presented in this report.

Chemical exposure control measures

There are many control measures that might potentially be utilised to reduce dermal exposure to chemicals in the workplace. Occupational exposure management is generally based on the ‘hierarchy of controls’ approach for limiting workers’ exposure. The hierarchy classifies controls according to their likely effectiveness based on the extent to which each control relies on the behavioural contributions of individual workers. In other words, controls that do not depend on worker behaviour are the most effective. In practice, multiple control measures are normally used to ensure effective workplace protection.

In descending order, controls may be classified as:

- hazard-elimination
- hazard-substitution
- hazard-isolation
- engineering controls
- work practices/administrative controls, and
- personal protective equipment (PPE).

PPE (for example, gloves) and administrative measures (for example, task rotation) are low on the hierarchy of controls, implying that they should not be considered sufficient in

themselves as protective measures for workers. They should be considered components of larger exposure mitigation schemes, which also incorporate appropriate, higher level controls. For example, the effectiveness of gloves relies on workers remembering to wear them, and making sure they are correctly fitted, of the correct type, changed at appropriate intervals and are not removed at inappropriate times – all common problems with the use of personal protective equipment. Eliminating the exposure altogether or substituting the exposure for a less hazardous one (for example by modifying the manufacturing process) are more effective control measures and may reduce the need for lower level controls such as PPE or administrative controls.

The *Skin Exposure* website (US National Institute of Occupational Safety and Health) explains in detail how the hierarchy might be applied to skin exposures: <http://www.cdc.gov/niosh/topics/skin/recommendations.html>. (US National Institute of Occupational Safety and Health 2010) In the Australian context, Safe Work Australia and its predecessors, the Australian Safety and Compensation Council (ASCC) and the National Occupational Health and Safety Commission (NOHSC) have National Standards and Codes of Practice for a range of hazardous substances <http://www.safeworkaustralia.gov.au/>.

Exposure to a potentially hazardous chemical can be eliminated if the process is changed, eliminating the use of the chemical or substituting it for a less hazardous alternative. This could be either a less hazardous chemical or a less hazardous form of the chemical e.g. capsules instead of powders. This principle is often possible as new processes and products become available that involve fewer hazardous chemicals or less hazardous alternatives. The general aim of engineering controls is to separate the operator from the hazard. In the context of skin exposures this may include remote operation, or mechanisation of processes otherwise done by hand.

Administrative controls are controls managed at the workplace-level and include training, labelling and signage, and systems that rotate workers through tasks with high exposure potential and/or redeployment of workers when a certain predefined limit of exposure has been reached during a specified time period. In situations where PPE has a defined break-through time, or where workers would find wearing protective equipment uncomfortable for long periods administrative controls to limit cumulative exposure are a particularly useful adjunct. In this way exposed tasks are distributed among a group of workers over time so that the total cumulative exposure time of each individual worker is minimised. However, solutions designed to reduce the cumulative duration of dermal exposure are often ineffective for preventing sensitisation and subsequent allergic contact dermatitis skin reactions since these effects are not generally associated with cumulative dermal exposure. In some cases the use of specific administrative controls is required by relevant regulations.

PPE is a last line of exposure mitigation and may include a range of items worn by the worker to create a proximate barrier between the worker's skin and the contaminant. All PPE has limitations and for gloves and other skin protective equipment these are often quantified as break-through times. In the case of a glove, the break-through time represents the point in time at which the chemical is expected to permeate the material of the glove, in other words the duration of protection which the glove is capable of providing in practice. It should be noted that the correct choice of protective equipment, for example the correct glove-type for the chemical being used and the task being performed, is key to its effectiveness (MacFarlane et al. 2007; Macfarlane et al. 2008; MacFarlane 2010). It should also be noted that the use of gloves in some circumstances may also cause or contribute to occupational contact dermatitis, particularly when occlusive gloves provide an environment that may result in excessive sweating. If occlusive gloves are used for long periods it is recommended that thin cotton gloves are worn under the outer gloves to address the potential damage to the skin from excessive sweating (ASCC 2005). Workers may also inadvertently use contaminated gloves. For example in hairdressing salons workers commonly turn gloves inside out between clients and reuse them with the contaminated surfaces of the glove touching the skin. These examples highlight the reasons why PPE is low on the hierarchy of

controls and should be seen as a last line of exposure mitigation and why higher level control measures are so important.

The NHEWS survey also collected information regarding provision of workplace amenities in the form of washing facilities. Provision of washing facilities are an important workplace resource in case of failure of PPE or other higher order controls.

Finally it is important to note that under Australian state-based legislation, employers have a number of obligations if they introduce a new product into the workplace, particularly if the product is classified as 'hazardous'. Employers are obliged to provide information to employees about any changes to the work environment, including for hazards associated with new chemicals/substances introduced to workplaces. They are also required to fulfil labelling and MSDS requirements, carry out appropriate induction and training, and in some cases keep a record of risk assessments and carry out regular health surveillance. In Part 4, Section 36 of the current Victorian legislation (Occupational Health and Safety Act 2004)¹, employers are required to consult with their employees when identifying or assessing hazards or risks, making decisions about controlling risks, or when proposing changes to how work is done, or to the workplace, plant, substances or other things used at the workplace. This is also reflected in Part 5, division 2 of the Model Work, Health and Safety Act². This legislation provides policy guidelines regarding communication of chemical risks within the workplace.

Questions that may have elicited information about control measures that eliminate the use of hazardous workplace chemicals, change the way tasks with dermal chemical exposure are undertaken, or substitute a hazardous workplace chemical with a less hazardous substances were not included in the 2008 NHEWS survey. Thus, information about the use of higher level controls in Australian workplaces are outside the scope of this report.

Research objectives

This report has three main objectives.

The first is to determine the percentage of Australian workers who self-report dermal exposure to chemicals in the workplace and to describe the various employment and demographic characteristics of groups of workers who report these exposures.

The second is to discern patterns in the provision of chemical control measures with reference to the employment and demographic characteristics of the workers. Information from these first two research objectives will inform work health and safety policy and workplace intervention and it is hoped that this will contribute ultimately to reduction and better management of workplace exposure to chemicals associated with occupational contact dermatitis and subsequent reduction in occupational contact dermatitis occurrence.

The third objective of this report is to provide researchers with directions for future research. While the results of this survey may provide advances for the body of knowledge in the area, more research in this field is required. Recommendations regarding further research are included in the report, as well as recommendations regarding the type of exposure surveillance data which is required over time to discern trends in exposure patterns across industries and groups of workers.

Overview of NHEWS survey methodology

The NHEWS survey collected data on occupational exposures, including skin exposure to chemicals, from 4500 Australian workers using computer assisted telephone interviews

¹ <http://www.legislation.vic.gov.au/>

² http://www.safeworkaustralia.gov.au/AboutSafeWorkAustralia/WhatWeDo/Publications/Documents/598/Model_Work_Health_and_Safety_Bill_23_June_2011.pdf

(CATI). An earlier report has described the results of airborne exposure to chemicals (Safe Work Australia 2010).

Survey participants were asked the following questions relevant to chemical exposures:

- On a typical day at work last week, how long did you work with chemicals such as cement, cleaning products, disinfectants, solvents, resins, paints, pesticides or other chemical substances?
- What were the main types of chemical products or substances you worked with last week? (Workers could identify multiple chemical products or substances).

Workers who reported that they worked with chemicals were also asked:

- (If self-employed 'Do you': If an employee 'Does your employer') do any of the following to prevent health problems caused by exposure to chemical products or substances?
 - provide gloves
 - provide protective clothing
 - provide labelling and warning signs
 - provide washing facilities
 - provide training
 - nothing

Workers were also asked:

- What kind of gloves do you normally use?

The chemicals/substances that were reported by the workers surveyed were grouped according to the Type of Occurrence Classification System (TOOCS version 2.1) (NOHSC 2002), which is used to classify the agency of injury or illness in the National Data Set (NDS) for compensation-based statistics. The coding was based on standard coding practices and two expert coders cross-checked a sample of cases to ensure consistency. The self-reported exposure data was recorded verbatim by the interviewers, as far as possible and expert judgment, informed by the job and industry details, was used to resolve cases where insufficient detail was recorded or where the recorded information was ambiguous.

Demographic and workplace data collected by the NHEWS survey are presented as descriptive statistics (percentages). Data were analysed using univariate logistic regressions. Significant variables from the univariate models were included in the multiple logistic regression models. These models described the odds of reporting skin exposure to chemicals/substances with respect to employment and demographic factors for each of the seven main chemical exposures. Models for each of the chemical exposure variables were run separately, however the models are presented in two common tables, with the same included categories for ease of comparison. If a variable was significant in a model for one chemical exposure it was retained for all models. For example, number of employees at a workplace was a common confounder and was included in each of the models. Variables were removed sequentially from the models until the most parsimonious model (across all the chemical exposure variables) was obtained.

This approach was also used to present the descriptive data for the provision of workplace controls and to estimate the odds of exposed workers being provided with particular types of control measures against chemical/substance exposure.

The data presented in this report are unweighted and are therefore only representative of the survey sample. Unless otherwise stated, the data presented in this report relate to the portion of the sample that reported skin exposure to chemicals. Some descriptions of

categorical variables (such as occupational skill level categories³) are presented elsewhere in this report to facilitate ease of reading. Full details of the survey design, fielding methodology and the data analysis methodology can be found in Appendix A of this report.

Results

This section provides an overview of the main results from the analysis of the data pertaining to dermal chemical exposures from the 2008 NHEWS survey. Additional tables are presented in Appendix B.

Overall exposure to chemicals in the workplace

Overall 1679 or 37% (95% Confidence Interval [95% CI]: 36-39%) of NHEWS survey respondents reported that they had worked with chemicals in the week preceding the survey.

A higher percentage of males (39%) compared to females (35%) reported exposure to at least one type of chemical, and this difference was statistically significant ($p < 0.05$). There were also significant differences in the reporting of chemical exposure by age group. The age group that recorded the highest percentage (52%) of workers who reported exposure was the 15-24 year old age group ($p < 0.000$). For occupational skill level, workers classified as 'Tradesperson or related work and advanced clerical or service work' (skill level three) were the group with the highest percentage of workers (53%) who reported exposure to chemicals. The group that recorded the second highest percentage was the lowest occupational skill level group 'Elementary clerical, sales or service work and labourer or related work' (skill level five) - 50% of workers in this group reported exposure.

A higher percentage (41%) of temporary or casual workers reported exposure to at least one chemical compared to workers on permanent or fixed term contracts (35%) ($p < 0.05$). There were also differences in self reported exposure to chemicals by workplace size. Workplaces with fewer than five employees recorded the highest percentage of workers who reported exposure to at least one chemical (46%). The percentage of workers who reported exposure to chemicals decreased with increasing workplace size: 43% of workers in workplaces with five to 19 employees, 32% of workers in workplaces with between 20 to 199 employees and 31% of workers in workplaces with 200 or more employees reported exposure to at least one type of chemical.

When considering overall chemical exposure by the industrial groupings, there was a spread in terms of the percentages of workers who self-reported exposure. The industry with the highest percentage of workers who reported exposure to chemicals was Accommodation, cafes and restaurants, where 57% of workers reported exposure. This was followed by the Agriculture, forestry and fishing (50%), Health and community services (47%) and Construction (45%) industries. The industries that recorded the lowest percentages of workers who reported chemical exposure were Communication services (6%), Finance and insurance (7%) and Government administration and defence (12%).

Duration of exposure to chemicals in the workplace

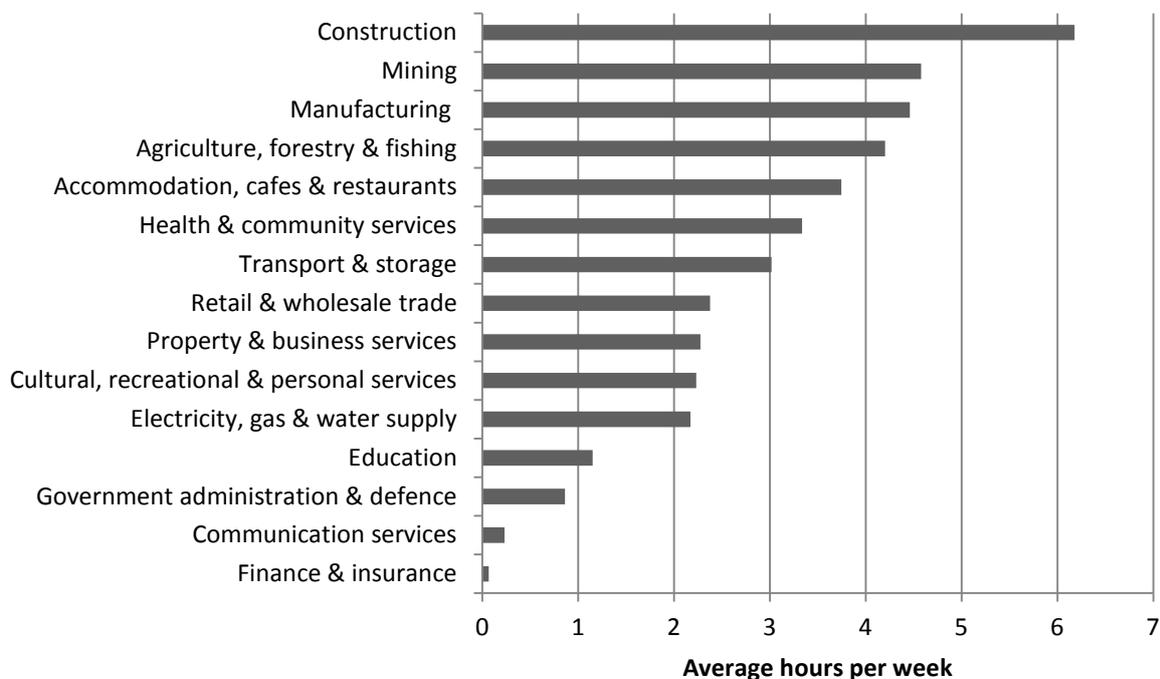
NHEWS survey participants were asked to report on how long they worked with chemicals. Respondents typically reported working with multiple chemicals but the question relating to duration was asked first and covers all work with chemicals. Therefore, it was not possible to analyse duration of exposure to specific chemicals and duration of exposure has not been included in the analyses of specific exposures.

