

## **The Australian Work Exposures Study: Prevalence of occupational exposure to formaldehyde**

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## **ABSTRACT**

### **Introduction**

The aims of this study were to produce a population-based estimate of the prevalence of work-related exposure to formaldehyde, to identify the main circumstances of exposure, and to describe the use of workplace control measures designed to decrease those exposures.

### **Methods**

The analysis used data from the Australian Workplace Exposures Study, a nationwide telephone survey which investigated the current prevalence and exposure circumstances of work-related exposure to 38 known or suspected carcinogens, including formaldehyde, among Australian workers aged 18 to 65 years. Using the web-based tool OccIDEAS, semi-quantitative information was collected about exposures in the current job held by the respondent. Questions were addressed primarily at tasks undertaken rather than about self-reported exposures.

### **Results**

124 (2.5%) of the 4,993 included respondents were identified as probably being exposed to formaldehyde in the course of their work (extrapolated to 2.6% of the Australian working population – 265,000 (95% confidence interval 221,000 – 316,000) workers). Most (87.1%) were male. About half worked in technical and trades occupations. In terms of industry, about half worked in the construction industry. The main circumstances of exposure were working with particle board or plywood typically through carpentry work, building maintenance or sanding prior to painting; with the more common of other exposures circumstances being fire fighters involved in fighting fires, fire overhaul and clean-up or back-burning; and health workers using formaldehyde when sterilizing equipment or in a pathology laboratory setting. The use of control measures was inconsistent.

### **Conclusion**

Workers are exposed to formaldehyde in many different occupational circumstances. Information on the exposure circumstances can be used to support decisions on appropriate priorities for intervention and control of occupational exposure to formaldehyde, and estimates of burden of cancer arising from occupational exposure to formaldehyde.

Keywords: cross-sectional study; population prevalence; workers

Word count: 1,944

## INTRODUCTION

Formaldehyde is considered carcinogenic to humans and is classified by the International Agency for Research on Cancer (IARC) as a known human carcinogen (Group 1) (International Agency for Research on Cancer 2012, 2006). Other organisations have classified formaldehyde similarly to IARC (National Toxicology Program 2011). The carcinogenicity classification of formaldehyde is based on strong evidence that it causes cancer of the naso-pharynx and (myeloid) leukaemia in humans, with strong suggestion of a link also with sino-nasal cancer. The main non-carcinogenic health effects of formaldehyde are direct irritation of the eyes and mucous membranes of the respiratory tract, and skin irritation and sensitisation (National Industrial Chemicals Notification and Assessment Scheme (NICNAS) 2006).

Very low level exposure to formaldehyde is almost ubiquitous due to the presence of formaldehyde in the environment as a result of natural processes. IARC identifies three main sources of exposure above background - during production of formaldehyde solutions, during the manufacture and use of products containing formaldehyde (particularly formaldehyde-containing resins), and through the burning of products containing formaldehyde (International Agency for Research on Cancer 2006). Occupational exposure can occur in a wide variety of circumstances, most notably in various types of manufacturing such as formaldehyde manufacture and the manufacture of formaldehyde-based resins, plastics manufacture, manufacture of composite wood such as particle board and plywood, furniture production, and textile manufacture. Other exposure circumstances include fire fighting, embalming, carpentry, and pathology laboratory work (International Agency for Research on Cancer 2012, 2006; National Toxicology Program 2011). There is no nationally representative or comprehensive information about the nature of this exposure in Australia and limited data about exposures at a population level elsewhere (CAREX Canada 2012; Finnish Institute of Occupational Health 1998; Peters et al. 2015). Information on the nature of exposure to formaldehyde would help inform current workplace chemicals policy development activities.

The aims of this study were to produce a population-based estimate of the prevalence of work-related exposure to formaldehyde, to identify the main circumstances of exposure, and to describe the current use of workplace control measures designed to decrease those exposures.

## **METHODS**

The analysis presented in this report used data from the Australian Workplace Exposures Study (AWES) (Carey et al. 2014). The methods are described in detail elsewhere (Carey et al. 2014; Driscoll et al. 2015) and are summarised here. The AWES was a nationwide telephone survey which investigated the current prevalence and exposure circumstances of work-related exposure to 38 known or suspected carcinogens, including formaldehyde, among Australian workers aged 18 to 65 years. Using the web-based tool OccIDEAS (Fritschi et al. 2009), semi-quantitative information was collected about exposures in the current job held by the respondent. Questions were addressed primarily at tasks undertaken rather than self-reported exposures. The data and 2011 Census data (Australian Bureau of Statistics 2011) were also used to estimate the number of Australian workers currently exposed to formaldehyde in the course of their work, stratified by gender and conducted separately by occupational group. All statistical analyses were conducted using SAS version 9.3 and Excel. Confidence intervals for proportions were also calculated using an on-line tool (Lowry 2013).

