

ORIGINAL ARTICLE

Prevalence of occupational exposure to asthmagens derived from animals, fish and/or shellfish among Australian workers

Sonia El-Zaemey,¹ Renee N Carey,¹ Ellie Darcey,¹ Alison Reid,¹
 Deborah Catherine Glass,² Geza P Benke,² Tim R Driscoll,³ Susan Peters,⁴ Si Si,¹
 Michael J Abramson,² Lin Fritsch¹

¹School of Public Health, Curtin University, Perth, Western Australia, Australia

²School of Public Health & Preventive Medicine, Monash Centre for Occupational and Environmental Health, Monash University, Melbourne, Victoria, Australia

³Sydney School of Public Health, University of Sydney, New South Wales, Australia

⁴School of Population Health, The University of Western Australia, Perth, Western Australia, Australia

Correspondence to

Dr Sonia El-Zaemey, School of Public Health, Curtin University, Bentley, Western Australia 6102, Australia;
sonia.el-zaemey@curtin.edu.au

Received 31 March 2017
 Revised 26 October 2017
 Accepted 9 November 2017

ABSTRACT

Objective Several animal, fish and/or shellfish derived substances encountered in the workplace can initiate or exacerbate asthma. The aims of this study were: to produce a population-based estimate of the current prevalence of occupational exposure to animal, fish and/or shellfish derived asthmagens, to identify the main circumstances of exposures and to identify occupations with the highest proportions of exposed respondents.

Methods We used data from the Australian Work Exposure Study-Asthma, a national telephone survey that investigated the current prevalence of occupational exposure to asthmagens among Australian workers. A web-based tool was used to collect job task information and assign exposure to asthmagens, including animal, fish and/or shellfish derived asthmagens. Prevalence ratios to determine risk factors for exposure were estimated using modified Poisson regression.

Results Of the 4878 respondents, 12.4% were exposed to asthmagens derived from animals, fish and/or shellfish. Exposure to these asthmagens was significantly higher in workers residing in regional and remote areas, compared with major cities. The main circumstance of exposure to animal derived asthmagens was through cleaning up rat/mice infestations, while the main circumstance of exposure to fish and/or shellfish derived asthmagens was through preparing and cooking salmon. Occupational groups with the highest proportion of exposure to animal or fish and/or shellfish derived asthmagens were farmers/animal workers and food workers, respectively.

Conclusions This is the first study investigating occupational exposure to animal, fish and/or shellfish derived asthmagens in a nationwide working population. The results of this study can be used to inform the direction of occupational interventions and policies to reduce work-related asthma.

INTRODUCTION

Animals, fish and shellfish are used as food for humans and other animals, for products such as wool, enzymes, leathers, hormones and fertilisers, and as substitutes for humans in laboratory studies. Close contact with specific animals, fish, shellfish or their products in the workplace is a well recognised cause of asthma among workers.¹ Occupational asthma has been reported in previous research among many workers including those processing

What this paper adds

- ▶ There is limited information on how many of the current workers are exposed to asthmagens derived from animals or fish and/or shellfish and what tasks they are undertaking that leads to their exposure.
- ▶ We found that exposure to asthmagens derived from animals or fish and/or shellfish is common in a range of occupations and occurs through different tasks.
- ▶ Interventions should focus on workers in the farming, food preparation and education occupations because these occupations represented most of the exposed workers. Interventions should take into account the different tasks undertaken that result in exposure, meaning that a 'one size fits all' strategy may not be effective.

trout² and salmon,³ farmers, laboratory animal workers, veterinary technicians, and fish and crustacean processors.⁴

The prevalence of occupational asthma varies between occupations. For example, studies have found the prevalence of occupational asthma among seafood workers is estimated to be between 2% and 36%,⁵ whereas the prevalence of occupational asthma among laboratory animal workers is approximately 20%.⁶ Exposure to asthmagens derived from animals, fish or shellfish can induce an allergic IgE response in susceptible individuals and cause occupational asthma by an IgE-mediated mechanism.^{7,8} The asthmagens in animals are usually present in hair, dander, saliva, serum and urine, while for fish/shellfish, the allergens are usually present in the aerosols generated during fish/shellfish processing.^{1,9,10} For example, Mus m1¹¹ and tropomyosin⁵ are major allergens in mice and crustaceans, respectively.

Controlling occupational exposures to asthmagens derived from animals, fish and/or shellfish species can be difficult and may require a range of solutions because of the variety of tasks and working environments where exposures might occur. Prevention or minimisation of occupational exposures to animals, fish, shellfish and their



CrossMark

To cite: El-Zaemey S, Carey RN, Darcey E, et al. *Occup Environ Med* Published Online First: [please include Day/Month/Year]. doi:10.1136/oemed-2017-104459

Workplace

derived asthmagens should reduce the incidence and prevalence of occupational asthma. Hence, a better understanding of the extent of exposure and the main exposure circumstances allows for the application of specific control measures that can effectively minimise exposure.