Figure 1 presents information on duration of exposure to chemicals by industry. The industry with the highest mean reported duration of exposure was Construction, where respondents, on average, were exposed to chemicals for over six hours per week. Other industries with

³ For a full explanation of occupational skill level categories see page 23 of this report.

high mean exposure durations (hours per week) were Mining, Manufacturing and Agriculture, forestry and fishing, with mean durations of exposure of greater than four hours in each case. The industries with the lowest mean duration of exposure were Finance and insurance, Communication services, and Government administration and defence with means of under an hour per week.

Figure 1. The average number of hours per week workers reported exposure to chemicals in Australian industries



Types of self-reported chemical exposure

Participants in the NHEWS survey were asked to specify the chemicals they worked with within the workplace. As this was an open-ended question, a range of chemicals and substances were reported, and were identified by respondents in a number of ways. Participants were also able to nominate multiple chemicals.

Broadly, participants reported their chemical exposures in several different ways. Some exposures were reported as specific, basic chemical entities, for example chlorine, zinc sulphate, nitric acid. Respondents also reported chemical exposures by functionality, based on what the product in question does rather than its actual chemical nature. For example, “oven cleaner”, “metal polish”, and “cutting fluid” are functional descriptions of products which may vary in chemical composition. Finally, some exposures were reported by commercial product names, such as “Roundup” (a herbicide) or “Miltons” (a disinfectant). Many commercial product names represent complex mixtures of different chemicals.

The self-reported exposures were systematically classified into groups according to the TOOCS 2.1 classification system (NOHSC 2002). The TOOCS coding system enables coding by both specific chemicals (eg chlorine or benzene) and by certain, common functional groups (eg detergents or pharmaceuticals). As a rule commercial product names were coded either by chemical constituents or by functional group, particularly in the case of complex or variable mixtures.

Due to the unstructured nature of this question in the survey and the self-reported data, some misclassification may have occurred. However, classification was undertaken by

occupational health researchers with specialised knowledge of occupational exposures in a wide variety of workplace contexts and experienced at coding imperfectly reported data. Although misclassification due to mis-coding may be minimal other sources of potential error may result in some misclassification.

Table 1 presents the distribution of chemical exposures by TOOCS categories for all chemical exposure categories where more than one percent of respondents reported exposures. It must be noted that the categories are not mutually exclusive because respondents who nominated more than one chemical exposure can be counted in more than one category, consequently percentage totals may be greater than 100 per cent. Table 8 in Appendix B presents the complete list of self-reported chemical exposures by TOOCS categories. The distribution of chemical exposures by TOOCS categories (Table 1 and Table 8) shows that exposures were infrequently reported by specific chemical names. Chlorine was reported explicitly by only 17 respondents and other specific chemicals were less commonly reported. A comparatively large proportion of the specific chemicals reported were coded as “other nominated chemicals”, this being a variable group of unusual chemicals specified by particular chemical name. The small number and highly variable nature of the specifically nominated chemicals would suggest that a small proportion of the respondent group were highly informed about their chemical exposures, working with particular chemicals.

The majority of respondents reported more general descriptions of the chemicals they worked with, including commercial product names and/or functionality. The most commonly reported chemical exposures were *Detergents*, reported by over a third of respondents. These were predominantly domestic or commercial cleaning agents.

Over 20% of workers who reported working with chemicals reported exposure to unspecified *Disinfectants*. *Disinfectants* for which more detail was supplied were coded to the relevant TOOCS categories (generally either *Bases and alkalis* for bleach-based disinfectants or *Organic solvents* for alcohol-based disinfectants). However, because TOOCS 2.1 does not include a category specific to the functional designation *Disinfectants*, the *Disinfectants* exposures for which no further information was provided would normally be coded into an “other” category in TOOCS. Due to the large number of NHEWS survey participants who reported exposure to *Disinfectants* without providing further information, an additional category was created: *Disinfectants* (not elsewhere classifiable).

Over a quarter of respondents who reported that they worked with chemicals reported exposure to *Organic solvents*. This category includes industrial solvents, such as degreasers, as well as thinners for paints and other purposes (other than hydrocarbons). As the *Organic solvents* category also includes alcohol-based disinfectant products and disinfectant hand-cleansers commonly used in health-care workplaces to prevent the spread of infections, nurses and personal care workers frequently reported exposures in this category.

The most commonly reported exposures in the *Bases and alkalis* category included bleaches of various types including bleach-based disinfectants and cleaning products. Industrial caustic alkali products are also included in the *Bases and alkalis* group but were reported less commonly than bleaches.

Cement and lime were reported by approximately 10% of respondents who reported that they worked with chemicals. This category represents dry *Cement and lime* products, as distinct from wet cement. As most cement reporting respondents were actually involved with end-use of cement products (concreting, brick-laying etc) they were also coded as working with Wet concrete. Twenty-two respondents were coded working with *Cement and lime* only. These were predominantly workers who were handling cement products in the manufacturing or supply chain rather than end users.

Table 1. Types of self-reported exposures to chemicals

Type of chemical exposure	Number of workers who reported exposure	Percentage of exposed workers (n=1679) who reported exposure	Percentage of all workers surveyed who reported exposure
Detergents	572	34.1	12.7
Organic solvents <i>Includes: thinners, acetates, degreasers-solvent based</i>	464	27.6	10.3
Disinfectants	346	20.6	7.7
Bases and alkalis <i>Includes: caustic soda, caustic potash, sodium hydroxide</i>	199	11.8	4.4
Paints, varnishes and inks <i>Includes: water or oil-based paints, acrylic paints, vehicle paints, inks, printing inks, rust and conversion treatments</i>	187	11.1	4.2
Cement and lime <i>Includes: in powder form</i>	176	10.5	3.9
Non-bituminous hydrocarbon fuels <i>Includes: petrol, diesel, kerosene, aviation fuel, turpentine, paraffin, toluene, kerosene, LPG, lubricating oils</i>	167	9.9	3.7
Wet concrete <i>Includes: just poured or just mixed</i>	154	9.2	3.4
Other chemical products <i>Includes: glue, dyes</i>	79	4.7	1.8
Acids <i>Includes: battery acid, spirits of salt, hydrofluoric acid and hydrofluoric acid products</i>	72	4.3	1.6
Plant treatment chemicals <i>Includes: fungicides, weedkillers, fertilisers, crop sprays, insecticides, defoliants</i>	69	4.1	1.5
Plastic materials, synthetic resins and rubbers <i>Includes: polyurethanes, foam plastic, PVC piping, guttering</i>	51	3.0	1.1
Animal treatment chemicals <i>Includes: insecticides, animal dips and drenches, pesticides, rat poisons, snail bait, fly sprays, fumigants</i>	48	2.9	1.1
Pharmaceuticals <i>Includes: cosmetics, creams, medicines, drugs</i>	24	1.4	0.5
Abrasive powders <i>Includes: grain, grit, jewellers' rouge</i>	22	1.3	0.5
Other basic and unspecified chemicals <i>Includes: carbon dioxide in the form of dry ice</i>	18	1.1	0.4
Chlorine	17	1.0	0.4
Other nominated chemicals <i>Includes: cadmium, MOCA: 4,4'-methylene bis (2-chloroaniline), acrylonitrile, thallium, vinyl chloride, polycyclic aromatic hydrocarbons (PAH), pentachlorophenol</i>	17	1.0	0.4

Paints, varnishes and inks and related chemical products were reported by over a fifth of respondents. Chemicals in this group ranged from industrial surface coatings/treatments, two-pack automotive paints and wood finishes, to artists' paints (reported by teachers as well

as artists) and printing inks, mostly reported in the context of commercial printing businesses.

Non-bituminous hydrocarbon fuels and associated products were reported by nearly 10% of respondents. Chemicals in this group included auto mechanical fuels/lubricants as well as metalworking fluids and lubricants. Liquid hydrocarbons, such as turpentine and kerosene, which are commonly used as thinners for oil-based paint, were also included in this category.

Acids were reported by fewer than five percent of respondents. A variety of products and chemicals were reported in this category, including specific acids (e.g. nitric acid and hydrochloric acid) as well as acid-based products (e.g. acid cleaners/degreasers and acid etching gels/liquids).

Plant and animal treatment chemicals were reported by approximately 4% and 3% of respondents respectively. The *plant treatment chemicals* were dominated by weedicides/herbicides. Some fungicides were also reported and are included in this group. The *animal treatment chemicals* category represents a broader range of reported chemicals including veterinary medicines as well as pesticides. This group includes insecticides for animal application (such as sheep dips), insecticides for general application (e.g. domestic insect spray) and other pesticides (e.g. rodenticides).

Approximately 3% of respondents reported working with *Plastics, synthetic resins and rubbers*. The majority of products reported in this category were silicone gel-based products (e.g. plumbers' silicone caulking).

Other chemical products were reported by approximately five percent of respondents. The specific items coded in this category were mostly glues, including craft glues, cabinetry glues, adhesive cements, plumbers' adhesives, two-pack and contact adhesives.

Apart from exposure to *Cement and lime* and *Wet concrete*, exposure to "Materials and Substances" (TOOCS categories 611-639) were reported only occasionally. These substances included non-metallic minerals, timber, metals, stock-feed, foods/drinks and oils/fats. Due to the wording of the survey question, it is possible that respondents generally did not consider that work with these materials and substances were relevant. For example, a small number of respondents reported working with food products, but many more respondents reported employment in occupations such as cooks or kitchen hands.

The main types of dermal chemical exposure

As shown in Table 1 and Table 8 there were 42 different chemicals and substance types reported by workers in the NHEWS survey. In order to discern patterns of dermal exposure, it was decided to limit further description and analyses to data from those categories most frequently reported by respondents. Therefore, unless otherwise specified, the remaining analyses in this report were limited to the following seven dermal exposure categories:

- Detergents
- Organic solvents
- Disinfectants
- Bases and alkalis
- Paints, varnishes and inks
- Cement and lime, and
- Non-bituminous hydrocarbon fuels.

Over 150 workers reported exposure to each of these dermal chemical exposure categories. *Wet concrete* was not included in further analyses despite more than 150 workers reporting exposure to this category of chemicals/substances. This was because, as discussed above, the categories *Wet concrete* and *Cement and lime* represent nearly the same group of respondents. All those coded as *Wet concrete* were also coded as *Cement and lime* and for this reason the *Cement and lime* category was chosen for reporting and analysis purposes.

Employment and demographic factors that affected self-reported exposure to chemicals in the workplace

Summary statistics of the seven most commonly reported chemical categories by demographic and employment factors are provided in Table 9 (Appendix B). Individual respondents may be counted in more than one exposure category; therefore percentages may not add up to 100 per cent. Descriptive results, together with figures, are summarised below.

Worker gender

Male and female workers tended to report that they worked with different types of chemicals (Figure 2). Compared to females, much higher percentages of male workers reported exposure to *Cement and lime*. Higher percentages of males also reported exposure to *Organic solvents*, *Non-bituminous hydrocarbon fuels* and *Paints, varnishes and inks*. In contrast, larger percentages of female workers reported exposure to *Disinfectants*, *Detergents* and *Bases and alkalis* than male workers.

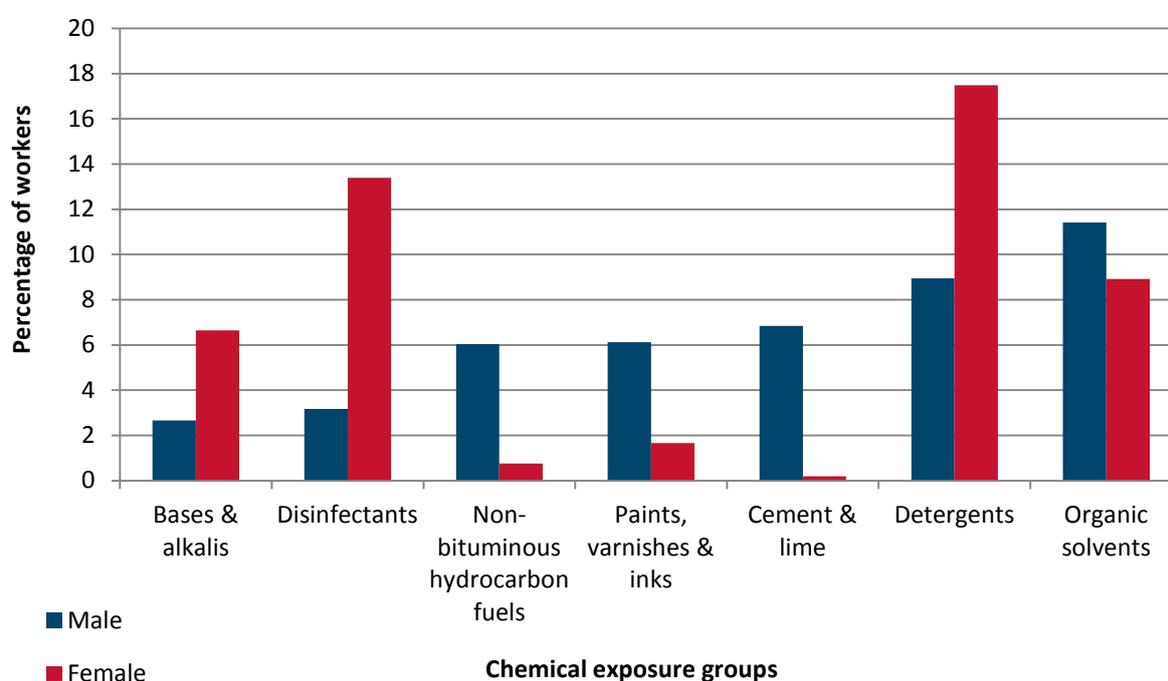


Figure 2. The types of self-reported chemical exposure categories by worker gender

Worker age

There was some variation in the distribution of workers' age groups across the main types of chemicals or substances that were reported in the NHEWS survey (Figure 3). A much greater percentage of workers aged 15-24 years reported exposure to *Detergents* than workers in the older age groups. There was a similar pattern for *Disinfectants*. Likewise, larger percentages of the youngest workers reported exposure to both *Cement and lime* and *Bases and alkalis* and in both cases there appeared to be a pattern of decreasing percentages of workers reporting exposure with increasing age. For the other exposure categories, *Non-bituminous hydrocarbon fuels*, *Paints, varnishes and inks* and *Organic solvents*, the percentages of workers reporting exposure were similar across the age groups, although again there was an apparent tendency towards higher reporting of these exposures in younger age groups. In several exposure categories the oldest age group (>55 years) reported exposure more often than the 45-55 age group, for example *Detergents*, *Disinfectants*, *Organic solvents* and *Paints, varnishes and inks*. It should be noted that the non-representative nature of the sampling frame, as well as the age distributions in the

occupations or industries where the substances are being used, may have an influence on the age-group distributions.