## **RESULTS**

One hundred and twenty four (2.5%) of the 4,993 respondents included in the analysis were assessed as having probable exposure to formaldehyde - 108 males (3.9% of all males) and 16 females (0.7% of all females in the sample), with males comprising 87.1% of the exposed persons. Another 40 respondents had possible exposure (these are not considered further in this analysis - examples included teaching woodwork, police officers working in emergency response to hazardous chemicals and persons working in a veterinary surgery). The level of exposure was deemed to be high for six (4.8%), medium for 73 (58.9%) and low for 45 (36.3%). Just over half (67: 54.0%) of the exposed respondents worked in technical and trades occupations, with 25 (20.2%) working as community and personal service workers and 19 (15.3%) as managers. Occupations with the highest proportion of respondents exposed were technicians and trades workers (8.0%) and labourers (5.8%) - this was observed both overall and for males (Table 1). Specific occupation groups with considerable numbers of exposed workers were carpenters, fire fighters, painters and plumbers (Table 2).

INSERT TABLE 1 ABOUT HERE

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Construction was the industry of employment of about half the exposed respondents (53.2%), with health care and social assistance (12.1%), public administration and safety (10.5%) and manufacturing (9.7%) the next highest-represented industries. Industries with the highest proportion of respondents exposed were public administration and safety (18.6%), construction (11.9%), trade (8.0%) and manufacturing (7.6%). The industries with the highest prevalence of exposure were similar when men alone were considered, except that for men health care and social assistance was the fourth highest industry and trade had a low proportion of exposed workers (Table 3).

INSERT TABLE 3 ABOUT HERE

About 265,000 Australian workers, or 2.6% of the workforce, were estimated to probably be exposed to formaldehyde when undertaking work activities. The estimated exposure occurs predominantly in men. Approximately 235,000 men or 4.4% of the male workforce and approximately 30,000 women or 0.6% of the female workforce are estimated to be exposed.

#### Circumstances of exposure

The assessed formaldehyde exposure occurred in a variety of circumstances. Overall, the main exposure circumstance was working with particle board or plywood typically through carpentry work, building maintenance or sanding prior to painting (68: 55%). Other common exposure circumstances were fire fighters involved in fighting fires, fire overhaul and clean-up or back-burning (21: 17%); health workers using formaldehyde when sterilizing equipment or in a pathology laboratory setting (11: 9%) and painters sanding particle board (10: 8%) (Table 4).

INSERT TABLE 4 ABOUT HERE

#### The use of ventilation systems and respiratory protection equipment

The use of appropriate exposure controls by workers potentially exposed to formaldehyde was inconsistent. These controls would usually include using effective local exhaust ventilation and/or half face respirators. Overall, 59% of the exposed respondents for whom information was available on controls either used personal protective equipment regularly or worked where area or local exhaust ventilation was in place. Taking into account that 17 respondents used only a half-face paper dust mask that is unlikely to have provided effective protection against

formaldehyde exposure, this means that about 39% of the workers probably exposed to formaldehyde appeared to use appropriate respiratory controls while working.

Fifty-two respondents reported using power tools (usually sanding or cutting) while working with particle board or plywood in their role as carpenters. Of these, 17 (33%) reported usually using a simple half face paper dust mask, seven (13%) used ventilation (apparently mainly local exhaust ventilation), 14 (27%) used both the half-face paper dust mask and ventilation and 14 (27%) reported not using any form of respiratory protection in the workplace. Of the ten painters who reported sanding particle board or plywood, seven (70%) said they usually used a powered sander and only two reported using a respirator whilst sanding. Two of the three timber mill workers exposed to sawn plywood reported that a ventilation system was fitted to the machine closest to them.

Taking into account all fire-fighting activities (front-line fire-fighting, fire overhaul and clean-up, or back-burning), nine fire fighters (43%) always or usually used breathing apparatus while undertaking fire fighting activities and 12 fire fighters (57%) never or only sometimes used breathing apparatus, with particularly low use of breathing apparatus during back-burning.

Information on the use of personal protective equipment or ventilation was not available for respondents exposed to formaldehyde in other circumstances.

## **DISCUSSION**

This study estimated that approximately 2.6% of the Australian workforce (265,000 workers) is likely to be exposed to formaldehyde when performing work activities. Particularly common activities that entailed probable exposure were working with particle board or plywood, fire fighting, and; health workers using formaldehyde when sterilizing equipment or in pathology laboratories.