Limited data exist regarding the prevalence of exposure to asthmagens derived from animals, fish and/or shellfish using population based data, including Australia, with most of the studies focusing on exposure in specific industries, including the seafood industry.¹² Furthermore, asthmagens derived from animals, fish and/or shellfish tend to be under-recognised compared with other well known asthmagens such as flour and latex. We conducted the Australian Work Exposures Study (AWES)–Asthma in 2014 to investigate the prevalence of work-related exposure to asthmagens, reported elsewhere.¹³ The current study uses these data to explore in more detail exposure to asthmagens derived from animals, fish and/or shellfish. Specifically, this study will produce a population-based estimate of the prevalence of work-related exposure to asthmagens derived from animals, fish and/or shellfish, identify the main circumstances of exposure and identify the occupations with the highest proportion of respondents exposed. This information was not reported in the previous publication.

METHODS

AWES–Asthma was a cross-sectional telephone survey to investigate the prevalence of work-related exposure to 27 groups of asthmagens,^{13 14} including asthmagens derived from animals, fish and/or shellfish, among the Australian working population in 2014. The data collection for AWES–Asthma has been described in more detail previously.¹³

In brief, Australian residents aged between 18 years and 64 years who were currently employed, and able to complete a telephone interview were eligible to participate. Of 6314 eligible people who were contacted, 4996 interviews were completed, reflecting a cooperation rate (completed interviews/eligible households) of 79%. One hundred and eighteen respondents were excluded due to missing job history information, resulting in data from 4878 respondents for analyses. Compared with the Australian working population, respondents were similar regarding sex, country of birth (Australia vs other), education and socioeconomic status of residence. However, our sample under-represented younger workers (18–34 years), and those living in major cities as well as manager/administration workers among men.

Data from respondents were collected by trained interviewers using computer-assisted telephone interviews after verbal informed consent was provided. Demographic information including age, gender, highest education level completed and country of birth were collected. We derived socioeconomic status (according to the Socio-Economic Indexes for Areas disadvantage score) and remoteness of residence¹⁵ (according to the Accessibility/Remoteness Index of Australia) from the respondent's residential postcode.¹⁶

Occupational information about the current job held by the respondent was also obtained. When the respondent's occupation fell into one of seven predetermined job categories not considered exposed to any of the 27 asthmagen groups (eg, office and clerical workers, customer service workers) no further questions were asked. Otherwise, the interviewer obtained more information (including job title, industry type, the number of hours worked per week and weeks worked per year) and based on this information the interviewer then assigned one of 52

job-specific modules (JSMs). The JSMs were part of OccIDEAS, a web-based tool which manages interviews and the exposure assessment process.¹⁷ Each JSM contained questions about specific occupational tasks, which had been identified as potential determinants of exposure to one or more of the asthmagen groups.

The questions in the JSMs sought information regarding exposure to 12 asthmagens belonging to the fish/shellfish group and to 13 asthmagens belonging to the animal group. The asthmagens that were included in the fish/shellfish group were: *Anisakis simplex* (herring worm), clam, crab, cuttlefish, fish feed, nacre dust, octopus, prawn, red soft coral, soft coral, salmon, shrimp meal and trout. Asthmagens that were included in the animal group were: bat guano, bovine serum albumin, casein, cat, chicken, cow dander, frog, guinea pig antigens, lactoserum, mice, pig, rabbit antigens and rat antigens.¹⁴

Automatic assessment on the likelihood of exposure (either 'no' or 'possible' or 'probable') to these asthmagens was provided by OccIDEAS using predetermined rules developed on the basis of expert opinion. These rules were based on occupational hygienists' practical experience of workplace exposures and available exposure measures in the literature. For the automatic assessment of 'possible' exposures, the project staff and an occupational hygienist reviewed the context of the job and the free text answers in order to categorise the 'possible' exposures into either 'probable' or 'no' exposure.

Eleven of the 52 JSMs (animal worker, baker, butcher, chef/cook, farmer, food processing, food retail, hospitality, lab worker/chemist, teaching, shipping/fishing) contained questions related to exposure to fish/shellfish derived asthmagens. Questions related to exposure to animal derived asthmagens were included in 22 JSMs (animal worker, baker, butcher, construction, chef/cook, farmer, electrician, food processing, food retail, hospitality, shipping/fishing, teaching, carpenter/cabinet maker, cleaner, forestry/timber mill, gardener/groundskeeper, janitor, pesticide user, plumber, railway, sewage worker, rubbish tip worker).

Information on how the air in the workplace was ventilated was collected by all JSMs except for driver, textiles, police, shipping and fishing JSMs. Additionally, information on the use of respiratory protective equipment (RPE) when doing the job was collected in all JSMs except for the driver, florist, food retail and textile worker JSMs.