Employment arrangements

With a couple of exceptions, the percentage of temporary or casual workers who reported exposure to each of the main types of chemical exceeded that of permanent or fixed term workers (Figure 4). This pattern was most noticeable for *Detergents*, *Disinfectants* and *Bases and alkalis*. This may be due to patterns of employment arrangement among cleaners, food handlers and/or health care workers, which are occupations that are characterised by use of these products and also casual employment. Slightly larger percentages of permanent or fixed term employees reported exposure to *Non-bituminous hydrocarbon fuels* and *Organic solvents* than temporary/casual workers, however these differences were marginal.

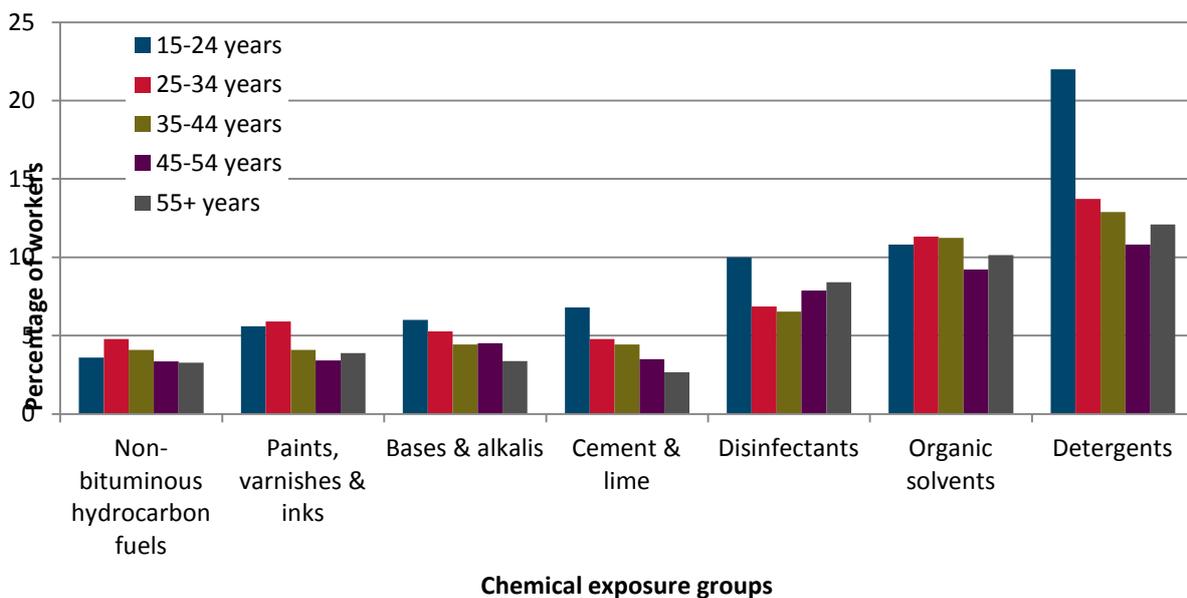


Figure 3. The types of self-reported chemical exposure categories by worker age group

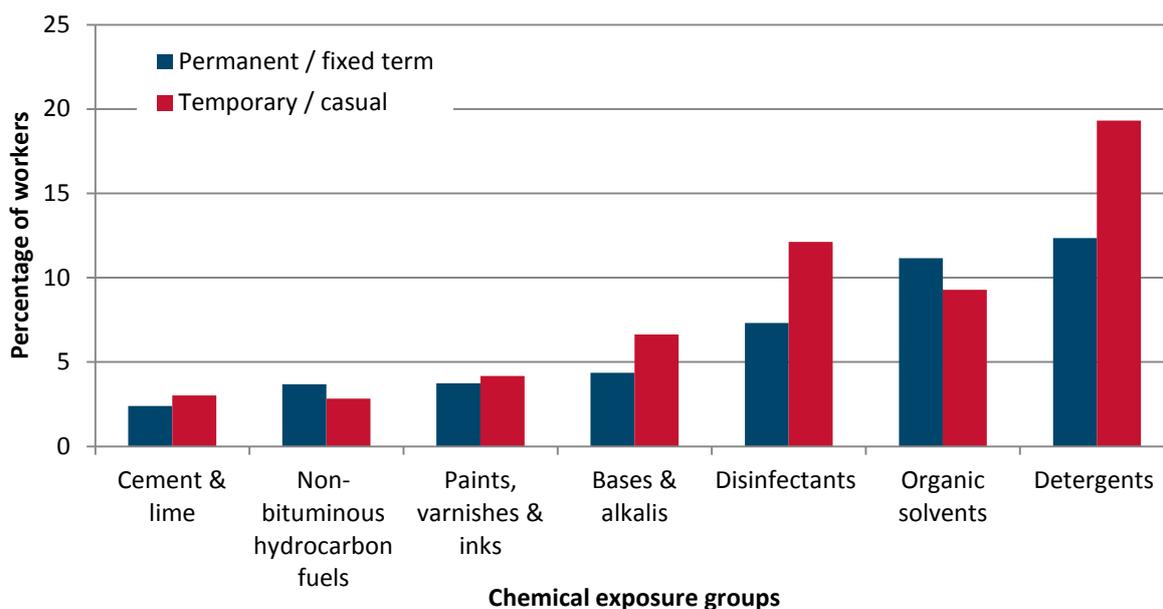


Figure 4. The types of self-reported chemical exposure by worker employment arrangement

Occupational skill level

The job data provided by NHEWS survey respondents were coded to the Australian and New Zealand Standard Classification of Occupations (ANZSCO) occupational skill level categories. The ANZSCO occupational skill level classification is designed to categorise the skill level normally necessary to perform a given occupation. ANZSCO takes into account the formal education/training, occupational experience and on-the-job training that are usually necessary to perform a given occupation. The skill level classification applies to occupations and not to individuals performing that occupation. Within this report, comparisons between occupational skill level and the self-reported chemicals exposures reveal the kinds of chemical exposures that typically are associated with occupations of differing skill levels.⁴ The occupational skill level groups are explained below using categories described by La Montagne et al. (2008).

- Occupational Skill Level 1 (Managers and professionals) is the highest skill level, usually commensurate with a bachelor degree or higher qualification or greater than five years of relevant experience. This group includes professionals and managers.
- Occupational Skill Level 2 (Technicians and associate professional workers) includes occupations usually requiring an associate degree, advanced diploma, diploma or greater than three years of relevant experience. This group includes associate professionals, advanced trades, skilled clerical, community and personal service occupations.
- Occupational Skill Level 3 (Tradesperson or related workers and advanced clerical or service workers) includes occupations usually requiring Australian Qualifications Framework (AQF) certificate III with on-the-job-training, AQF certificate IV or at least 3 years of relevant experience. This group includes trades and technical occupations.
- Occupational Skill Level 4 (Intermediate clerical, sales or service workers and intermediate plant operator / transport workers) includes occupations normally requiring AQF certificate II or III or at least one year of relevant experience. This group includes intermediate sales and clerical / administrative and service occupations.
- Occupational Skill Level 5 (Elementary clerical, sales or service workers and labourer or related workers) includes occupations normally requiring AQF Certificate I, compulsory secondary education and elementary on-the-job training. This group also includes occupations with no formal qualification or on-the job training requirements. This group includes elementary clerical and sales occupations, machine operators and labourers.

Among NHEWS respondents, the types of chemicals workers reported exposure to varied between workers of different occupational skill levels (Figure 5). Much larger percentages of the lowest skilled workers (skill level five, elementary clerical, sales or service work and labourer or related work) compared to workers of higher skill level, reported exposure to *Bases and alkalis* and *Detergents*. In contrast, considerably greater percentages of workers in skill level three (tradesperson or related work and advanced clerical or service work) reported exposure to *Non-bituminous hydrocarbon fuels*, *Paints, varnishes and inks*, *Organic solvents* and *Cement and lime* than workers of other skill levels. In the case of all four of these chemical groups, occupational skill level five recorded the second highest percentage of workers who reported exposure.

⁴<http://www.abs.gov.au/Ausstats/ABS@.nsf/0/64AECDF29CFFD6CCA2571E2008355FE?opendocument>

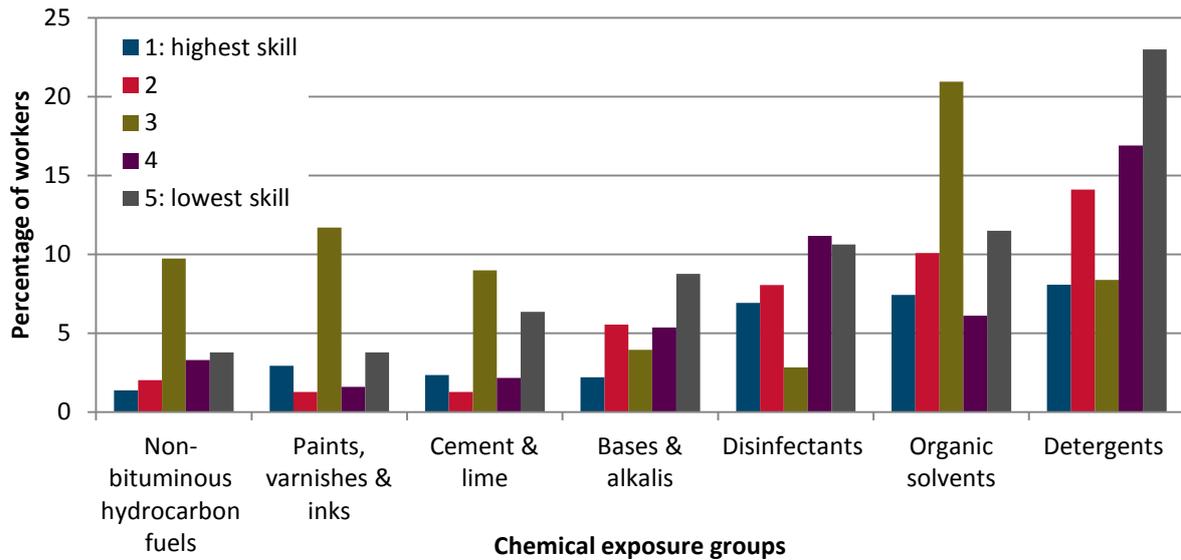


Figure 5. The types of self-reported chemical exposure by worker occupational skill level

Workplace size

There were noticeable differences in the percentages of workers who reported exposure to the main types of chemicals when patterns of self-reported exposure within workplace size (as measured by the number of employees in the respondent's workplace) were examined (Figure 6). Larger percentages of workers in the smallest workplaces (< five employees) than in the larger workplaces reported exposure to *Cement and lime* and the percentage of workers who reported exposure to this chemical group declined considerably with increasing workplace size. This may be due to the structure of the *Construction* industry, a sector in which small contractors are common. A similar pattern could also be seen for *Paints, varnishes and inks* and *Non-bituminous hydrocarbon fuels*, possibly for similar reasons since these exposures are also associated with the *Construction* industry.

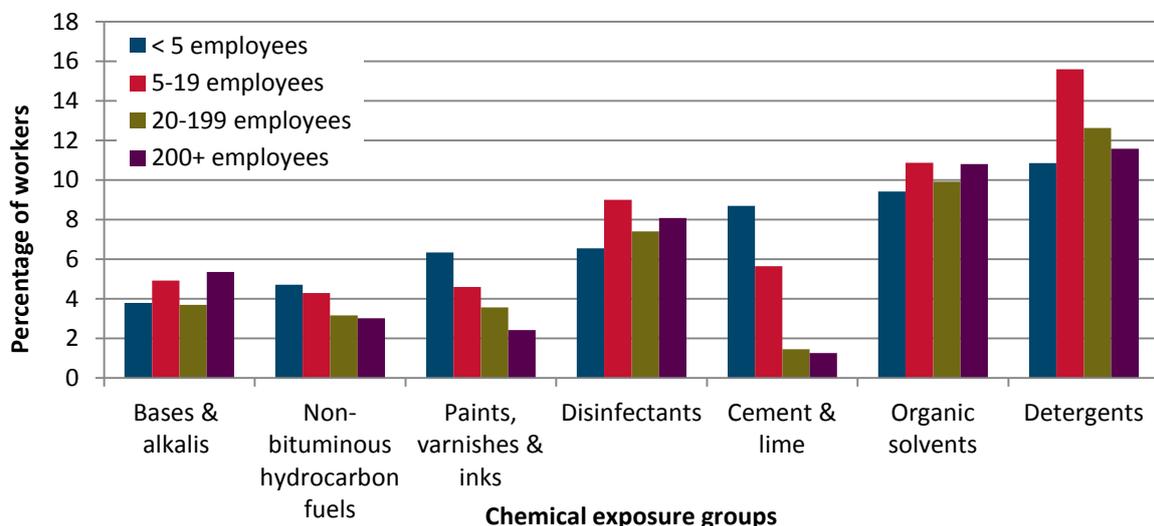


Figure 6. The types of self-reported chemical exposure by workplace size

Similar proportions of workers from each workplace size reported exposure to *Organic solvents*, *Detergents*, *Disinfectants* and *Bases and alkalis*, although a greater percentage of workers in workplaces with five to 19 employees reported exposure to *Detergents* than for other workplace sizes. The similarity of proportions across workplace size may reflect the fact that cleaning is a common task in all workplaces. For example *Health and Community Services*, an industrial sector with stringent cleaning requirements, includes very large workplaces such as major teaching hospitals, medium workplaces such as suburban

hospitals and nursing homes, and small workplaces such as private-practice clinics. Cleaning work is often undertaken by specialised cleaning contractor companies which may be small, medium and large businesses.

Industry

The percentages of workers within each industry who reported exposure to each of the seven main dermal chemical exposure categories are presented in Table 2. These percentages should be interpreted with some caution as the sample size for some of the non-priority industries, e.g. Mining or Electricity, gas and water supply, were very small.

