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POSITION STATEMENT

Work-related asthma: A position paper from the Thoracic Society of Australia and New Zealand and the National Asthma Council Australia

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ABSTRACT

Work-related asthma (WRA) is one of the most common occupational respiratory conditions, and includes asthma specifically caused by occupational exposures (OA) and asthma that is worsened by conditions at work (WEA). WRA should be considered in all adults with asthma, but especially those with new-onset or difficult to control asthma. Improvement in asthma symptoms when away from work is suggestive of WRA. Clinical history alone is insufficient to diagnose WRA; therefore, objective investigations are required to confirm the presence of asthma and the association of asthma with work activities. Management of WRA requires pharmacotherapy similar to that of non-WRA, however, also needs to take into account control of the causative workplace exposure. Ongoing exposure will likely lead to decline in lung function and worsening asthma control. WRA is a preventable condition but this does rely on increased awareness of WRA and thorough identification and control of all potential occupational respiratory hazards.

Key words: asthma, occupational asthma, occupational health, preventative medicine, work-exacerbated asthma.

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INTRODUCTION

Asthma affects approximately 2.7 million Australians, and remains a significant cause of death, with more than 400 people dying of asthma in Australia in 2017. More than one-third of people with asthma report that this significantly affects their daily living, and the economic and social costs of asthma remain high despite improvements in treatment. Work-related causes of asthma are often forgotten about by patients and healthcare professionals, yet remain an important preventable cause of morbidity and disablement.

Work-related asthma (WRA) is a general term which includes both asthma caused by an inciting exposure in the workplace (occupational asthma, OA) and asthma that is worsened by workplace conditions (work-exacerbated asthma, WEA) (Fig. 1).[1] WRA is a common occupational lung disease in developed, low- and middle-income countries and is generally preventable.[2] It is estimated that 25% of adults with asthma have WRA.[1,3] Although WRA is likely to be encountered frequently in clinical practice, it remains under-recognized and under-reported.[4] Failure to identify and

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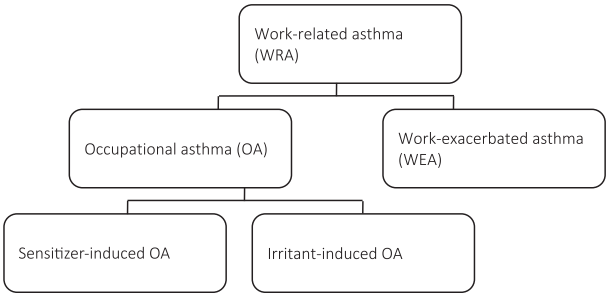

Figure 1 Relationship of asthma to the workplace (Reproduced from Tarlo *et al.*,[1] with permission).

manage WRA may lead to worsening asthma control. Conversely, inaccurate diagnosis may lead to unnecessary absence from work and potential economic hardship.[5]

The purpose of the position paper is to increase awareness of the association between work and asthma, and provide a structure for diagnosis and management. The paper is intended to provide general advice and does not represent guidelines. The target audience is all healthcare professionals who manage patients with asthma. The clinical relevance of the paper will be reviewed 5 years after the date of publication.

In accordance with the Thoracic Society of Australia and New Zealand (TSANZ) policy, a call for expressions of interest was sent to all members of the Society. Following review of provided curriculum vitae, the position paper writing group was established with 10 respiratory physicians and 1 occupational physician. Based on their areas of expertise, members were assigned specific sections to undertake a comprehensive literature review and develop draft recommendations. Inclusion of articles was determined by the assigning author and they were not systematically reviewed. All drafted sections were reviewed by the entire group for the opportunity to provide further contributions. Three authors (R.H., J.R. and J.B.) then compiled and edited the manuscript. All authors reviewed and approved the final manuscript.

DEFINITIONS

OA is new-onset asthma, or the recurrence of previously quiescent asthma, induced by an occupational exposure. The timely diagnosis of OA is important as ongoing exposure to the causative agent may result in rapid and often irreversible decline in lung function.[6,7] OA can be characterized as sensitiser-induced or irritant-induced occupational asthma.

