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## Isocyanates in Australia: current exposure to an old hazard

Exposure to isocyanates has consistently been reported as the most common cause of occupational asthma. The objectives of this study were to assess how many Australian workers are currently exposed to isocyanates, identify the occupations with highest proportion of exposed workers and identify the main circumstances of exposures. Data comes from the Australian Workplace Exposure Study-Asthma, a national telephone survey which explored the prevalence of current occupational exposure to 227 asthmagens, grouped into 27 groups, among current Australian workers aged 18-65 years. A web-based tool, OccIDEAS, was used to collect job task information and to assign exposure to asthmagens, including isocyanates. Of the 4,878 eligible participants, 2.5% of them were deemed to be probably exposed to isocyanates at work in their current job (extrapolated to 3.0% of the Australian working population). The majority of those exposed were males (90.8%). The most common tasks undertaken that led to these exposures were using expanding foam fillers/sprays and isocyanate and/or polyurethane paints. Exposure occurred mainly among construction workers, wood workers and painters or printers. This study investigating occupational exposure to isocyanates in a national working population provides information that can be used to inform the direction of occupational interventions and policies to decrease occupational asthma.

## INTRODUCTION

Exposure to isocyanates and increased risk of occupational asthma was first described in the 1950s<sup>(1)</sup>. Exposure to isocyanates has consistently been reported as the most common cause of occupational asthma in industrialized countries<sup>(2)</sup>. In Australia, an occupational respiratory surveillance scheme conducted between 1997-2001 reported that isocyanates accounted for 5.8% of reported occupational asthma diagnoses<sup>(3)</sup>.

Isocyanates are used in a broad range of manufacturing processes and products that are used in domestic and industrial settings<sup>(4)</sup>. The most common forms of isocyanates are hexamethylene diisocyanates (HDI), isophorone diisocyanate (IPDI), toluene diisocyanate (TDI), and methylene diphenyl diisocyanate (MDI), which are mostly used to produce paints, coating, flexible foams and rigid foams, respectively<sup>(5)</sup>. In a large proportion of product formulations many diisocyanate monomers have been replaced by their oligomers, which have lower vapour pressure to reduce inhalation exposure<sup>(6)</sup>. The 8 hour occupational exposure limit for isocyanates in Australia should not exceed 0.02 mg/m<sup>3</sup><sup>(7)</sup>.

Workers are exposed to isocyanates across a range of industries, including the adhesive, automotive, mining, chemicals and plastics industries, and among carpenters and joiners, foundry workers, mechanics, metallurgists and painters. Motor vehicle repair body shop paint sprayers were at the greatest risk of occupational asthma from isocyanate exposure in the UK<sup>(8)</sup>. However, there is evidence from international studies that the proportion of workers exposed to isocyanates has decreased over time and a similar decrease in the incidence and prevalence rates of associated occupational asthma has been observed<sup>(9-11)</sup>. For instance, a decline in both urinary isocyanate biomarkers as well as cases of asthma between 2006-2014 has been reported among motor vehicle repairers in the UK suggesting a decline in exposure to isocyanates among a traditional high-use group<sup>(10)</sup>. Furthermore, the average annual number of cases of occupational asthma attributed to isocyanate exposure and diagnosed by chest

physicians in the UK decreased from 66 per annum (p.a.) between 1998-2000 to 16 p.a. between 2013-2015<sup>(11)</sup>. This decrease followed a concerted campaign by the Health and Safety Executive to identify and publicise effective spray painting control measures<sup>(8)</sup>.

Given the long-term and widespread knowledge about the health hazard associated with exposure to this substance, we aimed to assess how many Australian workers are currently exposed to isocyanates, identify the occupations with the highest proportion of exposed workers and identify the main tasks they are undertaking that lead to this exposure.

## **METHODS**

The analysis presented here used data from the Australian Workplace Exposure Study - Asthma (AWES-Asthma)<sup>(12)</sup>, which was conducted between June 2014 to November 2014. Briefly, AWES-Asthma was a national telephone survey of Australian workers aged 18–64 years that investigated the current prevalence and exposure circumstances for 277 workplace asthmagens, assembled into 27 groups. Isocyanates was one of these groups. Using the web-based tool OccIDEAS<sup>(13)</sup>, 52 job-specific modules (JSMs), asked a series of questions about the specific tasks performed in the participant's current job.. Of these modules, 27 JSMs contained questions related to specific tasks, which may have exposed workers to isocyanates (Supplemental Table S1). Based on the responses to these questions, participants were classified as non-exposed or probably exposed to isocyanates.

Using the self-reported job titles, each participant's job was coded according to the Australian and New Zealand Standard Classification of Occupations (ANZSCO)<sup>(14)</sup> and then categorised into one of 24 occupational groups determined to have a relatively similar likelihood of exposure to the 27 asthmagens studied.

We used raked weighting to adjust for the statistically significant difference between our sample and the labour force population to estimate how many workers in Australia are currently exposed to isocyanates<sup>(15)</sup>. Our data structure was made similar to the national labour

force population in terms of age, remoteness, and manager/other occupation (for males only). The raked data were then extrapolated to the 2011 Census <sup>(16)</sup>. All analyses were performed using Stata 14.