Each of the respondent's job titles was coded according to the Australian and New Zealand Standard Classification of Occupations.¹⁸ These codes were then categorised into 24 occupational groups, containing occupations, which were broadly similar with regard to the relevant tasks undertaken. Two members of the team independently grouped the occupations and any differences between the two members were then resolved by discussion.

A dichotomous measure of exposed or not exposed to any of the asthmagens derived from animals, fish and/or shellfish was used for the main analysis. Modified Poisson regression models incorporating the robust sandwich variance estimator were used to estimate the prevalence ratio (PR) and 95% CI to identify which demographic variables were associated with exposure. This model was used, rather than a logistic regression model because PR was considered a better measure of risk than an OR, which may overestimate effect size.^{19 20} The proportion of respondents within a given occupation who were exposed to asthmagens derived from animals or fish/shellfish was estimated by dividing the number of exposed respondents by the number of respondents within that occupation. Prevalence of exposure was extrapolated to the Australian working population with

Table 1 Adjusted prevalence ratios and 95% CIs for associations between demographic characteristics and exposure to animal or fish and/or shellfish derived asthmagens in current job

Demographic characteristics	N	Asthmagens derived from animals, fish and/or shellfish	
		Exposed (n=604) (%)	Adjusted prevalence ratio *
Age (in years)			
18–34	528	63 (11.9)	1
35–50	2165	253 (11.7)	0.94 (0.75–1.70)
51–64	2185	288 (13.8)	0.88 (0.70–1.10)
			P-trend=0.18
Gender			
Men	2441	354 (14.5)	1
Women	2437	250 (10.3)	1.08 (0.93–1.25)
Country of birth			
Australia	3850	526 (13.7)	1
Other	1028	78 (7.6)	0.89 (0.73–1.09)
Highest education level			
Bachelor degree	528	181 (10.6)	1
Trade certificate or diploma	2165	205 (14.6)	1.20 (0.93–1.30)
High school or less	2185	218 (12.3)	0.90 (0.75–1.06)
			P-trend=0.10
Socioeconomic status (SES) [†]			
Fifth quintile (highest)	1079	94 (8.7)	1
Fourth	998	118 (11.8)	1.10 (0.89–1.36)
Third	1042	130 (12.5)	0.98 (0.79–1.22)
Second	1026	158 (15.4)	1.10 (0.90–1.35)
First quintile (lowest)	722	98 (13.6)	0.99 (0.78–1.25)
			P-trend=0.97
Remoteness [‡]			
Major city	2448	186 (7.6)	1
Inner regional	1878	302 (16.1)	1.28 (1.09–1.52)
Outer regional/remote/very remote	552	116 (21.1)	1.24 (1.01–1.54)
			P-trend=0.02

*Adjusted for all variables in the model including occupational groups.

[†] From Socio-Economic Index for Areas Index of Relative Socio-economic Disadvantage (SEIFA IRSD)[‡] From Australian Standard Geographical Classification Accessibility/Remoteness Index of Australia (ARIA+)

reference to the 2011 census¹⁶ to provide an overall estimate of how many workers in Australia were exposed to asthmagens derived from animals or fish/shellfish. We weighted our sample by age group, remoteness and manager/other occupation (for men only) when extrapolating our numbers to better represent the Australian population. These extrapolations were stratified by gender. All analyses were performed using Stata V.14 (StataCorp, College Station, Texas, USA).²¹

RESULTS

Characteristics of participants

Of the 4878 respondents included in the analyses, 12.4% were estimated to be exposed to asthmagens derived from animals, fish and/or shellfish. The prevalence of exposure did not vary across age group, gender, country of birth, education level or socioeconomic status. However, exposure to these asthmagens was significantly higher in workers residing in regional and remote areas compared with major cities (table 1).

Among the 546 workers who were exposed to asthmagens derived from animals, the occupational groups with the highest number of exposed subjects were farmers and animal workers, education workers and construction workers (table 2). Occupational groups with the highest proportion of respondents exposed were farmers and animal workers (74.8%), electric and electronic workers (52.0%), and construction workers (33.3%). These proportions varied by gender. For example, more male than female cleaners were exposed, while more female than male education workers were exposed.

Among workers who were considered exposed to asthmagens derived from animals, the main exposure circumstances were through cleaning up rat or mice infestations (39.7%), coming into contact with livestock (37.9%), and entering the roof or crawl spaces of existing buildings (20.5%). Among these workers, 71.4%, 19.2% and 9.4% were exposed to animal-derived asthmagens by one, two and three or more circumstances, respectively (table 3).

Contact with livestock was mostly reported by farmers and animal workers (n=138) and education workers (n=55). Cleaning up mice or rodent infestations was common among farmers and animal workers (n=94), education workers (n=45) and cleaners (n=19). Entering roof or crawl spaces of existing buildings was common among construction workers (n=62) and electric and electronic workers (n=39).