General patterns across chemical exposure groups

In line with *Detergents* being the most commonly reported dermal chemical exposure group in the NHEWS survey, this category recorded the largest percentages of self-reported exposures within most industries. However, a considerably higher percentage of workers in the Accommodation, cafes and restaurants industry (46%)⁵ reported exposure to *Detergents* than in the other industries. Other industries in which large percentages of workers reported exposure to *Detergents* included Wholesale and retail trade (25%) and Health and community services (23%).

There were a number of industries in which noticeably larger percentages of workers reported exposure to particular chemical substances in comparison to other industries. For example, more than 20% of workers in the Construction industry reported exposure to *Cement and lime*, with the next highest industry being Agriculture, forestry and fishing where 4% of workers reported exposure. More than 22% of workers in the Health and community services industry reported exposure to *Disinfectants* but there were also reasonably large percentages of workers who reported exposure to *Disinfectants* in the Accommodation, cafes and restaurants (13%) and Cultural, recreational and personal services (13%) industries. Exposure to *Bases and alkalis* was common in the Accommodation, cafes and restaurants industry as well as the Health and community services industry in comparison to other industries.

Almost 10% of workers in Construction and just over 7% of workers in Manufacturing reported exposure to *Paints, varnishes and inks*. There were a number of industries in which similar proportions of workers reported exposure to either *Non-bituminous hydrocarbon fuels* or *Organic solvents*, with no industry associated with significantly larger percentages of workers who reported exposure.

Patterns within industries

Manufacturing The most frequently reported chemical exposure in the Manufacturing industry was *Organic solvents*, for which approximately 15% of workers in this industry reported exposure. Other commonly reported chemicals or substances included *Detergents, Paints, varnishes and inks* and *Non-bituminous hydrocarbon fuels*, which were all reported by more than 6% of the Manufacturing industry workers.

Transport and storage The Transport and storage industry was characterised by varied exposures. Approximately 12% of workers in this industry reported exposure to both *Detergents* and *Organic solvents*. *Non-bituminous hydrocarbon fuels* were reported by about 8% of workers in this industry, which is expected given the importance of fuels and lubricants in transport.

Construction Exposure to *Cement and lime* was reported by nearly 21% of workers in the Construction industry. Among workers in this industry, *Paints, varnishes and inks, Organic solvents* and *Non-bituminous hydrocarbon fuels* were also prominent. Once again this is consistent with the nature of work in this industry.

⁵ The industry sample size for Accommodation, cafes and restaurants was 91 workers. Therefore, all findings related to this industry should be treated with caution.

Agriculture, forestry and fishing At least 4% of Agriculture, forestry and fishing workers reported exposure to each of the main chemical exposure categories. This is consistent with the varied nature of work in agri-businesses. *Detergents* were the most commonly reported chemical exposure in this sector (11%) and this appears to be associated with animal husbandry, in particular, dairy operations.

Health and community services Over 22% of Health and community services industry workers reported exposure to *Detergents* and *Disinfectants* and approximately 14% and 9% of workers reported exposure to *Organic solvents* and *Bases and alkalis* respectively. In the context of health care occupations, *Organic solvents* are predominantly alcohol-based skin disinfectant products and *Bases and alkalis* are predominantly bleach-based cleaning products. Cleaning is an important task in the context of healthcare, particularly for infection control. Clinical environments tend to be areas of intense human occupation and are subject to ordinary soiling, as well as potentially infectious contamination, both of which must be managed by more frequent and thorough cleaning than most other workplaces.

Wholesale and retail trade The Wholesale and Retail trade industries were combined in the NHEWS survey dataset to combat small sample sizes in these industries. Wholesale and retail trade workers reported exposure to a wide range of the main chemical exposure groups. It is possible that some of these self-reported exposures may be related to exposure to stock in trade rather than actual use. Exposure to *Detergents* was reported by about one quarter of all workers in the Wholesale and retail trade industry. Following the Accommodation, cafes and restaurants industry, this was the second largest proportion of workers within an industry to report exposure to *Detergents*. Participants' responses suggested that many of these workers used cleaning products in the process of cleaning checkouts, counters and shelves. *Organic solvents*, *Disinfectants* and *Bases and alkalis* were reported by approximately 10%, 8% and 5% of these workers respectively. Many of these exposures also appear to be associated with cleaning.

Accommodation, cafes and restaurants Workers in the Accommodation, cafes and restaurants sector frequently reported exposure to *Detergents* (46%). In addition, approximately 20% and 13% of workers also reported exposure to *Bases and alkalis* and *Disinfectants* respectively. Cleaning of accommodation areas, kitchens and food consumption areas is an important task in this industry and therefore the frequency of exposure to detergents, bleaches and other disinfectants is not surprising. *Organic solvents* exposure was reported by approximately 9% of workers in this group. This likely reflects the type of cleaning in this industry, where the emphasis is on environmental cleaning and detergents and bleaches are more likely to be used than alcohol-based cleansers.

Property and business services About 10% of workers in the Property and business services industry reported exposure to *Detergents*. Exposure to *Organic solvents* and *Disinfectants* were each reported by about 5% in this industry. These exposures may reflect property maintenance tasks amongst these workers.

Education About 9% of workers in the Education industry reported exposure to *Detergents*. *Organic solvents* and *Disinfectants* exposures were reported by 8% and 5% of workers respectively. Certain education environments require comparatively frequent cleaning, particularly early childhood environments, as well as specialised teaching areas, such as laboratories and other practical teaching environments.

Cultural, recreational and personal services Nearly 19% of Cultural, recreational and personal services workers reported exposure to *Detergents*. This likely reflects the intensity of human activity that is characteristic of many cultural and recreational environments. Furthermore, over 12% of workers in this sector reported exposure to *Organic solvents* and *Disinfectants* and over 8% of workers reported *Bases and alkalis*. It should be noted that this category includes beauty therapists, nail technicians and other personal service workers for whom cleaning and disinfection duties are important and who may also use solvent-based products in their core-business tasks.

Table 2. The types of self-reported exposure to chemicals within industries

Industry of main job	The percentage of workers within industries who reported exposure to each of seven main dermal chemical exposure categories						
	Detergents	Organic solvents	Disinfectants	Bases & alkalis	Paints, varnishes & inks	Cement & lime	Non-bituminous hydrocarbon fuels
Manufacturing	8.0	15.1	2.4	3.8	7.4	1.4	6.9
Transport & storage	12.5	12.5	2.8	1.8	3.8	1.5	8.2
Construction	2.8	8.6	1.4	0.6	9.9	20.9	6.4
Agriculture, forestry & fishing	11.0	5.1	5.4	4.4	3.8	4.1	5.1
Health & community services	22.5	14.3	22.7	9.1	0.7	0.0	0.5
Electricity, gas & water supply**	8.1	2.7	0.0	2.7	2.7	0.0	8.1
Wholesale and retail trade	25.3	10.1	7.6	4.6	2.5	0.8	2.1
Accommodation, cafes & restaurants*	46.2	8.8	13.2	19.8	1.1	0.0	1.1
Communication services**	0.0	6.0	0.0	0.0	0.0	0.0	2.0
Finance & insurance*	5.3	0.0	2.1	0.0	0.0	0.0	0.0
Property & business services	10.7	5.0	4.6	3.4	2.7	0.8	1.2
Government administration & defence	5.4	2.5	1.7	1.7	0.4	1.2	1.2
Education	9.1	7.5	4.7	2.5	4.7	0.3	0.9
Cultural, recreational & personal services*	19.0	12.6	12.6	8.4	3.2	2.1	1.1
Mining**	0.0	18.4	0.0	2.6	2.6	0.0	7.9

* Industry sample size: 90-100 workers, ** Industry sample size: ≤50 workers, caution is required when interpreting these percentages

Multivariate analyses of self-reported exposure to chemicals

Logistic regression models were run to identify workplace and demographic predictors of self-reported exposure to each of the seven main chemical exposure categories. The data were analysed initially using univariate logistic regression (data not reported). Variables that were statistically significantly associated with self-reported exposure in the univariate models were included in the multivariate logistic regression models. For each of the seven chemical exposures, these models described the likelihood (or odds)⁶ of reporting skin exposure to chemicals/substances with respect to employment and demographic factors. The models for each of the chemical exposure variables were run separately, but are presented in common tables (Table 3 and Table 4) for ease of comparison. If a predictive factor was statistically significant in a model for one chemical exposure it was retained for all models. Significant associations, i.e. workplace or demographic factors that affect the likelihood of reporting exposure to particular chemicals, have been highlighted in bold font in the tables. Model diagnostics (Hosmer-Lemeshow goodness of fit tests) are presented at the bottom of each separate model. These confirm that all the models had acceptable fit.

Bases and alkalis

The logistic regression model for *Bases and alkalis* (Table 3) identified a number of worker groups that were more (or less) likely to report exposure to this chemical category. Female workers were almost three times more likely to report exposure to *Bases and alkalis* than male workers. Relative to workers in the highest skill level - Level one (Managers and professionals), workers in each of the lower occupational skill levels were more likely to report exposure to Bases and alkalis. This increased likelihood was greatest for workers in the lowest occupational skill level - Level five (Elementary clerical, sales or service work and labourer or related work), who were more than four times more likely to report exposure to these chemicals (OR 4.28, 95% CI: 2.70-6.78). The likelihood of exposure to *Bases and alkalis* was similar for most workers based on workplace size. However, workers in workplaces with between 20 to 199 workers were about half as likely to report exposure to *Bases and alkalis* (OR 0.59, 95% CI: 0.40-0.87) compared to workers in the largest workplaces (200 or more workers).

Non-bituminous hydrocarbon fuels

The model examining self-reported exposure to *Non-bituminous hydrocarbon fuels* (Table 3), found that female workers were much less likely to report exposure than male workers (OR 0.16, 95% CI: 0.09-0.27). Similar to *Bases and alkalis*, occupational skill level was also associated with differences in the likelihood a worker reported exposure to *Non-bituminous hydrocarbon fuels*. Compared to workers in the highest skill level, workers in occupational skill level three (Tradesperson or related worker and advanced clerical or service workers) were more than five times more likely to report exposure to *Non-bituminous hydrocarbon fuels* (OR 5.28, 95% CI: 3.20-8.71). The likelihood of reporting exposure was also elevated for workers in skill level four (OR 2.71, 95% CI: 1.56-4.71) and skill level five (OR 2.70, 95% CI: 1.45-5.02).

⁶ An odds ratio is a measure of the effect size, quantifying the strength of association between an outcome variable (eg reported exposure to *Bases and alkalis*) and a second variable which is hypothesised to be potentially associated with the outcome (eg gender). The 95% confidence interval is an indicator of the likely reliability of the odds ratio as an estimate of the 'true' ratio in the population. For example, the 95% confidence interval for females exposed to *Bases and alkalis* is 1.99 to 3.80. This means that, if the statistical model is correct, there is only a 5% probability that the true population prevalence is outside this range. Confidence intervals that do not include 1.0 (the point of no difference) are said to be 'statistically significant' because it is unlikely that the true ratio in the population is on the other side of 1.0.

Table 3. Results (odds ratios and 95% confidence intervals) of the multivariate logistic regression models examining self reported exposure to: Bases and Alkalis, Non-bituminous hydrocarbon fuels, Organic solvents, and Paints, varnishes and inks

Employment or demographic factor	The likelihood (OR) that a worker reported exposure to each chemical type relative to the reference group for each factor							
	Bases & Alkalis		Non-bituminous hydrocarbon fuels		Organic solvents		Paints, varnishes & inks	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Gender								
Male (ref)	1.00		1.00		1.00		1.00	
Female	2.75	1.99-3.80	0.16	0.09-0.27	1.00	0.80-1.24	0.41	0.27-0.61
Age group								
15-24 (ref)	1.00		1.00		1.00		1.00	
25-34	0.95	0.50-1.82	1.96	0.90-4.27	1.33	0.81-2.16	1.39	0.72-2.68
35-44	0.81	0.44-1.49	1.68	0.80-3.54	1.37	0.86-2.17	0.92	0.49-1.75
45-54	0.78	0.43-1.42	1.43	0.68-3.00	1.12	0.71-1.77	0.84	0.45-1.58
55+	0.64	0.34-1.22	1.47	0.68-3.17	1.32	0.82-2.12	0.96	0.50-1.85
Occupational skill level								
Level 1 (highest skill) (ref)	1.00		1.00		1.00		1.00	
Level 2	2.51	1.43-4.40	1.52	0.67-3.49	1.42	0.97-2.09	0.44	0.17-1.11
Level 3	2.60	1.55-4.35	5.28	3.20-8.71	3.66	2.78-4.81	3.19	2.17-4.70
Level 4	2.43	1.56-3.77	2.71	1.56-4.71	0.83	0.60-1.14	0.57	0.32-1.01
Level 5 (lowest)	4.28	2.70-6.78	2.70	1.45-5.02	1.74	1.25-2.41	1.18	0.69-2.02
Workplace size								
200 or more employees (ref)	1.00		1.00		1.00		1.00	
20-199 employees	0.59	0.40-0.87	1.01	0.63-1.63	0.91	0.70-1.19	1.42	0.87-2.33
5 to 19 employees	0.75	0.49-1.13	1.22	0.74-2.00	0.88	0.66-1.19	1.62	0.97-2.72
<5 employees	0.70	0.45-1.08	1.10	0.68-1.78	0.67	0.49-0.91	1.86	1.14-3.03
Observations	4331		4331		4331		4331	
Hosmer-Lemeshow goodness-of-fit	0.4134		0.7449		0.8207		0.172	

Table 4. Results (odds ratios and 95% confidence intervals) of the multivariate logistic regression models: Detergents, Disinfectants, Cement and lime

Employment or demographic factor	The likelihood (OR) that a worker reported exposure to each chemical type relative to the reference group for each factor					
	Detergents		Disinfectants		Cement and lime	
	OR	95% CI	OR	95% CI	OR	95% CI
Statistically significant relationships are shown in bold						
Gender						
Male (ref)	1.00		1.00		1.00	
Female	2.07	1.70-2.51	4.43	3.38-5.81	0.04	0.01-0.10
Age group						
15-24 (ref)	1.00		1.00		1.00	
25-34	0.62	0.42-0.93	0.57	0.34-0.97	1.07	0.50-2.08
35-44	0.56	0.39-0.81	0.56	0.41-0.92	0.92	0.44-1.71
45-54	0.44	0.31-0.64	0.66	0.48-1.07	0.81	0.27-1.49
55+	0.55	0.38-0.80	0.80	0.62-1.31	0.54	0.14-1.07
Occupational skill level						
Level 1 (highest skill) (ref)	1.00		1.00		1.00	
Level 2	1.86	1.31-2.62	1.12	0.73-1.71	0.45	0.16-1.29
Level 3	1.25	0.90-1.74	0.63	0.39-1.02	1.94	1.26-2.99
Level 4	2.23	1.73-2.87	1.59	1.19-2.12	1.00	0.58-1.75
Level 5 (lowest)	3.31	2.50-4.37	1.66	1.18-2.34	2.46	1.50-4.03
Workplace size						
200 or more employees (ref)	1.00		1.00		1.00	
20-199 employees	1.04	0.81-1.35	0.89	0.65-1.21	0.98	0.48-1.99
5 to 19 employees	1.30	0.99-1.71	1.09	0.78-1.53	3.94	2.11-7.36
<5 employees	1.06	0.79-1.42	1.05	0.74-1.50	5.19	2.85-9.48
Observations	4331		4331		4331	
Hosmer-Lemeshow goodness-of-fit	0.514		0.4426		0.5036	

Organic solvents

The logistic regression model of self-reported exposure to *Organic solvents* (Table 3) showed differences in the likelihood of reporting exposure to these substances by occupational skill level. Workers in skill level three (tradesperson or related workers and advanced clerical or service work) were over three times more likely to report exposure to *Organic solvents* (OR 3.66, 95% CI: 2.78-4.81) than workers in the highest skill level. Workers in skill level five (elementary clerical, sales or service workers and labourer or related workers) were also more likely to report exposure to *Organic solvents* than the highest skilled workers (OR 1.74, 95% CI: 1.25-2.41). When considering workplace size, workers in workplaces with fewer than five employees were less likely to report exposure to *Organic solvents* than workers in the largest workplaces with 200 or more employees (OR 0.67, 95% CI: 0.49-0.91).