Sensitiser-induced OA is the most common form of OA (approximately 90%) and may be caused by high- or low-molecular weight (HMW and LMW) agents.[1] Sensitiser-induced OA is characterized by development of asthma after a latency period ranging between days and years after initial occupational exposure. HMW agents (>10 kDa) act as antigens and induce production of antigen-specific IgE.[8] Although some LMW agents also induce specific IgE by acting as haptens, most LMW chemicals induce asthma via cellular immune-mediated pathways. Sensitisation to more than one occupational agent may occur, and more than one mechanism can be involved in any individual. The phenotypes of HMW and LMW OA appear to differ. An international multicentre study noted that HMW OA was more associated with work-related rhinitis, early asthmatic reactions and airflow limitation, and LMW OA more with work-related chest tightness, late reactions and severe exacerbations.[9]

Over 300 workplace agents have been described to cause OA (Table 1).[10] Australian prevalence data from 2014 showed that occupational exposure to one or more agent is common (47% men, 40% women).[11] Among men, common exposures include bioaerosols (29%), metals (27%), arthropods/mites (25%) and latex (22%), and among women: latex (25%), industrial cleaning and sterilizing agents (20%), bioaerosols (18%) and arthropods/mites (16%).

The primary risk factor for the development of sensitiser-induced OA is the level or dose of workplace exposure to the inciting agent, but the duration of exposure is also important.[14] A history of atopy also confers a higher risk of developing sensitiser-induced OA when exposed to HMW antigens. A history of smoking is a risk factor for the development of OA for most antigens, but this has not been demonstrated for all.

Where uncertainty exists regarding exposure to potential agents, there are useful web-based lists of agents with search tools which can help in deciding whether an agent is a likely cause of OA (e.g. www.occupationalasthma.com and www.aoecdata.org).

In 1985, Brooks described *reactive airway dysfunction syndrome* (RADS) as sudden-onset asthma occurring within a few hours of a single high-level exposure to an irritant substance.[15] Subsequently, the term *irritant-induced (occupational) asthma* (IIA) has been utilized more widely. IIA includes the RADS clinical phenotype, but also development of asthma in workers with multiple irritant exposures and asthma with a delayed onset after chronic exposure to moderate levels of irritants[1,4,15–17] (Table 2). The association between IIA and frequent low-level exposures to respiratory irritants is not entirely clear, but has been described in case reports and small case series involving cleaners (domestic and industrial), nurses, textile workers, poultry workers and aluminium pot room workers.[4,20] There has been increasing recognition of the association between cleaning agents and disinfectants and asthma, in particular formaldehyde, glutaraldehyde, hypochlorite bleach, hydrogen peroxide and enzymatic cleaners.[21] There is evidence that irritant mechanism is more common in association with these agents; however, an immunological mechanism has been noted in case reports.[22]

Although the definitive pathogenic mechanism remains unclear, IIA is likely due to bronchial epithelial cell damage resulting in pro-inflammatory responses, neurogenic inflammation due to exposed nerve endings, increased lung permeability and remodelling of the airway epithelium.[18]

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Table 1 Summary of workplace agents causing sensitiser-induced occupational asthma[4,10–13]