Among the 100 workers who were exposed to asthmagens derived from fish and/or shellfish, the occupational groups with the highest number of exposed subjects were food preparation workers, followed by education workers and carers (table 2). Occupational groups with the highest proportion of respondents exposed were: food preparation workers (26.0%), followed by education workers (8.8%), carers (4.8%) and food service workers (5.0%). The proportion of workers exposed within occupational groups varied by gender. For example, more female than male education workers were exposed, while more male than female food service workers were exposed.

Among workers who were considered exposed to asthmagens derived from fish and/or shellfish, the most common exposure circumstances were preparing (beheading, degutting, slicing, filleting, mincing) and cooking salmon (35.0%), handling fish feed (34.0%) and boiling or steaming shellfish (23.0%). Among these workers, 30.4%, 23.9% and 45.7% were exposed to fish and/or shellfish derived asthmagens by one, two, three or more circumstances, respectively (table 3).

Preparation and cooking of salmon were mainly reported by food preparation workers (n=25) and education workers (n=6). While handling or coming in contact with fish feed was mainly reported by education workers (n=27) and carers (n=5).

Of the 600 workers who were exposed to animals, fish and/or shellfish asthmagens and where information about air ventilation systems in the workplace was available, 192 (32.0%) workers reported that they worked inside with no special ventilation and 311 (51.8%) workers worked outside (table 4).

Among the 590 workers who were considered exposed to animals or fish and/or shellfish asthmagens and were asked about the use of RPE when doing their job, 45.4% (n=268) of them reported wearing RPE. Two hundred and seven workers reported using a simple dust mask (35.1%), 73 used a chemical cartridge respirator (12.4%), 25 used an air-supplied respirator (4.2%) and 22 used other types of respiratory protection (3.7%).

Workplace

Table 2 Occupations of exposed respondents (number and per cent) and proportion of respondents in each occupation who were exposed to asthmagens derived from animals or fish/shellfish

Occupational groups	Total N*	Asthmagens derived from animals				Asthmagens derived from fish/shellfish			
		Number exposed (n=546) (%)†	Proportion exposed in job (%)‡	Proportion of men exposed	Proportion of women exposed	Number exposed (n=100) (%)†	Proportion exposed in job (%)‡	Proportion of men exposed	Proportion of women exposed
Carers	124	15 (2.7)	12.1	—	13.9	6 (6.0)	4.8	6.3	4.6
Cleaning	107	19 (3.5)	17.8	25.0	14.1	—	—	—	—
Construction	186	62 (11.4)	33.3	33.5	—	—	0	—	—
Education	431	129 (23.6)	29.9	20.5	32.4	38 (38.0)	8.8	5.7	9.6
Electric/electronic	75	39 (7.1)	52.0	52.0	—	—	—	—	—
Farming/animal worker	238	178 (32.6)	74.8	74.0	78.3	5 (5.0)	2.1	1.7	3.3
Food preparation	150	12 (2.2)	8.0	8.9	7.0	39 (39.0)	26.0	26.6	25.4
Food service	60	4 (0.7)	6.7	5.6	7.1	3 (3.0)	5.0	11.1	2.4
Gardening	79	15 (2.7)	19.0	19.4	17.6	—	—	—	—
Manager/administration	2000	6 (1.1)	0.3	0.5	0.2	2 (2.0)	0.1	0.11	0.09
Manufacturing	86	9 (1.6)	10.5	12.5	4.5	1 (1.0)	1.2	1.6	—
Mechanical workers	65	1 (0.2)	1.5	1.6	—	—	—	—	—
Metal workers	84	2 (0.4)	2.4	2.4	—	—	—	—	—
Nurse/medical	272	3 (0.5)	1.1	—	1.3	—	—	—	—
Other (NOS)	34	6 (1.1)	17.6	26.1	—	—	—	—	—
Retail	348	6 (1.1)	17.2	1.4	2.0	3 (3.0)	0.9	—	1.5
Technical/engineering	77	22 (4.0)	28.6	24.3	32.5	3 (3.0)	3.9	5.4	2.5
Transport	184	3 (0.5)	1.6	1.8	—	—	—	—	—
Woodworkers	78	15 (2.7)	19.2	18.4	50.0	—	—	—	—

*Number of respondents in each occupational group.

†Number and per cent of respondents in each occupational group who were exposed.

‡Proportion of all respondents (and by gender) in each occupational group who had exposure.