Paints, varnishes and inks

The logistic regression model of self-reported exposure to *Paints, varnishes and inks* (Table 3) revealed significant differences in the likelihood of reporting exposure by gender, with females much less likely to report exposure to these chemicals than males (OR 0.41, 95% CI: 0.27-0.61). In addition, workers in occupational skill level three were more likely to report exposure to *Paints, varnishes and inks* than workers in the highest skill level (OR 3.19, 95% CI: 2.17-4.70). There were also differences associated with workplace size. Workers in workplaces with less than five employees were more likely to report exposure to *Paints, varnishes and inks* (OR 1.86, 95% CI: 1.14-3.03) than workers in the largest workplaces (200 or more employees).

Detergents

The logistic regression model examining self-reported exposure to *Detergents* (Table 4) showed that females were twice as likely as males to report exposure to this chemical type (OR 2.07, 95% CI: 1.70-2.51). Like many of the other types of chemicals, occupational skill level was also associated with differences in the likelihood of reporting exposure to *Detergents*. Workers in occupational skill level two (OR 1.86, 95% CI: 1.31-2.62), skill level four (OR 2.23, 95% CI: 1.73-2.87) and skill level five (OR 3.31, 95% CI: 2.50-4.37) were more likely to report exposure to *Detergents* than the highest skilled workers. Age also affected the likelihood of reporting exposure to *Detergents*, with the youngest workers (15-24 years olds) being the most likely to report exposure to this chemical group.

Disinfectants

Female workers were almost five times more likely to report exposure to *Disinfectants* than male workers (OR 4.43, 95% CI: 3.38-5.81) (Table 4). There were also differences in the likelihood of reporting exposure to *Disinfectants* associated with occupational skill level. Workers in the two lowest occupational skill levels (level four: OR 1.59, 95% CI: 1.19-2.12 and level five: OR 1.66, 95% CI: 1.18-2.34) were more likely to report exposure to *Disinfectants* than the highest skilled workers. Compared to the youngest age group, workers in the 25-34 year old age group (OR 0.57, 95% CI: 0.34-0.97) and workers in the 35-44 year old age group (OR 0.56, 95% CI: 0.41-0.92) were significantly less likely to report exposure to *Disinfectants*.

Cement and lime

The logistic regression model examining self-reported exposure to *Cement and lime* (Table 4) revealed significant differences associated with worker gender. Females were much less likely to report exposure to *Cement and lime* than males (OR 0.04, 95% CI: 0.01-0.10). There were also differences in the likelihood of reporting exposure to this group of chemicals associated with occupational skill level. Workers in Level three (Tradesperson or related work and advanced clerical or service work) (OR 1.94, 95% CI: 1.26-2.99) and Level five (Elementary clerical, sales or service work and labourer or related work) (OR 2.46, 95% CI: 1.50-4.03) were more likely to report exposure to *Cement and lime* than the highest skilled workers. There were also significant differences by workplace size. Workers in workplaces

with five to 19 employees were almost four times more likely to report exposure (OR 3.94, 95% CI: 2.11-7.36) than workers in the largest workplaces. The likelihood of reporting exposure to *Cement and lime* was even further increased for workers in workplaces with less than five employees, with these workers more than five times more likely to report exposure than workers from the largest workplaces (OR 5.19, 95% CI: 2.85-9.48).

Chemical exposure control measures provided in Australian workplaces

Participants in the NHEWS survey who reported any type or level of exposure to chemicals were asked about the control measures that were provided in their workplaces for dermal chemical exposure. Workers who did not report exposure to chemicals were not asked the control measure questions. Therefore, the sample for analysis of the provision of control measures is restricted to n=1676, 37% of the total sample. When considering these results it must be remembered that there may be some underestimation within the presented data of the full scope of chemical control measures utilised in Australian workplaces. For example, there may have been some workers participating in the survey who were employed in workplaces where engineering processes had isolated work systems, thereby greatly reducing potential dermal chemical exposure. Obtaining information about these most effective source-focused controls was outside the scope of the NHEWS survey.

Survey participants who reported exposure to chemicals were asked *“Do you/does your employer do any of the following to prevent health problems caused by exposure to chemical products or substances?”*

- provide gloves
- provide protective clothing
- provide labelling and warning signs
- provide washing facilities
- provide training, or
- nothing.

Workers who reported the provision of gloves were also asked about the type of gloves they normally used.

The percentages of workers, within each industry and overall, who were provided with the various control measures are presented in Table 5 and are discussed by control type below. The percentages of workers who reported they were provided with the controls by other key demographic and employment characteristics are presented in Table 10 (Appendix B).

As for the self-reported chemical exposures, the data on controls were analysed using univariate logistic regression (data not reported). Statistically important factors identified by the univariate models were included in the multivariate logistic regression models. These models described the odds that control measures were provided with respect to employment and demographic factors. Although the models for each of the control measures were run separately, they are presented in one common table (Table 7), with the same factors for ease of comparison. If a factor was statistically significant in a model for one control measure it was retained for all models. Statistically significant associations have been highlighted in bold font in the tables. Model diagnostics (Hosmer-Lemeshow goodness of fit tests) are presented at the bottom of each model. All models included 1250 observations and all models showed acceptable fit.

Table 5. The provision of controls for dermal chemical exposure: the percentage of workers who reported each type of control was provided within industry

Industry	The percentage of workers within industries who reported each of the controls were provided, or that none of the surveyed controls were provided					
	Gloves	Protective clothing	Labelling and warning signs	Washing facilities	Chemical safety training	Nothing provided
Manufacturing	87.3	65.7	77.6	87.7	59.3	4.9
Transport & storage	78.2	65.3	73.4	85.5	61.3	5.7
Construction	73.2	55.3	51.5	68.5	49.8	11.5
Agriculture, forestry & fishing	85.6	70.6	66.9	83.1	61.9	6.9
Health & community services	92.0	67.0	80.53	92.7	75.4	2.9
Wholesale & retail trade	77.2	45.7	65.2	87.0	54.4	4.4
Accommodation, cafes & restaurants	80.4	41.2	66.7	88.2	52.9	3.9
Property & business services	71.2	38.5	57.7	78.9	48.1	3.9
Government administration & defence	76.7	70.0	80.0	93.3	73.3	3.3
Education	67.1	25.6	56.1	81.7	46.3	8.5
Cultural, recreational & personal services	75.6	43.9	53.7	68.3	34.2	9.8
Mining [#]	100	90.9	90.9	100	90.9	0
Finance & insurance [#]	28.6	0	14.3	100	28.6	0
Communication services [#]	100	66.7	66.7	66.7	100	0
Electricity, gas & water supply [#]	87.5	87.5	100	100	87.5	0
Total	82.4	59.6	69.2	84.3	60.9	5.9

[#] Results are indicative only - caution required due to very low denominator size (small numbers of workers who reported chemical exposure)

Gloves

Gloves were a commonly provided control measure among workers participating in the NHEWS survey, with 82% of workers who reported exposure to chemicals also reporting the provision of gloves. There was some variation in the provision of gloves between industries. For example, provision of gloves was as high as 92% of workers in the Health and community services industry, whereas only 73% of workers in the Construction industry reported they were provided with gloves (Table 5 and Table 6). It should be noted that in addition to protecting workers from dermal chemical exposure gloves are routinely used as a method of food contamination prevention and infection control. Therefore, it is possible that some workers may have reported that gloves were provided in their workplace when the gloves were provided for a separate purpose to dermal chemical exposure protection.

Workers were also asked about the type of glove they normally used and this information is provided in Table 6. Many different types of gloves were provided to workers. Some of these are appropriate within specific industries but not others. For example, latex gloves provide protection against infection but are generally considered inappropriate for food handlers since they may be handling food for consumers with latex sensitivity (Lee et al. 2001). The most commonly provided gloves were disposable latex gloves, with 41% of workers who answered the question regarding glove type reporting the use of disposable latex. Consistent

with the fact that latex gloves are effective for infection control, the industry with the highest percentage of workers who reported the provision of disposable latex gloves was Health and community services. Other industries where a high proportion of workers reported the provision of disposable latex gloves were Accommodation, cafes and restaurants and Education. It is not clear whether the use of disposable latex gloves was appropriate in these industries, particularly for workers in the Accommodation, cafes and restaurants industry where the use of latex gloves may be unsafe if food becomes contaminated by latex. Other commonly provided gloves were rubber gloves (29%) and leather gloves (17%). There are recommendations that workers who regularly use occlusive gloves wear cotton gloves underneath their outer gloves to protect their hands against excessive sweating (ASCC 2005). The use of cotton gloves was reported by only 5% of the total sample and was mostly reported by workers in the Manufacturing industry (12% of Manufacturing industry workers).

The logistic regression model that examined the likelihood that gloves were provided as a control measure for dermal chemical exposure showed that there were a number of work and demographic factors associated with the provision of this control (Table 7). Compared to workers in the youngest age group (15- 24 years), workers in the 25-34, 35-44 and 55+ year old age groups were all almost twice as likely to report the provision of gloves as a control measure. Furthermore, compared to workers in workplaces with 200 or more workers, workers in workplaces with less than five employees and those with between five and 19 workers were both approximately 60% less likely to report the provision of gloves as a control measure.

As a personal protective measure, glove use is considered to be a last line of worker protection since it does not reduce the exposure to chemicals at the source and because glove efficacy relies heavily on the behaviour of the worker. Therefore gloves are usually only effective as a component part of a broader protection program which emphasises higher level controls. As previously discussed, use of occlusive gloves for long periods is also itself recognised as a possible risk factor for dermatitis (ASCC 2005; BAuA 2008). Employers must ensure that workers are supplied with appropriate gloves in the workplace and both employers and employees must ensure that the gloves are used correctly.

Protective clothing

The provision of protective clothing was reported by almost 60% of the NHEWS survey participants who reported dermal exposure to chemicals (Table 5). Industries in which high percentages of workers reported the provision of protective clothing included: Mining (91%), Electricity, gas and water supply (87%), and Agriculture, forestry and fishing (71%).

The logistic regression model that examined the provision of protective clothing (Table 7) revealed a number of worker groups that were associated with decreased likelihoods of reporting the provision of protective clothing. Workers were less likely to be provided with protective clothing if they worked in workplaces with fewer than 200 employees. This was most striking in workplaces with between 5 to 19 employees (OR 0.21, 95% CI: 0.14-0.30) and in workplaces with less than five employees (OR 0.23, 95% CI: 0.15-0.37). Furthermore, compared to males, female workers were much less likely to report the provision of protective clothing, as were employees in occupational skill level four (intermediate clerical, sales or service work and intermediate plant operator/transport work) relative to the highest skilled workers. Compared to permanent and fixed term contract employees, casual employees were also less likely to report the provision of protective clothing.