Many of the industries with higher exposure prevalence in the current study (agriculture, forestry and fishing; public administration and safety; and accommodation and food services; and mining) were similar to those found in the CAREX study for Western Europe in the early 1990s (manufacturing, construction and mining) (Finnish Institute of Occupational Health 1998) and the more recent CAREX Canada study (wood product manufacturing, sawmills and wood preservation and hospitals) (CAREX Canada 2012). The exposure prevalence of 2.6% seen in this study was much higher than the 0.7% exposure prevalence estimation determined by

CAREX and the estimate of about 1% in 2012 by CAREX Canada. The most likely reasons for these differences are considered in more detail elsewhere (Driscoll et al. 2015), but they are probably related to differences in the methods used in the studies and in particular lower levels of exposure or a lower required probability of exposure than those used in the other studies. The level of exposure in the AWES project was based on exposure whilst undertaking the relevant task(s). The AWES data does provide some qualitative information on exposure level, but frequency of activity was not taken into account in these determinations, and duration only to a limited extent. Therefore AWES data address the level of exposure during an activity rather than attempting to provide an assessment of full time-weighted average exposures. The methods used in the AWES project suggest the study is likely to provide a nationally representative estimate of exposure.

Exposure to formaldehyde when working with particle board appears to come from a combination of formaldehyde released by the glues and resins used to bind the wood, release of formaldehyde from wood dust that comes into contact with biological surfaces, and possibly direct contact with resin binder containing formaldehyde. Newer glues and resins release less formaldehyde. Some release still occurs, although quantitative estimates come largely from the manufacturing sector or from simulated laboratory studies rather than from carpentry work in the field (Australian Safety and Compensation Council 2008; Lavoué, Gerin, and Vincent 2011; Lavoué, Vincent, and Gerin 2008; Mount Sinai Selikoff Centers for Occupational Health 2015; National Industrial Chemicals Notification and Assessment Scheme (NICNAS) 2006).

The available data on the use of control measures in circumstances that entailed probable exposure to formaldehyde suggested this use was inconsistent. Overall, about 60% of the exposed respondents for whom information was available on the use of controls used personal protective equipment or worked where ventilation was in place. A little less than half of the respondents appeared to use formaldehyde-appropriate respiratory protection while working. Using power tools on particle board or similar wooden products was found to be the most common form of exposure to formaldehyde and most respondents exposed in that manner reported usually using some form of respiratory exposure control measures. However, a half-face paper dust mask is unlikely to be fully effective against formaldehyde, but would be intended to reduce exposure to wood dust when using power tools while working with particle board and plywood. About 40% of fire fighters reported always or usually using breathing apparatus where appropriate while working, meaning that about 60% were commonly not protected for some of their tasks.

The methodological limitations and strengths of the study are also considered in more detail elsewhere (Driscoll et al. 2015) and included non-response, self-report data, limitations on the amount of detailed data and the qualitative nature of the assessments. Strengths of the approach include that it was task-focused and provided nationally representative information. The main implications of the study are that occupational exposure to formaldehyde is not rare, that many occupational tasks potentially involve non-trivial exposure to formaldehyde and that the use of exposure controls by exposed workers was inconsistent.

## **CONCLUSIONS**

This study provides the first population-based estimate of occupational exposure to formaldehyde in Australia and is one of few internationally to provide an estimate based on the nature and extent of reported tasks rather than self-reported exposure to specific agents. A variety of different occupational circumstances involves exposure to formaldehyde. This information, and information on the circumstances of exposure, including the use of personal protective equipment, can be used to support decisions on appropriate priorities for intervention and control of occupational exposures, and estimates of burden of cancer arising from occupational exposure to formaldehyde.

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**Table 1: Occupation of all probably formaldehyde-exposed respondents (number and per cent) and proportion of respondents in each occupation who were probably exposed to formaldehyde (males, females and persons – per cent) - by exposure level (per cent)**

Occupation	Probably exposed respondents		Proportion probably exposed <sup>a</sup>			Exposure level			Total
	Number <sup>b</sup>	% <sup>c</sup>	Males % <sup>d</sup>	Females % <sup>e</sup>	Persons % <sup>f</sup>	High % <sup>g</sup>	Medium % <sup>g</sup>	Low % <sup>g</sup>	
Professionals	10	8.1	-	0.8	0.6	20.0	70.0	10.0	100
Technicians and trades workers	67	54.0	10.4	4.8	9.7	-	74.6	25.4	100
Community and personal service workers	25	20.2	17.4	1.5	6.5	36.0	16.0	48.0	100
Labourers	19	15.3	7.8	-	5.4	5.3	15.8	78.9	100
Other <sup>h</sup>	3	2.4	-	-	-	-	100.0	0	100
<b>Total</b>	<b>124</b>	<b>100.0</b>	<b>3.9</b>	<b>0.7</b>	<b>2.5</b>	<b>9.7</b>	<b>54.0</b>	<b>36.3</b>	<b>100</b>

a: Percentages not provided if there were less than three subjects in the category.