The prevalence of exposure to asthmagens derived from animals and fish/shellfish in the Australian workforce

When extrapolated to the Australian working population in 2011, 11.5% (95% CI 10.3% to 12.8%) of Australian workers were estimated to be exposed to asthmagens derived from animals, fish and/or shellfish. While it was estimated that 9.7% (95% CI 8.7% to 10.8%) and 2.3% (95% CI 1.6% to 3.0%) of Australian workers are exposed to asthmagens derived from animals and fish/shellfish in the workplace, respectively. The proportion exposed to asthmagens derived from animals among male workers was 13.0% (95% CI 11.3% to 15.0%), whereas among

the female workforce the proportion was 6.4% (95% CI 5.3% to 7.6%). The proportion exposed to asthmagens derived from fish/shellfish among male workers was 2.3% (95% CI 1.5% to 3.3%), whereas among the female workforce the proportion was 2.4% (95% CI 1.6% to 3.5%). In total, approximately 918 000 and 219 000 Australian workers are estimated to be exposed to asthmagens derived from animals and fish/shellfish, respectively.

DISCUSSION

We investigated the current prevalence of occupational exposure to animal, fish and/or shellfish derived asthmagens among

Table 3 Main activities resulting in exposure to asthmagens derived from animals or fish/shellfish

Asthmagens derived from animals n=546		Asthmagens derived from fish/shellfish n=100	
Exposure circumstance	N (%)		N (%)
Cleaning up rat or mice infestations	217 (39.7)	Beheading, degutting, slicing, filleting, mincing, cooking salmon	35 (35.0)
Coming in contact with livestock*	207 (37.9)	Handling and coming into contact with fish feed	34 (34.0)
Entering roof or crawl spaces of existing buildings	112 (20.5)	Cleaning, beheading, peeling, deveining, grinding prawns	31 (31.0)
Contact with chickens	103 (18.9)	Boil or steam shellfish	23 (23.0)
Contact with cats	51 (9.3)	Heading, degutting, slicing, filleting, mincing, cooking trout	11 (11.0)
Handling or coming into contact with mice or rats	43 (7.9)	Bagging up fish meal	11 (11.0)
Contact with frogs	37 (6.8)	Cleaning, cracking, butchering or degilling of crabs	10 (10.0)
Make or process cheese	10 (1.8)	Production of fish meal	15 (15.0)
Bovine serum albumin	9 (1.5)	Working with molluscs	12 (12.0)
Handling or coming in contact with casein	6 (1.1)	Grinding fish meal	7 (7.0)
Contact with bats	3 (0.5)	Feeding animals with fish meal	5 (5.0)
Contact with feathers	2 (0.4)		
Handle or come in contact with cattle hides	1 (0.2)		

Respondents could have been exposed through more than one activity.

*Livestock include: pigs, cattle, rabbits, guinea pigs.

Table 4 Ventilation in the workplace (n=600) and the use of respiratory protective equipment (n=590) among workers who were exposed to animals or fish/shellfish derived asthmagens

	N	%
Ventilation type*		
Worked outside	311	51.8
Open doors or windows	306	51.0
Worked inside with no special ventilation	192	32.0
Wall or ceiling fan	141	23.5
Local exhaust ventilation or fume hood	69	11.5
Fan in the window or doorway	35	5.8
Work was done in a specially ventilated room or booth	21	3.5
Process or system was complete enclosed	18	3.0
Respiratory protective equipment type *		
Used any RPE	268	45.4
Simple dust mask	207	35.1
Chemical cartridge respirator	73	12.4
Air-supplied respirator	25	4.2
Others	22	3.7

*Please note that respondents were allowed multiple answers for this question.
RPE, respiratory protective equipment.

Australian workers. It was estimated that 11.5% of Australian workers are likely to be exposed to asthmagens derived from animals, fish and/or shellfish in the workplace. Exposure to animal, fish and/or shellfish derived asthmagens was more common among subjects residing in regional and remote areas compared with major cities. The main exposure circumstance for animal derived asthmagens was through cleaning up rat or mice infestations. For fish/shellfish derived asthmagens, the main exposure circumstance was through preparing and cooking salmon.

In our study, we found that 12% of respondents were exposed to asthmagens derived from animal or fish and/or shellfish. We are unaware of studies that have estimated the population prevalence of exposure to these asthmagens, specifically. However, the National Hazard Exposure Worker Surveillance (NHEWS) survey conducted in 2008 by Safe Work Australia,²² found that 12% of workers were exposed to live animals including cattle, sheep, poultry, fish and invertebrates, and their urine and faeces. Despite the similarity in the estimated prevalence, the NHEWS survey had a different sampling frame, exposure assessment methodology and different exposure questions. The current study included a cross section of workers across all industries, while NHEWS targeted specific priority industries for inclusion. Furthermore, the NHEWS Survey asked workers expressly about their exposure to live animals, which was different to the list of agents included in the animal, fish and/or shellfish group in our study. For example, NHEWS examined exposure to sheep specifically, while our study did not. Hence, our study probably gives a better prevalence of exposure to asthmagens derived from animal or fish and/or shellfish than do previous studies.