Table 6. Provision of gloves for dermal chemical exposure control: the percentage of workers within industry who reported gloves were provided and the percentages of workers within industry who reported they normally used each glove type

Industry [∞]	The percentage of workers* who said gloves were provided	Type of glove the percentage of workers** within each industry who reported they normally used each type of glove										
		Disposable latex	Rubber gloves	Leather gloves	Surgical latex	Reusable rubber	Disposable vinyl	Cotton gloves	Disposable nitrile	Reusable PVC	Surgical nitrile	Riggers' gloves
Health & community services	92	67	14	1	18	3	2	1	5	0.5	3	0.2
Manufacturing	87	26	36	26	5	9	1	12	6	7	1	5
Agriculture, forestry & fishing	86	23	34	20	3	14	1	5	2	10	1	1
Accommodation, cafes & restaurants	80	56	46	0	5	7	2	2	0	5	0	0
Transport & storage	78	21	32	32	5	6	1	6	4	7	2	6
Wholesale & retail trade	77	44	38	8	1	8	0	1	4	1	1	3
Construction	73	20	33	39	2	15	1	7	1	5	1	4
Education	67	56	33	7	2	4	4	5	4	4	0	0
Mining [#]	100	27	54	45	9	0	0	9	9	0	0	18
Government administration & defence [#]	77	43	22	22	9	9	0	4	4	9	0	0
Cultural, recreational & personal services [#]	76	42	35	3	3	10	0	6	3	0	3	3
Property & business services [#]	71	49	32	16	3	13	3	5	0	3	0	0

∞ Only industries in which 10 or more workers reported that gloves were provided are presented in this table
* The denominator used in this calculation is the number of workers in the industry who reported they were exposed to chemicals
** The denominator used in this calculation is the number of workers in each industry who reported gloves were provided
Results are indicative only - caution required due to low denominator size (small numbers of workers who reported chemical exposure and reported gloves were provided)

Table 7. Results (odds ratios and 95% confidence intervals) of the multivariate logistic regressions examining the provision of dermal exposure controls

MODEL FACTORS	The likelihood (OR) that a worker reported the provision of each of the dermal chemical exposure controls, or that no controls were provided, relative to the reference group (ref) for each factor											
	Gloves		Protective clothing		Labelling and warning signs		Washing facilities		Chemical safety training		No control provision	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Gender												
Male (ref)	1.00	-	1.00	-	1.00	-	1.00	-	1.00	-	1.00	-
Female	1.30	0.92-1.84	0.69	0.53-0.90	0.91	0.68-1.21	1.51	1.04-2.20	1.27	0.97-1.66	0.91	0.50-1.63
Age group												
15-24 years (ref)	1.00	-	1.00	-	1.00	-	1.00	-	1.00	-	1.00	-
25-34 years	1.82	1.02-3.24	1.17	0.73-1.88	0.79	0.47-1.34	0.87	0.45-1.69	0.71	0.44-1.14	1.19	0.39-3.62
35-44 years	1.94	1.12-3.37	1.44	0.91-2.27	0.83	0.50-1.37	0.83	0.44-1.58	0.82	0.52-1.30	1.01	0.34-3.05
45-54 years	1.53	0.90-2.58	1.49	0.95-2.33	0.73	0.45-1.19	0.62	0.34-1.15	0.76	0.48-1.19	1.95	0.71-5.36
55+ years	1.90	1.04-3.48	1.45	0.89-2.37	0.96	0.55-1.66	0.79	0.40-1.58	0.90	0.55-1.48	0.84	0.24-2.90
Occupational skill												
Level 1 (ref)	1.00	-	1.00	-	1.00	-	1.00	-	1.00	-	1.00	-
Level 2	1.64	0.79-3.38	1.22	0.73-2.03	1.78	0.97-3.28	1.43	0.58-3.51	1.87	1.08-3.24	0.44	0.09-2.08
Level 3	1.51	0.90-2.55	1.11	0.74-1.66	1.04	0.67-1.60	0.68	0.38-1.22	1.06	0.72-1.57	0.91	0.36-2.29
Level 4	1.12	0.70-1.77	0.63	0.45-0.91	0.99	0.67-1.45	0.58	0.34-0.99	0.99	0.69-1.41	1.40	0.63-3.10
Level 5 (lowest skill)	1.12	0.68-1.85	0.80	0.54-1.19	0.93	0.61-1.42	0.62	0.35-1.12	1.18	0.79-1.74	1.15	0.48-2.78
Employment arrangement												
Permanent / fixed term (ref)	1.00	-	1.00	-	1.00	-	1.00	-	1.00	-	1.00	-
Casual	0.90	0.59-1.37	0.65	0.47-0.91	0.67	0.47-0.94	0.74	0.48-1.13	0.49	0.35-0.68	0.98	0.48-2.00
Workplace size												
200+ employees (ref)	1.00	-	1.00	-	1.00	-	1.00	-	1.00	-	1.00	-
20-199 employees	0.51	0.31-0.84	0.47	0.33-0.68	0.60	0.40-0.89	0.45	0.25-0.82	0.54	0.38-0.76	2.28	0.84-6.23
5-19 employees	0.36	0.22-0.61	0.21	0.14-0.30	0.33	0.22-0.49	0.27	0.15-0.49	0.30	0.21-0.43	3.71	1.36-10.1
<5 employees	0.38	0.21-0.69	0.23	0.15-0.37	0.24	0.15-0.39	0.19	0.10-0.37	0.29	0.19-0.45	4.76	1.61-14.1
Hosmer-Lemeshow goodness-of-fit	0.6582		0.5847		0.5322		0.1865		0.0944		0.7977	

Labelling and warning signs

Labelling and warning signs are important chemical control measures because they provide workers with information about the hazardous properties of specific chemicals being used in the workplace and/or ways to minimise the risks of exposure. In the context of exposure to chemicals, this includes elements such as signs about the appropriate ways to protect skin, labelling of ingredients contained in products to which workers are exposed as part of their work, as well as warnings about the dangers associated with exposure to specific chemicals.

The provision of labelling and warning signs was reported by almost 70% of the NHEWS survey participants who also reported exposure to chemicals (Table 5). This percentage was higher among workers in industries such as Mining (91%), Health and community services (80%), Government administration and defence (80%) and Manufacturing (78%). Labelling and warning signs were reported by relatively fewer workers in the Construction industry, with only 51% reporting labelling and warning signs provided as a control measure.

The logistic regression model (Table 7) that explored the employment and demographic factors associated with the provision of labelling and warning signs revealed that there were a number of groups of workers who had a decreased likelihood of reporting the provision this control. Compared to the largest workplaces (200 or more employees), smaller workplaces were less likely to provide labelling and warning signs. Workplaces with less than five employees (OR 0.24, 95% CI: 0.15-0.39) and workplaces with between five to 19 employees (OR 0.33, 95% CI: 0.22-0.49) were significantly less likely to report labelling and warning signs. Casual employees were also less likely to report the provision of labelling and warning signs compared to fixed term and permanent employees.

Washing facilities

Overall, nearly 85% of workers who reported exposure to chemicals also reported the provision of washing facilities in their workplaces (Table 5). In some industries, very high percentages of workers reported the provision of washing facilities. For example, 93% of workers in the Health and community services industry and 73% of workers in the Government administration and defence industry reported the provision of this control. In the highly exposed Construction industry, only 68% of workers who reported exposure to chemicals, reported provision of washing facilities.

The logistic regression model that examined the factors affecting the provision of washing facilities (Table 7) found that female workers were significantly more likely to report the provision of washing facilities than male workers. There were also a few worker groups that were associated with decreased likelihood of reporting the provision of washing facilities. These included people in occupational skill level four (Intermediate clerical, sales or service work and intermediate plant operator/transport work) relative to workers of the highest skill level. Furthermore, relative to the largest workplaces, the likelihood that washing facilities were provided decreased with decreasing workplace size. Workers from workplaces with between 20-199 employees were about half as likely to report washing facilities as workers from the largest workplaces, while workers from workplaces with between five and 19 employees were about two thirds less likely to report washing facilities and workers in workplaces with less than five employees were about 80% less likely to report washing facilities.

Training on safe handling of chemicals

Training on the safe handling of chemicals was reported by 61% of NHEWS participants who also reported exposure to chemicals (Table 5). Industries where high percentages of workers reported the provision of training were Health and community services (75%) and Government administration and defence (73%). This contrasts with workers in the Construction industry where, despite high exposure to chemicals such as Cement and lime, the percentage of workers in this industry reporting exposure who reported the provision of training was 50%. Other industries that reported low percentages of self-reported provision

of training included Cultural, recreational and personal services (34%), Finance and insurance (29%) and Education (46%).

The logistic regression model that examined the factors affecting the provision of training (Table 7) revealed that there was only one group of workers associated with increased odds for the provision of training on safe handling of chemicals. Compared to workers in occupational skill level one (Manager and professional), workers in Level two (Technician and associated professional work) were more likely to receive training on safe handling of chemicals. However, there were a number of groups associated with decreased likelihoods of reporting training. Once again this included all workers in workplaces with fewer than 200 employees. Similar to provision of washing facilities, the odds of the provision of training on safe handling of chemicals decreased with decreasing numbers of employees in the workplace. Relative to workers in the largest workplaces (200 or more employees), workers in workplaces with 20-199 workers were about half as likely to report the provision of training on the safe handling of chemicals while workers in workplaces with less than five, or five to 19 employees were more than two thirds less likely. The other group of workers associated with decreased odds of reporting training on the safe handling of chemicals were casual employees. Compared to permanent employees and those on fixed term contracts, casual employees were half as likely to report the provision of training as a control measure for chemical exposure.

No control measures

Overall, only 6% of the 1676 workers in the NHEWS survey who reported some exposure to chemicals reported no control measures at all were provided in their workplaces. However, it is of concern that these workers seem to be overrepresented in specific workplace groups and industries. In the highly exposed Construction industry, 11% of workers who reported exposure to chemicals reported they were provided with no control measures. Percentages were also high in Cultural, recreational and personal services (10%), Education (8%) and in the Agriculture, forestry and fishing (7%) industries.

The logistic regression model (Table 7) that examined the likelihood that workers reported none of the controls were provided shows that compared to workers in workplaces with 200 or more employees, workers in workplaces with fewer than 20 employees were more likely to report no provision of control measures. Specifically, workers in workplaces with between five and 19 employees were almost four times as likely to report no control provision and workers in workplaces with less than five employees were almost five times more likely to report no control provision for chemical exposure. These figures are of even greater concern when considered in relation to the results for chemical exposure showing that workers in small workplaces also have increased odds of reporting exposure to *Cement and lime* (Table 4). Of those reporting exposure to *Cement and lime*, nearly two thirds of workers reporting no control provision were in workplaces with less than five employees and a third were in workplaces with between five to 19 employees (data not shown).

Discussion

The NHEWS study represents a first attempt to obtain information at the Australian national level about the nature and extent of exposure to chemicals used in the workplace. It should be noted that the underlying study sample was not randomly selected and therefore the results for the NHEWS survey cannot be considered as representative of the whole working population. However, because sampling was stratified by industries of particular interest, results within the priority industry groups (Manufacturing, Agriculture, forestry and fishing, Transport and storage, Construction, and Health and community services) may be more representative than results across all industries.

Main findings

1679 or 37% of workers who participated in the NHEWS survey reported exposure to chemicals at work in the week preceding the survey. Overall, a higher percentage of males reported exposure to chemicals than females and more workers in the younger age groups reported exposure to chemicals than older workers. In terms of the average duration of exposure, workers in the Construction industry recorded the longest average exposure of over six hours per week, followed by workers in the Mining, Manufacturing and Agriculture, forestry and fishing industries, where the mean durations of exposure were greater than four hours in each case.

In response to the open-ended question regarding what they were exposed to in the workplace, participants in NHEWS study reported a wide variety of chemicals and substances. The distribution of reported chemical exposures by TOOCS categories indicates that reporting tended to be more by functional groups (and commercial names) than by specific chemicals. This suggests that even among workers who nominated workplace exposures, knowledge of what chemicals they were specifically exposed to may have been limited. The small number and highly variable nature of the specifically nominated chemicals would suggest that there was a small proportion of the respondent group who were highly informed about their chemical exposures.

Reported by over a third of workers, the most commonly nominated group of chemical exposures were *Detergents*. About one in four respondents reported *Disinfectants* (not elsewhere classified) and it should be noted that this category includes only those disinfectants that could not be classified as a solvent or bleach/alkali-based due to insufficient information. Over a quarter of respondents reported exposure to *Organic solvents* and this group included industrial solvents, such as degreasers, as well as thinners for paints and other purposes (other than hydrocarbons). This category also includes alcohol-based disinfectant products, particularly disinfectant hand-cleansers commonly used in health-care workplaces by nursing and other personal care workers. *Bases and alkalis* included mainly bleaches of various types, such as bleach-based disinfectants and cleaning products. Industrial caustic alkali products are also included in the Bases and alkalis group but were reported less commonly than bleaches etc. *Cement and lime* were reported by approximately 10% of respondents. *Paints, varnishes and inks* and related products were reported by over a fifth of respondents. Chemicals in this category ranged from industrial surface coatings/treatments, two-pack automotive paints and wood finishes to artists' paints, reported by teachers as well as artists, and printing inks which were predominantly reported in the context of commercial printing operations. *Non-bituminous hydrocarbon fuels* and associated products were reported by nearly 10% of respondents. This group included auto-mechanical fuels/lubricants as well as metalworking fluids and lubricants. Liquid hydrocarbons, such as turpentine and kerosene, even if used as thinners, were also included in this category.

A range of controls for occupational chemical exposure were provided in workplaces for exposed workers. Chemical control measures information collected by the NHEWS survey included the provision of gloves and protective clothing, the use of labelling and warning

signs, provision of washing facilities and the provision of training on the safe handling of chemicals. Some form of chemical exposure control provision was reported by 94% of NHEWS survey participants. Provision of washing facilities and provision of gloves were the most commonly reported control measures. Training on the safe handling of chemicals was reported by 61% of NHEWS survey participants and was one of the least frequently reported control measures.

Predictors of most commonly reported exposure categories

There were a number of employment and demographic factors that were associated with higher likelihoods of being exposed to the seven most commonly reported types of chemical exposure.

There was a distinctive pattern of exposure to chemicals by worker gender. Female workers were more likely than male workers to report exposure to *Bases and alkalis*, *Detergents* and *Disinfectants*. On the other hand, males were more likely to report exposure to *Non-bituminous hydrocarbon fuels*, *Paints, varnishes and inks*, and *Cement and lime*. The difference between males and females for exposure to *Organic solvents* was not statistically significant. However, there may have been differences by the types of solvents reported. Alcohol hand rubs were commonly utilised by workers in *Health and community services*, an industry that has a large female working population. Male solvent exposures tended to be characterised by more industrial and trades-related solvents.

There were differences by age group for exposure to *Detergents* and *Disinfectants*. When compared to the youngest age group (15-24 years), workers in all older age groups were less likely to report exposure to *Detergents*. Similarly, workers in the 25-34 and the 35-44 year old age groups were less likely to report exposure to *Disinfectants* compared to the youngest age group. These findings may indicate that younger workers are more likely to be employed in cleaning jobs; however, it may also indicate that younger workers in any job may be more likely to be assigned cleaning tasks than older workers. This finding is of interest when considered with the occupational skill level findings, in which lower skilled workers were also more likely to be exposed to *Detergents* and *Disinfectants*. The multivariate models, which adjust simultaneously for all factors, indicated that both age and occupational skill level were both important factors in predicting self-reported *Detergents* and *Disinfectants* exposure. Therefore, young workers in the lowest occupational skill level groups are a population of particular interest in relation to *Detergents* and *Disinfectants* exposure.