b: Number of respondents who had probable exposure to formaldehyde.

c: Proportion of exposed respondents who were in each occupation group.

d: Proportion of all male respondents in each occupation group who had probable exposure to formaldehyde (female results not shown as the number of exposed respondents was too low).

e: Proportion of all female respondents in each occupation group who had probable exposure to formaldehyde.

f: Proportion of all respondents in each occupation group who had probable exposure to formaldehyde.

g: Percentage of persons exposed in the given exposure circumstance who were exposed at this exposure level.

h: There was at least one person from the manager and machinery operator and driver occupation categories. Numbers and percentages for these are not shown because there were less than three persons in the category. There were no exposed persons from other occupation categories not shown.

**Table 2: Exposure level and main activities resulting in exposure to formaldehyde – by specific occupation (per cent)**

Occupation <sup>a</sup>	N	Exposure level			Total %	Main activities resulting in exposure
		High % <sup>b</sup>	Medium % <sup>b</sup>	Low % <sup>b</sup>		
Carpenter	51	-	98.0	2.0	100	Using power tools with particle board
Fire fighter	21	28.6	19.0	52.4	100	Fire fighting and clean up
Painter	10	-	-	100	100	Sanding particle board
Plumber	9	-	22.2	77.8	100	Working with particle board

a: This table does not include all exposed respondents. Respondents could have been exposed through more than one activity.

b: Percentage of persons exposed in the given exposure circumstance who were exposed at this exposure level.

**Table 3: Industry of all formaldehyde-exposed respondents (number and per cent) and proportion of respondents in each industry who were exposed to formaldehyde (males, females and persons – per cent) - by exposure level (per cent)**

Industry	Probably exposed respondents		Proportion probably exposed <sup>a</sup>			Exposure level			
	Number <sup>b</sup>	% <sup>c</sup>	Male % <sup>d</sup>	Female % <sup>e</sup>	Persons % <sup>f</sup>	High % <sup>g</sup>	Medium % <sup>g</sup>	Low % <sup>g</sup>	Total
Manufacturing	12	9.7	8.5	-	7.6	-	83.3	16.7	100
Construction	66	53.2	12.4	-	11.9	-	65.2	34.8	100
Trade (wholesale and retail)	7	5.6	-	18.8	8.0	-	14.3	85.7	100
Professional, scientific and technical services	4	3.2	3.4	-	2.0	50.0	25.0	25.0	100
Public administration and safety	13	10.5	24.5	-	18.6	30.8	23.1	46.2	100
Health care and social assistance	15	12.1	5.6	3.0	3.7	33.3	40.0	26.7	100
Other <sup>h</sup>	7	5.6	-	-	-	14.3	42.9	42.9	100
<b>Total</b>	<b>124</b>	<b>100.0</b>	<b>3.9</b>	<b>0.7</b>	<b>2.5</b>	<b>9.7</b>	<b>54.0</b>	<b>36.3</b>	<b>100</b>

a: Percentages not provided if there were less than three subjects in the category.

b: Number of respondents who had probable exposure to formaldehyde.

c: Proportion of exposed respondents who were in each industry group.

d: Proportion of all male respondents in each industry group who had probable exposure to formaldehyde.

e: Proportion of all female respondents in each industry group who had probable exposure to formaldehyde.

f: Proportion of all respondents in each industry group who had probable exposure to formaldehyde.

g: Percentage of persons exposed in the given exposure circumstance who were exposed at this exposure level.

h: There was at least one person from each of the agriculture, forestry and fishing; mining; accommodation and food services; transport, postal and warehousing; and education and training industry categories. Percentages for these are not shown because there were less than three persons in each category. There were no exposed persons from other industry categories not shown.

**Table 4: Main circumstances resulting in probable exposure to formaldehyde**

Exposure circumstance <sup>a</sup>	Exposed persons	Exposure level				Exposed persons
	N	High % <sup>b</sup>	Medium % <sup>b</sup>	Low % <sup>b</sup>	Total %	% <sup>c</sup>
Working with particle board	68	-	76.5	23.5	100	54.8
Fire fighting	21	-	57.1	42.9	100	20.2
Fire overhaul and clean-up	18	-	38.9	61.1	100	14.5
Sanding (as painter)	10	-	-	100.0	100	8.1
Sterilizing	7	71.4	28.6	-	100	5.6
Manicure	5	-	-	100.0	100	4.0
Work in pathology lab	4	-	100.0	-	100	3.2

a: This table does not include all exposed respondents. Respondents could have been exposed through more than one activity.

b: Percentage of persons exposed in the given exposure circumstance who were exposed at this exposure level..

c: Percentage of all exposed persons included in the study who were exposed in the given exposure circumstance.

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