When we extrapolated our findings to the 2011 working population data, we found Australian male workers (13.0%) were more likely to be exposed to asthmagens derived from animals than Australian female workers (6.4%). However, this finding was not surprising, given that in developed countries, women work in different occupations and industries from men. For example, women are more likely to work in health and education, as service and sales workers, and clerks, while men are more likely to work in the agricultural, trades and manufacturing sectors.²³ Furthermore, the observed differences could be

due to the fact that men and women with the same occupation do not always carry out the same tasks. A number of studies have reported that men and women with the same occupation carry out different tasks.^{24 25} However, we did not find a difference in prevalence by gender for fish/shellfish derived asthmagens.

After adjusting for various demographic and occupational factors, we found workers living in outer regional/remote or very remote areas had a higher prevalence of exposure to asthmagens derived from animal, fish and/or shellfish than workers living in major cities. A possible explanation for this is that work that involves handling animals (eg, farming) is more likely to be done in remote areas and workers are likely to live near their workplace. Exposure to animal, fish and/or shellfish derived asthmagens did not differ by education level or country of birth, which is similar to other studies that examined exposure to other agents.²⁶

Our study showed cleaning up rodent infested areas was the main circumstance of exposure to asthmagens derived from animals, which was mainly reported by farmers/animal and education workers. Rodent infestations can occur in a wide range of workplaces such as farms, schools, hospitals, retail stores and restaurants,²⁷ placing workers at risk of exposure to rodent allergens. Infested areas are usually covered with dander, hair, saliva, urine and serum of the rodents, which are the sources of the allergens.²⁸ These allergens can become aerosolised during cleaning, which allows them to enter into the respiratory tract and lungs of the worker. Inhaling rodent allergens has been shown to be a major risk factor for asthma.¹⁰

The second most common circumstance of exposure to animal derived asthmagens was through handling and coming into contact with livestock, which was mainly reported by farmers and animal workers. Working with livestock was one of the main tasks usually reported by farmers and animal workers.^{29 30} Frequent exposure to livestock carries a risk of sensitisation to their allergens, which may lead to the development of allergic diseases including asthma. The main sources of allergens in livestock are the skin dander, urine, fur, hair and serum.^{28 31}

In this study, exposure to fish and/or shellfish derived asthmagens mainly resulted from beheading, degutting, slicing, filleting and mincing, as well as cooking salmon, which was mostly reported by food preparation workers. These activities result in the production of particulate aerosols containing allergens. Inhalation of such aerosols is a potential route for sensitisation and the development of asthma.^{5 32} Previous studies have shown that those who work in food preparation are exposed to several seafood allergens including allergens from handling salmon.³² An association between occupational asthma and exposure to allergens from handling and processing seafood including salmon has previously been reported.^{1 33}

Education and construction workers had the second and third highest proportions of exposure to animal derived asthmagens, respectively, after farmers and animal workers. Many of the education workers in our study reported that they handle and come in contact with animals or pets and that they clean up rodent infestations, while the construction workers reported entering roof and crawl spaces of buildings where small pests are present (eg, rats, mice). Exposure to fish/shellfish asthmagens were mostly reported by education workers and carers, after food preparation workers. This is because many of the education workers and carers reported that they handle, come in contact with or cook fish/shellfish.

Exposure to asthmagens derived from animals are well known to be common among laboratory and research lab workers.¹¹ However, in this study, laboratory and research lab workers who

Workplace

work with animals were included in the occupational group entitled 'technical/engineering', and in this group the overall prevalence of exposure to asthmagens derived from animals was low (4%). The low prevalence observed is due to the fact that laboratory workers who work with animals did not comprise a significant proportion in the technical/engineering occupational group.

Health risks posed by exposure to asthmagens derived from animals, fish and shellfish and the methods of preventing exposure should be well understood by employers and workers. However, the use of RPE and working in ventilated workplaces in this study was generally low. There is an opportunity to reduce and prevent work-related exposure to these asthmagens by such methods as improving ventilation, using mechanisation or automated equipment, better organisation of work, improving workplace conditions, using wet methods during prawn blowing operations, applying integrated pest management to reduce rodent infestations in the workplace and using protective devices.^{5 10 34} In particular, given the findings of the current study, increasing the use of RPE and ventilation may be an effective way to reduce exposure.

Workers who were exposed to asthmagens derived from animals, fish and/or shellfish differed in terms of the activities they undertook that resulted in exposure. This has an apparent implication for policy development, in which a 'one size fits all' strategy may not be operative at raising the profile of animal and fish/shellfish derived asthmagens and reducing worker exposure across these occupations. For example, farmers need to wear RPE when handling animals and food preparation workers need to use cold water jets when extruding prawns from their carapace. Interventions and policy development should focus on workers in the farming, food preparation and education occupations because these occupations represented most of the exposed workers and also had the highest proportion of exposed workers within the occupational groups.