Workers in the lowest occupational skill level jobs were also associated with increased likelihood of reporting exposure to *Bases and alkalis* compared to higher-skilled workers. The types of exposures reported by respondents in this category were characterised by bleach-based products, especially cleaners and disinfectant products and other caustic alkali cleaning products such as oven-cleaners. Exposure to *Bases and alkalis* in relation to occupational skill level follows the same pattern as *Detergents* and *Disinfectants* exposure, with increased exposure amongst workers in the lowest occupational skill level groups. However, whilst *Detergents* and *Disinfectants* exposure was associated with the younger age groups, *Bases and alkalis* exposure was not. The *Disinfectants* category represents unspecified disinfectant products for which inadequate detail was provided to classify more specifically.

The likelihood of exposure to *Cement and lime* was also highest for workers in the lowest occupational skill level. The second highest likelihood of exposure to *Cement and lime* was for workers in occupational skill level three (tradesperson or related workers and advanced clerical or service work). This finding is likely to be related to the predominance of construction trades jobs in skill level three and construction-related labourers in level five (elementary clerical, sales or service workers and labourer or related workers). The association of *Cement and lime* with skill levels three and five in this analysis, therefore, can

be largely attributed to the distribution of workers by occupational skill level in *Construction* and related areas.

For *Non-bituminous hydrocarbon fuels*, *Organic solvents* and *Paints, varnishes and inks*, exposure was associated with occupational skill level. For all these exposures, skill level three (tradesperson or related workers and advanced clerical or service workers) was most strongly associated with exposure. Occupational skill level three, as previously mentioned, is characterised by trades occupations; including printers, painters, mechanics, plumbers and building trades. For *Non-bituminous hydrocarbon fuels* and *Organic solvents* there was also increased likelihood of exposure for the lowest occupational skill level group, level five (elementary clerical, sales or service workers and labourer or related workers). This occupational skill level encompasses unskilled labourer jobs, many of which are allied with particular skill level three trades jobs (working as trades labourers) and sharing similar chemical exposures.

Cement and lime exposure was strongly associated with workplaces where there were less than five employees. *Paints, varnishes and inks* exposure was also associated with the smallest workplace size. For the jobs most associated with these exposures, much of their work is site-based rather than workshop based and workplace size may not be clear-cut. The building trades are most obviously and commonly associated with cement use and paint use. Bricklayers, concreters and painters are often organised into small business entities but in many instances these businesses operate as subcontractors on larger building sites. Although the question asked the number of employees in the workplace, respondents in these kinds of jobs may have tended to answer the question in relation to smaller business units with which they were associated, even though their work may have included potentially larger worksites.

Organic solvents exposure was associated with large workplaces with workers in the smallest workplaces significantly less likely to report exposure. This may in part be explained by the abundance of alcohol-based hand sanitisers reported by healthcare workers, especially nurses and carers, who are disproportionately associated with hospitals and other care facilities that are typically larger workplaces. Likewise *Bases and alkalis* exposure tended to be less associated less with smaller workplaces compared with large ones and this may also reflect frequently reported use of bleach-based cleaners in hospitals and other health-care facilities. The healthcare sector was a specific focus of recruitment for the NHEWS survey and so a disproportionate number of healthcare workers in the sample are likely to have had an influence on the results for cleaning and disinfectant products in general.

Factors predicting reported provision of controls

While the provision of controls section was intended to collect data on available control measures for dermal chemical exposure, responses to these questions are mediated by worker awareness and this should be borne in mind when interpreting the results. Certain groups of workers may be more or less aware of certain types of control measures available in their workplaces. For example, workers who are new to the workplace, workers who are highly mobile between employers and workers with highly variable workplaces, either because of inherently changeable environments or because the nature of the work takes them to different, unfamiliar sites, may be less aware of control measures available. Conversely sole-traders and small business owners can be expected to have high awareness. Because the survey question was limited to control measures low on the hierarchy of controls, the particular controls included all require at least some worker engagement for effectiveness so the results are likely to be informative even if highly influenced by worker awareness. For example, if a worker is unaware of chemical labelling and warning signs, they are unlikely to have seen these control measures in the workplace. Non-provision of controls (ie negative associations in the models) or the prevalence estimates for “no control provision” are of particular interest.

There were some groups of workers who were less likely to report the provision of controls. Compared to workers in largest workplaces (200 or more employees), workers in smaller workplaces were less likely to report provision of the range of individual control measures: gloves, protective clothing, labelling and warning signs, washing facilities and training in the safe use of chemicals. The industries in which workers were most likely to report that no controls were provided were Construction and Cultural, recreational and personal services. This is of concern because both of these industries were characterised by high levels of chemical exposure.

As discussed above, training on the safe use of chemicals appears to be an under-utilised control measure. Industries in which workers infrequently reported training provision were Property and business services, Education, Cultural, recreational and personal services and Construction. Exposures in these industries do include significant chemical hazards. Education workers reporting chemical exposures were predominantly science and art teachers and the Cultural, recreational and personal services industry includes beauticians and nail technicians. Lack of training provision in these industries may be of concern.

Compared to workers in permanent or contract positions, workers in casual or temporary positions were less likely to report the provision of labelling and warning signs, protective clothing and training on the safe use of chemicals in the workplace. This may reflect reduced awareness of available controls among a more transitory segment of the workforce. However, casual employees (especially in the Health and community services industry) may also include significant numbers of long-term employees, often working variable hours. Future interventions and further research about the relationships between chemical exposure, casual workers and the provision of control measures is also necessary to better understand this phenomenon in Australian workplaces.

Some of the groups of workers who reported lower provision of controls also reported a higher likelihood of exposure to the most commonly reported chemicals. Workers in workplaces with fewer than five employees were more likely to report exposure to *Paints, varnishes and inks* as well as *Cement and lime*. Of particular concern is the finding that these workers were also almost five times more likely than workers from the largest workplaces to report no provision of controls. The provision of controls in small workplaces and small trades businesses is an important target for policy and further research. Chemical exposures in these contexts may be better managed through increased provision of control measures and the potential benefits for these workers may be substantial.

Strengths and weaknesses

Participants in the NHEWS survey typically reported multiple chemical exposures, but duration of exposure was only asked once and in relation to all chemical exposures. Therefore, it was not possible to examine the duration of exposure to specific chemicals. Duration of exposure is of vital importance for chemical exposure, as the relationship between exposure time and health outcomes differs with specific chemical exposures and particular health outcomes. Future surveys should give consideration to collecting information that better integrates information on specific chemicals worked with and the length of time they are used.

Due to the unstructured nature of the question about specific exposures and the self-reported nature of the data, the data may be subject to some degree of misclassification. However, the classification coding was undertaken by specialist occupational health researchers with wide experience of occupational exposures in different workplaces and also experienced in coding imperfect data. The coders approached the classification task conservatively and systematically and therefore misclassification is likely to be minimal.

Another important consideration with the exposure data is that it may be affected by the recall bias of the individual study participants. This recall bias may also be different with different chemical exposures. Also, it is plausible that particular groups of workers are better

informed about their exposures and therefore better able to describe them accurately and specifically. For example higher skilled workers or workers with more experience or particular technical knowledge may be more knowledgeable about products they use and are exposed to. It was outside the scope of the NHEWS survey to perform objective exposure assessment but some form of validation of the self-reported exposure data to assess its likely accuracy would be highly informative for future surveys, as well as for interpretation of the present dataset.

The number of participants surveyed in the NHEWS study was large and this conveys comparatively high statistical power to detect patterns. The large sample size also enables examination of certain exposures which are particular to small portions of the workforce, particularly in the industries targeted in the stratified sampling strategy. The sampling frame has also captured certain typically hard-to reach workers such as casuals and those in smaller workplaces. Participation of these workers is often under-represented in workplace-based occupational health studies because of the practical difficulties such as gaining access to multiple small businesses.

The semi-stratified sample selection by priority industries is both a strength and a weakness. It limits the generalisability of results to the Australian population, although this is likely less the case for results within the priority industry groups. However, it does potentially enable enhanced insight into the industries which were selectively over-sampled: Manufacturing, Transport and storage, Construction, Health and community services and Agriculture, forestry and fishing.

Policy implications

From the raw verbatim data collected from the NHEWS survey participants, it is evident that a number of workers who reported working in occupations known to have high exposure to chemicals, did not report exposure to these chemicals. As an example, none of the beauticians/nail technicians participating in NHEWS reported exposure to acrylates or solvents. Closer examination of the raw NHEWS data and comparison with objective occupational data from a source such as a Job Exposure Matrix would provide useful information about the extent to which workers in specific contexts have awareness of the chemicals to which they are exposed. Validation of the self-reported exposure data is important for understanding its accuracy and would also provide insight into patterns of exposure reporting among Australian workers.

Training in the safe use of chemicals appears to be under-utilised as a control measure for chemical exposure. Of particular concern are temporary and casual employees who were less likely to be provided with training than permanent or contract employees. Further research in this group with a view to intervention is warranted, particularly given the apparent trend towards increasing casual employment and labour hire.

Targeted policies and education packages are required to guide intervention on exposure to chemicals within specific workplace contexts. Workers in workplaces with fewer employees were more likely to report they were not provided with any controls in their workplaces. These workers were also more likely to report exposure to *Paints, varnishes and inks* and *Cement and lime*. Policy suitable to the context of small businesses, particularly within the Construction industry is urgently required.

Further research

Validation of the NHEWS self-reported data would be a worthwhile avenue of research. A number of methods might be used for this validation including expert assessment of the raw NHEWS data by an experienced occupational hygienist or expert exposure panel, validation by occupation/industry using a Job Exposure Matrix approach or direct observation/measurement in workplaces.

For future NHEWS style surveillance research it is recommended that focussing on specific nominated chemicals in particular contexts or workplace settings of interest might provide the most useful exposure surveillance information.

Small and medium-sized businesses are unique environments that require specifically tailored interventions best developed in collaboration with the small and medium business sector. Future intervention research might focus on the development of tailored interventions, which will be acceptable (and successful) within the small business context. Research investigating in more detail what types of small businesses are likely to provide inadequate controls and the factors that influence control provision and use would also be a useful extension of the NHEWS program since this cannot be discerned from the present survey data and it is unlikely that all small businesses are homogeneous in terms of control provisions as they are variable in terms of chemical exposures.

A number of the industries with high exposures for chemicals were not national priority industries. In future surveys, a larger sample of workers from high risk industries such as Accommodation, cafes and restaurants and Mining would provide a clearer indication of specific groups of workers who may be at risk of exposure to chemicals, thereby providing more complete information for effective policy intervention.

Skin contact with chemicals is one of the main causes of or contributors to occupational contact dermatitis. While this report provides details of workplace settings where dermal exposures to chemicals are high, it does not provide information regarding settings with high rates of diagnosed occupational contact dermatitis, nor does it provide information regarding successful workers' compensation claims for occupationally-induced dermatitis. Previous studies have found large discrepancies between the numbers of workers diagnosed with occupational contact dermatitis and successful workers' compensation claims for occupationally-induced dermatitis (Keegel et al. 2005; Keegel et al. 2007; Rosen & Freeman 1992). Parallel studies to identify industries and workplace settings with elevated rates of diagnosed occupational contact dermatitis and compensated occupational dermatitis disease claims would confirm and extend the NHEWS survey findings. Existing Australian data sources could be used for this purpose. Occupational dermatitis disease outcome data is collected by the NSW and Victorian Skin and Cancer Foundations (Rosen & Freeman 1992; 1993; Williams et al. 2008) and national data regarding successful Australian workers' compensation claims is collated by Safe Work Australia.

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Appendix A. Detailed methodology

Survey design

The purpose of the NHEWS survey was to gather information to guide decision makers in developing prevention initiatives that ultimately lead to a reduction in occupational disease. Therefore, the survey was designed to collect demographic (e.g. sex, age, education level) and employment information (occupation, industry, employment conditions, size of workplace), exposure to a variety of different occupational hazards and information about the hazard controls provided in the workplace. The present report is focused on the skin contact to chemicals/substances.

The design and wording of the survey was undertaken by the Australian Safety and Compensation Council (ASCC) in consultation with Australian work health and safety regulators and a panel of experts. It was based on existing Australian and international hazard exposure survey instruments. These included the:

- European Working Condition Survey,
- National Exposures at Work Survey (NIOSH, USA),
- Swedish Workplace and Environment Survey,
- Victorian WorkCover Authority Worker Survey,
- Danish Work Environment Cohort Study Survey, and
- Working Life in New Zealand Study Survey.

A draft of the survey was reviewed by Dr Rebecca Lilley, Preventative and Social Medicine, Injury Prevention and Research Unit, University of Otago, New Zealand who is an expert on occupational hazard exposure. Comments and feedback from her review were incorporated into the survey instrument.

Skirmish testing (undertaken on ASCC staff) and cognitive testing on eleven workers, who were of a low literacy or non-English speaking background, and worked in several industries, was undertaken in face to face interviews.

The survey was piloted by the Victorian WorkCover Authority on 160 workers using the Computer Assisted Telephone Interview (CATI) technique. This assisted in revising the survey length and correcting CATI programming issues. Feedback from the cognitive and pilot testing was incorporated into the final survey instrument.

The NHEWS research design and survey instrument were submitted to the University of Sydney Human Research Ethics Committee. The approval reference number is: 02-2008/10506. The research design and instrument met the National Statistical Clearing House guidelines. The research design and instrument were also in accordance with the Australian Market and Social Research Society (AMRSRS) guidelines and the research company that undertook the CATI is a member of the AMRSRS and met all privacy and other guidelines.

More information, including the full survey instrument for all occupational hazards and their controls, can be found in the National Hazard Exposure Worker Surveillance (NHEWS): Survey Handbook and the National Hazard Exposure Worker Surveillance (NHEWS) Survey: 2008 Results, which are published on the Safe Work Australia website (<http://www.safeworkaustralia.gov.au/>).

Chemical exposure and control measure questions

The specific questions relating to skin contact to chemicals were as follows:

1. On a typical day at work last week, how long did you work with chemicals such as cement, cleaning products, disinfectants, solvents, resins, paints, pesticides or other chemical substances? (hours per day OR hours per week)
2. What were the main types of chemical products or substances you worked with last week? (open ended responses)
3. Does your employer (or, in the case of self-employed/contractors etc, do you) do any of the following to prevent health problems caused by exposure to chemical products or substances?
 - provide gloves
 - provide protective clothing
 - provide labelling and warning signs
 - provide training, and/or
 - nothing.
4. What kind of gloves do you normally use?
 - Cotton gloves
 - Disposable latex
 - Disposable vinyl
 - Disposable nitrile
 - Leather
 - Surgical latex
 - Surgical nitrile
 - Reusable neoprene
 - Reusable rubber, and
 - Reuseable PVC.