## **RESULTS**

Of the 4,878 eligible participants, 120 (2.5%) were identified, as probably exposed to isocyanates. Few females were probably exposed to isocyanates (90.8% of those exposed were men). Extrapolating to the whole Australian working population we estimate that 0.3% (95% confidence intervals (CI) 0.1-0.5) of female workers and 5.7% (95% CI 4.5-7.3) of male workers are probably exposed to isocyanates in their job, or 3.0% (95% CI 2.4-3.8) of workers, overall. This is equivalent to around 284, 500 Australian workers.

Occupational groups with the highest proportions of probably exposed workers were painters or printers (34.7%), wood workers (24.4%) and construction workers (17.7%) (Table 1).

The most common tasks associated with exposure were using expanding foam filler/spray (60.0%) and using isocyanate/polyurethane paints (22.2%). Other tasks associated with exposure included using sealers that contained isocyanates (11.1%), handling or coming in contact with roof bolting resins (3.4%), making or working with polyurethane plastic (1.7%), using 2 pack fillers that contain isocyanates (1.7%), and working with polyurethane foam (0.9%) (Data not shown).

Among the 26 workers who reported applying isocyanate/polyurethane paints using spray guns, 57.7% of them reported that they were in a booth while spraying.

### **(Table I)**

## **DISCUSSION**

To our knowledge, this is the first study that has estimated the national prevalence of exposure to isocyanates among all workers. Despite a reduction in isocyanate use which has been

documented worldwide <sup>(10, 11)</sup>, we estimated that 3% of all Australian workers are probably exposed to isocyanates at work in their current job. The most common tasks undertaken that led to these exposures were using expanding foam fillers/sprays and isocyanate and/or polyurethane paints. Exposure occurred mainly among construction workers, wood workers and painters or printers.

The jobs that incurred the highest probability of handling isocyanates in the past continue to incur the highest probability of exposure in the present. These include motor vehicle spray painters and powder coaters, foam manufacturers and furniture and cabinet makers <sup>(7)</sup>. Workplaces with the greatest risk of exposure include those where isocyanates are mixed with a resin and then sprayed to form an insulating foam; those where TDI is mixed with resins to manufacture foam; and where two part polyurethane paints are sprayed <sup>(17)</sup>. Efforts to reduce the incidence of isocyanate-induced asthma should concentrate on ensuring effective control measures in these jobs. For spray painters, these controls would include the use of spray booths (and observance of spray booth clearance times) <sup>(8)</sup>, local exhaust ventilation, or dilution ventilation, supplemented by the use of personal protective equipment. The use of unheated less volatile isocyanates such as MDI rather than TDI should be recommended where possible <sup>(18)</sup>. In addition, workers should be advised to shift from using volatile monomers to non-volatile oligomers, as these have been shown to reduce inhalation exposure<sup>(6)</sup>.

This study has some general limitations and strengths which have been previously described, including non-response and self-report data <sup>(12)</sup>. With regard to isocyanates, we did not assess exposure levels, but there are reports in the literature suggesting that occupational asthma is associated with concentrations of MDI well below the occupational exposure limits <sup>(19)</sup>. Strengths of this study include the use of a task-based assessment of exposure and the examination of exposure in jobs across the community rather than in high-risk industries alone.

In conclusion, this study indicates that there are still a considerable number of workers in Australia who are probably currently exposed to isocyanates through different tasks and occupations, which may, in turn, increase their risk for occupational asthma.

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Table I: Occupations of exposed workers (number and per cent) and proportion of workers within each occupational group who were exposed to isocyanates, AWES-Asthma, 2014

<b>Occupational groups</b>	<b>Total N<sup>a</sup></b>	<b>Number exposed and %<sup>b</sup></b>	<b>Proportion exposed within each occupational group%<sup>c</sup></b>
Painting/printing	49	17 (14.5)	34.7
Wood workers	78	19 (16.2)	24.4
Construction workers	186	33 (28.2)	17.7
Mining	27	4 (3.3)	14.8
Electric/electronic	75	8 (6.7)	10.7
Metal workers	84	8 (6.7)	9.5
Technical/engineering	77	6 (5.0)	7.8
Other (NOS)	34	2 (1.7)	5.9
Manufacturing	86	5 (4.2)	5.8
Gardening	79	4 (3.3)	5.1
Farming/animal worker	238	6 (5.0)	2.5
Mechanical	65	1 (0.8)	1.5
Education	431	4 (3.3)	0.9
Retail	348	2 (1.7)	0.6
Manager/Administration	2,000	1 (0.8)	0.1

<sup>a</sup> Number of respondents in each occupational group.

<sup>b</sup> Number and percentage of exposed respondents in each occupational group. The percentage was estimated by dividing the number of exposed respondents in each occupational group by the total number of the exposed respondents.

<sup>c</sup> Proportion of exposed respondents within each occupational group was estimated by dividing the number of exposed respondents in a given occupation by the total number of respondents within that occupation.