The strengths and limitations of AWES-Asthma are explained elsewhere in more detail.¹³ The study relied on self-reported data, which is likely to introduce some error into the exposure assessment. Nevertheless, workers were only required to answer questions regarding tasks in their current job, rather than having to recognise and recall specific exposures. This makes it less likely that exposure will be missed and less likely that specific exposures will be incorrectly reported.³⁵ Non-response is also an issue for any survey, raising the possibility that those who did participate in the current study had a different prevalence of exposure. Since there is no information available on non-participants, it is not possible to assess the potential of bias. The under-representation of younger workers in the sample compared with the general population, and the resultant potential under-representation of particular occupations, may have led to an underestimation of the prevalence of exposure. We did not collect information on level of exposure and so the exposure prevalence reported is not an assessment of the time-weighted average exposure but simply an indication of the number of people exposed regardless of frequency or level of exposure. Strengths of this study include a more detailed exposure assessment because of the use of task-based questions, and the large sample size, enabling analyses of subgroups, for example, occupational groups. An additional strength was the ability to generalise our results to the Australian working population, but the results may not be generalisable to countries with different workplace conditions such as developing countries.

This study provides the first population-based estimate of occupational exposure to animal, fish and/or shellfish derived

asthmagens in Australia and internationally based on reported task rather than self-reported exposure to specific agents. Exposure to animal, fish and/or shellfish derived asthmagens is common in a range of occupations and a variety of different circumstances. Given the high prevalence of exposure to these asthmagens, it is clear that further work needs to be done to reduce or prevent exposure. The estimated prevalence of exposure and the information on the circumstances of exposure can be used to establish appropriate priorities for intervention and control of occupational exposures, and estimates of the burden of asthma arising from occupational exposure to animal, fish and/or shellfish derived asthmagens.

Acknowledgements The authors thank Jonathan Burdon, Ryan Hoy, Jan-Paul Zock, Jeremy Beach, Sandy Ashton, Jenny Job and Brett Bissett at Safe Work Australia for their advice. The authors also thank Ines Florath for her help in the study's data management.

Contributors SE-Z drafted the manuscript and conducted all statistical analyses. LF directed the study and is responsible for its overall design. AR, TRD, DCG, RNC, ED, MJA, SS and SP were involved in the design of this study. All authors provided feedback on the draft of this manuscript. All authors read and approved the final manuscript.

Funding National Health and Medical Research Council (# 1056684) and Safe Work Australia. LF is supported by fellowships from NHMRC and Cancer Council Western Australia.

Competing interests None declared.

Patient consent Obtained.

Ethics approval Curtin University Human Research Ethics Committee.

Provenance and peer review Not commissioned; externally peer reviewed.

© Article author(s) (or their employer(s) unless otherwise stated in the text of the article) 2017. All rights reserved. No commercial use is permitted unless otherwise expressly granted.

REFERENCES

- 1 Jeebhay MF, Robins TG, Lehrer SB, *et al.* Occupational seafood allergy: a review. *Occup Environ Med* 2001;58:553–62.
- 2 Sherson D, Hansen I, Sigsgaard T. Occupationally related respiratory symptoms in trout-processing workers. *Allergy* 1989;44:336–41.
- 3 Douglas JD, McSharry C, Blaikie L, *et al.* Occupational asthma caused by automated salmon processing. *Lancet* 1995;346:737–40.
- 4 Eduard W, Douwes J, Omenaas E, *et al.* Do farming exposures cause or prevent asthma? Results from a study of adult Norwegian farmers. *Thorax* 2004;59:381–6.
- 5 Lopata AL, Jeebhay MF. Airborne seafood allergens as a cause of occupational allergy and asthma. *Curr Allergy Asthma Rep* 2013;13:288–97.
- 6 Bernstein JA. Occupational asthma, practical diagnosis and management. Mahmoudi M, ed. *Allergy and asthma* Switzerland: Springer International Publishing, 2016:253–70.
- 7 Wild LG, Lopez M. Occupational asthma caused by high-molecular-weight substances. *Immunol Allergy Clin North Am* 2003;23:235–50.
- 8 May S, Romberger DJ, Poole JA. Respiratory health effects of large animal farming environments. *J Toxicol Environ Health B Crit Rev* 2012;15:524–41.
- 9 HSE. *Asthma? Critical assessments of the evidence for agent implicated in occupational asthma*. London: Health and Safety Executive, 1997.
- 10 Jeal H, Jones M. Allergy to rodents: an update. *Clin Exp Allergy* 2010;40:1593–601.
- 11 Jones M. Laboratory Animal Allergy in the Modern Era. *Curr Allergy Asthma Rep* 2015;15:73.
- 12 Lopata AL, Baatjes R, Thrower SJ, *et al.* Occupational allergies in the seafood industry—a comparative study of Australian and South African workplaces. *Int Marit Health* 2004;55:61–73.
- 13 Fritschi L, Crewe J, Darcey E, *et al.* The estimated prevalence of exposure to asthmagens in the Australian workforce, 2014. *BMC Pulm Med* 2016;16:48.
- 14 Crewe J, Carey R, Glass D, *et al.* A comprehensive list of asthmagens to inform health interventions in the Australian workplace. *Aust N Z J Public Health* 2016;40:170–3.
- 15 ABS. *Socio-economic indexes for areas 2006*. Canberra: Australian Bureau of Statistics, 2008.
- 16 ABS. *Australian standard geographical classification*. Canberra: Australian Bureau of Statistics, 2011.
- 17 Fritschi L, Friesen MC, Glass D, *et al.* OcclDEAS: retrospective occupational exposure assessment in community-based studies made easier. *J Environ Public Health* 2009;2009:1–5.