Survey administration

The NHEWS survey was conducted by Sweeney Research Pty Ltd using CATI. The survey obtained an Australia-wide sample of 4500 workers across all 17 Australian industries. Households were randomly selected using the desk top marketing systems (DTMS) database, which collects its information from directories such as the White / Yellow pages. To be eligible for the research, respondents were required to have worked in the last week and to have earned money from the work. Where more than one individual was eligible for the research, the person whose birthday came next was selected. Overall, the survey achieved a 42.3% response rate.

The sampling scheme for the NHEWS can be considered as two stages with three waves of data collection. The first wave resulted in 1900 completed interviews which met quotas by sex within industry (five national priority industries: Manufacturing, Transport and storage, Construction, Health and community services and Agriculture, forestry and fishing) within state (1300 interviews), plus an additional sample coming from state contributions (600 interviews).

The second and third waves of the survey (n total = 2600) placed no restrictions on industry

and differed only in that some additional questions were asked. The second wave involved re-contacting those households that had not been interviewed in the first wave due to being out of scope (e.g. had no persons working in the priority industries) or quotas already being met, and had given permission to be re-contacted for further studies. This wave resulted in 485 completed interviews. The third wave (n=2115) resulted in the balance of the 4500 interviews, meeting sex within state quotas.

For reporting purposes the following industries were collapsed into two integrated industries: 1) Retail and Wholesale trade, and 2) Cultural and recreational services and Personal and other services.

Duration of exposure: On a typical day last week how long did you work with chemicals?

The analysis of the duration of exposure to chemicals/substances was complicated by the way data was collected in the NHEWS survey. Workers were able to report their duration of exposure by day (n=923) or by week (n=735). Conversion of these two scales of measurement to a common scale is complicated by possible differences in the patterns of exposure between those workers who reported daily patterns of exposure and those who reported weekly patterns of exposure.

Hours of exposure per day were converted to hours of exposure per week because it was assumed that reports of daily durations of exposure were more accurate. Conversion of hours per day to hours per week was carried out using the following formula:

$$E_{\text{week}} = E_{\text{day}} * (H_{\text{week}}/8)$$

where E_{week} is the number of hours exposed per week, E_{day} is the number of hours exposed per day and H_{week} is the number of hours worked per week. Dividing H_{week} by eight gives the number of standard eight hour working days worked per week. This calculation assumes that workers have the same exposure every day they work per week, which would appear to be justified given the wording of the question. Dividing by standard eight hour working days gives the data more sensitivity to workers who normally work less than or more than a standard day.

For the figure reporting mean exposure duration by industry, exposure duration was reported by week.

Classification of reported chemical exposures

Chemical exposures reported by participants were coded according to the Type of Occurrence Classification System (TOOCS, version 2.1) (NOHSC 2002), which is the classification system used for agency of injury or illness in the National Data Set (NDS) for compensation-based statistics. Chemical exposures were recorded by the interviewers essentially as reported by the participant over the telephone. The original data contained some apparently abbreviated terms and some phonetic spellings of unusual or specialised terms. Also, all exposures reported by the participant were entered as a single data field. The coding process involved deciphering and interpreting abbreviated and misspelled terms and also separating out multiple exposures – this sometimes meant that the final number of exposure codes assigned to a particular participant was different from the apparent number of exposures which were reported/recorded since some exposures reported were either synonymous or otherwise classifiable under a common TOOCS heading and some reported exposures represented more than one distinct chemical or substance. In the coding process, particularly where the exposures recorded were inadequately described, expert judgement was employed to make coding determinations, informed by the job and industry details recorded. Where expert judgement was applied a conservative approach was taken based on decisions with a high degree of probability based on expert experience and knowledge.

Statistical Analyses

All data were inspected prior to formal analysis for missing cases or unusual values.

The exposure data collected in the NHEWS survey were stratified by variables including gender, categorical age group, occupational level, number of employees in the workplace and industrial sector. Percentages were calculated by group. Categorical variables were compared using chi-squared tests or Fisher's exact test where appropriate. Statistical significance was set at the 0.05 level.

Data was analysed using univariate logistic regression. Significant variables from the univariate models were included in the multiple logistic regression models. These models described the odds of reporting skin exposure to chemicals/substances with respect to employment and demographic factors, by each of the seven chemical exposures. Models for each of the chemical exposure variables were run separately, however the models are presented in two common tables, with the same included categories for ease of comparison. If a variable was significant in a model for one chemical exposure it was retained for all models. For example, although the number of employees at a workplace was a significant variable for *Paints, varnishes and inks*, it was not significant for *Non-bituminous hydrocarbon fuels*, but it is included in the final model for *Non-bituminous hydrocarbon fuels*. Variables were removed sequentially from the models until the most parsimonious model (across all the chemical exposure variables) was obtained.

This approach was also used to present the descriptive data for provision of workplace controls and to estimate the odds of exposed workers being provided with particular types of control measures against chemical/substance exposure.

Odds ratios and 95% confidence intervals are reported for the multivariate models. Model fit was assessed using Hosmer-Lemeshow tests; all models presented had acceptable test statistics (>0.20).

All analyses were completed using the STATA 11 statistical programme (Stata Corporation, College Station, TX).

The data presented in this report are unweighted and therefore are only representative of the survey sample. Unless otherwise stated, the data presented in this report relate to those respondents who reported skin exposure to chemicals/substances.

Appendix B. Results Tables

Table 8. The percentage of workers who reported exposure to each type of chemical

Type of chemical worker reported exposure to	Percentage of exposed workers (n=1679) who reported exposure to type of chemical
Detergents	34.1
Organic solvents <i>Includes: thinners, acetates, degreasers-solvent based</i>	27.6
Disinfectants	20.6
Bases and alkalis <i>Includes: caustic soda, caustic potash, sodium hydroxide</i>	11.9
Paints, varnishes and inks <i>Includes: water or oil-based paints, acrylic paints, vehicle paints, inks, printing inks, rust and conversion treatments</i>	11.1
Cement and lime (in powder form)	10.5
Non-bituminous hydrocarbon fuels <i>Includes: petrol, diesel, kerosene, aviation fuel, turpentine, paraffin, toluene, kerosene, LPG, lubricating oils</i>	9.9
Wet concrete (just poured or just mixed)	9.2
Other chemical products <i>Includes: glue, dyes</i>	4.7
Acids <i>Includes: battery acid, spirits of salt, hydrofluoric acid and hydrofluoric acid products</i>	4.3
Plant treatment chemicals <i>Includes: fungicides, weedkillers, fertilisers, crop sprays, insecticides, defoliant</i>	4.1
Plastic materials, synthetic resins and rubbers <i>Includes: polyurethanes, foam plastic, PVC piping, guttering</i>	3.0
Animal treatment chemicals <i>Includes: insecticides, animal dips and drenches, pesticides, rat poisons, snail bait, fly sprays, fumigants</i>	2.9
Pharmaceuticals <i>Includes: cosmetics, creams, medicines, drugs</i>	1.4
Abrasive powders <i>Includes: grain, grit, jewellers' rouge</i>	1.3
Other basic and unspecified chemicals <i>Includes: carbon dioxide in the form of dry ice</i>	1.1
Chlorine	1.0
Other nominated chemicals <i>Includes: cadmium, MOCA: 4,4'-methylene bis (2-chloroaniline), acrylonitrile, thallium, vinyl chloride, polycyclic aromatic hydrocarbons (PAH), pentachlorophenol</i>	1.0
Bricks, tiles and concrete, cement and clay products <i>Includes: ceramic, clay, cement or concrete bricks, paving blocks, pipes, granite panels, tiles and precast concrete products stressed or unstressed, with or without reinforcement, railway sleepers (concrete)</i>	0.7
Bitumen, asphalt, tar, pitch <i>Includes: coke production products, coal production products, creosote</i>	0.5

Type of chemical worker reported exposure to	Percentage of exposed workers (n=1679) who reported exposure to type of chemical
<i>production products</i>	
Dust, not elsewhere classified <i>Includes: sand, soil, ash, mud and scale</i>	0.3
Oil and fat (animal or vegetable) <i>Includes: salad oil, cooking oil</i>	0.3
Ferrous and non-ferrous metal <i>Includes: ingot, bar, rod, pipe, rail, beam, tube, die, mould, girders, roofing iron, tinplate, sheet metal, aluminium roofing, cladding, molten metal</i>	0.3
Lead and lead compounds	0.2
Stock feed <i>Includes: grain, processed stock feed</i>	0.2
Arsenic and arsenic compounds	0.1
Benzene	0.1
Radioactive materials <i>Includes: radium, thorium, uranium, plutonium, pitchblende, radioactive isotopes</i>	0.1
Manufactured explosive substances <i>Includes: gunpowder, fireworks, ammunition, percussion caps, material manufactured for the purpose</i>	0.1
Rocks, stones, boulders	0.1
Food <i>Includes: spilt hot food, frozen food, where a source of contamination (eg food poisoning), where a source of choking</i>	0.1
Other substances <i>Includes: rubbish and garbage, potting mix</i>	0.1
Mercury and mercury compounds	0.1
Cyanide and cyanide compounds	0.1
Chromium and chromium compounds	0.1
Industrial gases, fumes <i>Includes: argon, nitrogen, acetylene, oxygen, carbon dioxide</i>	0.1
Diesel exhaust fumes	0.1
Crystalline silica <i>Includes: quartz, cristobalite, tridymite</i>	0.1
Sawn or dressed timber <i>Includes: sawn or dressed timber, plywood, particle board, chipboard, planks, beams, scantling, wooden railway sleepers, firewood, posts (not in situ)</i>	0.1
Other minerals and objects <i>Includes: coins, cloth, rag, duster, stock (unspecified)</i>	0.1
Beverages <i>Includes: spilt hot drink, where a source of contamination</i>	0.1

Table 9. Exposure to the most commonly reported chemical categories by worker demographic and workplace characteristics*

Employment and demographic characteristics	The percentage of workers who reported exposure to each of the main types of chemical exposure						
	Bases and alkalis	Non-bituminous hydrocarbon fuels	Paints, varnishes & ink	Organic solvents	Detergents	Disinfectants	Cement & lime
Sex n=4500							
Male	2.66	6.04	6.12	11.41	8.95	3.18	6.84
Female	6.65	0.76	1.66	8.92	17.48	13.40	0.20
Age group n=4464							
15-24 years	6.00	3.60	5.60	10.80	22.00	10.00	6.80
25-34 years	5.26	4.78	5.90	11.32	13.72	6.86	4.78
35-44 years	4.44	4.09	4.09	11.23	12.88	6.53	4.44
45-54 years	4.51	3.35	3.42	9.23	10.81	7.87	3.49
55+ years	3.38	3.28	3.89	10.14	12.09	8.40	2.66
Occupational skill level n=4392							
Level one (highest)	2.21	1.37	2.93	7.43	8.08	6.91	2.35
Level two	5.54	2.02	1.26	10.08	14.11	8.06	1.26
Level three	3.94	9.73	11.70	20.94	8.37	2.83	8.99
Level four	5.35	3.29	1.60	6.10	16.90	11.17	2.16
Level five (lowest)	8.75	3.77	3.77	11.49	22.98	10.63	6.35
Employment Arrangement n=3627							
Permanent / fixed term	4.36	3.68	3.74	11.16	12.36	7.32	2.39
Temporary / casual	6.63	2.84	4.17	9.28	19.32	12.12	3.03
Workplace size n=4472							
< 5 employees	3.79	4.71	6.35	9.42	10.85	6.55	8.70
5 to 19 employees	4.92	4.29	4.60	10.88	15.59	9.00	5.65
20 to 199 employees	3.70	3.17	3.57	9.92	12.63	7.41	1.46
200+ employees	5.36	3.02	2.43	10.81	11.59	8.08	1.27
* The total sample size (N) is 4500. Due to incomplete responses, not all survey respondents could be included in all sub-analyses, hence some sub-analyses have denominators (n) less than 4500							

Table 10 Chemical exposure controls provided in the workplace by worker demographic and workplace characteristics*

Employment and demographic characteristics	The percentage of workers who reported each of the chemical exposure controls was provided or that said none of the controls were provided					
	Gloves	Protective clothing	Labelling & warning signs	Washing facilities	Chemical safety training	Nothing provided
Sex n=1676						
Male	80.25	61.92	67.14	81.06	57.93	6.86
Female	85.41	56.22	71.96	88.7	64.95	4.43
Age group n=1661						
15-24 years	74.62	47.69	71.54	84.62	60	6.15
25-34 years	85.45	58.21	71.64	85.07	58.58	4.85
35-44 years	83.25	60.14	68.63	83.02	60.14	5.66
45-54 years	83.27	62.7	68.95	83.47	62.5	6.45
55+ years	81.05	60.06	67.35	86.01	62.1	5.83
Occupational skill level n=1650						
Level one (highest)	85.27	66.27	72.68	90.26	65.32	4.28
Level two	84.73	62.6	74.81	89.31	69.47	5.34
Level three	78.7	62.27	65.51	78.47	54.86	6.71
Level four	83.65	52.55	69.71	84.45	60.32	5.9
Level five (lowest)	80.89	52.56	64.85	80.55	59.39	7.17
Employment Arrangement n=1297						
Permanent / fixed term	85.65	64.63	76.57	87.96	67.78	4.35
Temporary / casual	81.11	46.08	64.06	81.57	48.85	5.53
Workplace size n=1663						
< 5 employees	91.11	79.68	85.4	94.6	79.05	1.9
5 to 19 employees	85.54	65.58	78	88.59	67.62	4.07
20 to 199 employees	80.34	45.7	64.62	81.33	53.56	7.13
200+ employees	74.44	51.78	52.22	74.44	47.33	9.56
* The total sample size for this analysis (N=1676) is the number of workers who reported any type of chemical exposure. Due to incomplete responses, not all survey respondents could be included in all sub-analyses; hence some sub-analyses have denominators (n) less than 1676.						