- 18 ABS. *Australian and New Zealand standard classification of occupations*. First Edition. Canberra: Australian Bureau of Statistics, 2006.
- 19 Lee J, Tan CS, Chia KS. A practical guide for multivariate analysis of dichotomous outcomes. *Ann Acad Med Singapore* 2009;38:714–9.
- 20 Coutinho LM, Scazufca M, Menezes PR. Methods for estimating prevalence ratios in cross-sectional studies. *Rev Saude Publica* 2008;42:992–8.
- 21 StataCorp. *Stata statistical software: release 14*. College Station: StataCorp LP, 2015.
- 22 Safe Work Australia. *National hazard exposure worker surveillance – exposure to biological hazards and the provision of controls against biological hazards in Australian workplaces*. Canberra: Safe Work Australia, 2011.
- 23 Eng A, 't Mannetje A, McLean D, *et al*. Gender differences in occupational exposure patterns. *Occup Environ Med* 2011;68:888–94.
- 24 Messing K, Dumais L, Courville J, *et al*. Evaluation of exposure data from men and women with the same job title. *J Occup Med* 1994;36:913–7.
- 25 Nordander C, Ohlsson K, Balogh I, *et al*. Fish processing work: the impact of two sex dependent exposure profiles on musculoskeletal health. *Occup Environ Med* 1999;56:256–64.
- 26 Safe Work Australia. *Exposure to multiple hazard among Australian workers*. Canberra: Safe Work Australia, 2015.
- 27 Cohn RD, Arbes SJ, Yin M, *et al*. National prevalence and exposure risk for mouse allergen in US households. *J Allergy Clin Immunol* 2004;113:1167–71.
- 28 Zahradnik E, Raulf M. Animal allergens and their presence in the environment. *Front Immunol* 2014;5:1–21.
- 29 Beane Freeman LE, Deroos AJ, Koutros S, *et al*. Poultry and livestock exposure and cancer risk among farmers in the agricultural health study. *Cancer Causes Control* 2012;23:663–70.
- 30 Levêque-Morlais N, Tual S, Clin B, *et al*. The AGRiculture and CANcer (AGRICAN) cohort study: enrollment and causes of death for the 2005-2009 period. *Int Arch Occup Environ Health* 2015;88:61–73.
- 31 Chapman MD, Wood RA. The role and remediation of animal allergens in allergic diseases. *J Allergy Clin Immunol* 2001;107:S414–21.
- 32 Jeebhay MF, Cartier A. Seafood workers and respiratory disease: an update. *Curr Opin Allergy Clin Immunol* 2010;10:104–13.
- 33 Rodríguez J, Reaño M, Vives R, *et al*. Occupational asthma caused by fish inhalation. *Allergy* 1997;52:866–9.
- 34 Moscato G, Pala G. Occupational asthma in the food industry. *Curr Treat Options Allergy* 2017;4:191–200.
- 35 Parks CG, Cooper GS, Nylander-French LA, *et al*. Comparing questionnaire-based methods to assess occupational silica exposure. *Epidemiology* 2004;15:433–41.



Prevalence of occupational exposure to asthmagens derived from animals, fish and/or shellfish among Australian workers

Sonia El-Zaemey, Renee N Carey, Ellie Darcey, Alison Reid, Deborah Catherine Glass, Geza P Benke, Tim R Driscoll, Susan Peters, Si Si, Michael J Abramson and Lin Fritschi

Occup Environ Med published online November 24, 2017

Updated information and services can be found at:
<http://oem.bmj.com/content/early/2017/11/24/oemed-2017-104459>

These include:

References

This article cites 27 articles, 4 of which you can access for free at:
<http://oem.bmj.com/content/early/2017/11/24/oemed-2017-104459>
#BIBL

Email alerting service

Receive free email alerts when new articles cite this article. Sign up in the box at the top right corner of the online article.

Notes

To request permissions go to:
<http://group.bmj.com/group/rights-licensing/permissions>

To order reprints go to:
<http://journals.bmj.com/cgi/reprintform>

To subscribe to BMJ go to:
<http://group.bmj.com/subscribe/>