	Agent	At-risk occupations
High-molecular weight agents (>10 kDa[3])		
Plant allergens	Grains, cereals (e.g. rye, soya, malt and wheat flour)	Farmers, bakers, millers, combine harvester drivers
	Dust (tea, tobacco, coffee beans)	Packers, cafe workers
	Flowers, pollen	Florists, gardeners
	Vegetable gums	Pharmaceutical industry, carpet factory workers
	Cotton	Textile industry workers
	Hay	Farmers
	Psyllium	Healthcare workers
	Latex	Healthcare workers, toy and medical equipment manufacturers
Animal allergens	Dander, excreta	Laboratory workers, veterinary workers, farmers, breeders, animal handlers, groomers
	Insects	Laboratory workers, entomologists
	Bird products, egg protein	Process workers, breeders, poultry and hatchery workers
	Crustaceans, seafood	Process workers, cooks, fishermen
Enzymes	Protease, amylase, lipase, cellulase	Detergent manufacturers, warehouse workers, bakers, cleaners, hospital staff
Fungi	Moulds, yeasts	Food processors, bakers, farmers
Low-molecular weight agents (<10 kDa[3])		
Chemicals	Isocyanates	Spray painters, adhesive workers, polyurethane foam manufacturers, insulation workers, automotive industry
	Formaldehyde	Embalmers, healthcare workers, cosmetic industry
	Glutaraldehyde	Laboratory workers, tanners, plastic industry workers, endoscopists
	Dyes and bleaches	Fabric and fur dyers, hairdressers
	Alkaline persulphates	Hair dressers, plastic and synthetic rubber manufacturers
	Complex amines	Agrichemical and pharmaceutical manufacturers
	Fungicides	Gardeners
	Glues and resins (epoxy, acrylates, acid anhydrides)	Flooring installers, tilers, plastic manufacturers, polyurethane foam manufacturers, dental technicians
Metal salts, dusts or fumes	Platinum salts, nickel, cobalt, chromium, iron, tin, zinc oxide, titanium, stainless steel, tungsten	Metal platers and galvanizers, electronic industry workers, photographers, dentists, chemists
Aluminium pot room emission	Aluminium fluoride, chlorine, sulphur dioxide, hydrofluoric acid	Aluminium smelter workers
Pharmaceuticals	Penicillins, tetracycline, cephalosporins, opiates, colistin	Chemists, healthcare professionals
Solder flux	Colophony	Metallurgists, jewellery makers, artists, electronics workers, welders
Wood dusts	Western red cedar (plicatic acid), oak, redwood, chicory, exotic woods	Carpenters, saw mill workers, arborists, sanders

WEA describes the exacerbation of pre-existing or coincident (new-onset, non-occupational) asthma because of workplace conditions.[16] WEA may present with increased symptom frequency, medication use or acute exacerbations. Conditions at workplaces that can exacerbate asthma are common and varied (Table 2).[16] WEA is common, with a median prevalence of 21.5% among adults with asthma.[16]

EPIDEMIOLOGY

To date, epidemiological estimates of WRA have been wide-ranging. Surveillance-based systems suggest that the incidence of OA is approximately 4–17/100 000 workers per year,[23,24] although data from a prospective multi-national survey, which included Australia, suggest that the incidence may be as high as

Table 2 Common workplace exposures associated with work-exacerbated asthma and irritant-induced asthma[16,18,19]

Work-exacerbated asthma	Irritant-induced asthma
Respiratory irritants (dusts, fumes, sprays, gas, aerosols, liquids)	Acetic, hydrochloric, sulphuric and other acids
Aeroallergens (dust mite, pollens, animal dander)	Bleaching, cleaning, sealing agents, diesel exhaust
Thermal stress	Sulphur dioxide
Emotional stress	Ammonia
Physical exertion	Chlorine, chlorofluorocarbons

Table 3 Differential diagnosis of work-associated respiratory symptoms and diagnostic evaluation

Condition	Diagnostic evaluation
WRA	Refer to Table 4
WILS (also known as vocal cord dysfunction)[35]	Clinical history and laryngoscopy
COPD	Pulmonary function testing and high-resolution CT chest
Bronchiectasis and other obstructive lung disorders	Pulmonary function testing and high-resolution CT chest
Upper respiratory tract irritation	Clinical history
Hypersensitivity pneumonitis	Pulmonary function testing and high-resolution CT chest, specific serum IgG antibodies, when available
Rhinosinusitis	Clinical history, CT sinuses, specific IgE antibodies
Eosinophilic bronchitis	FeNO, induce sputum cytology
Non-WRA	Pulmonary function testing
Odour or irritant-induced hyperventilation	Clinical history
Psychogenic factors	Clinical history

COPD, chronic obstructive pulmonary disease; CT, computed tomography; FeNO, fractional exhaled nitric oxide; WILS, Work-associated Irritable Larynx Syndrome; WRA, work-related asthma.

25–30/100 000 people per year.[25] The no longer operational voluntary reporting scheme SABRE (Surveillance of Australian workplace Respiratory Based Events) recorded an incidence of OA of 0.5/100 000 workers per year in NSW and 3/100 000 in Victoria.[26] These rates are far lower than similar countries overseas, likely to be due to under-reporting to this scheme.[26] Finland has one of the most comprehensive data sets regarding work-related disease due to compulsory physician reporting of all known or suspected occupational diseases.[23] The Finnish Registry of Occupational Disease (FROD) reported a mean OA annual incidence rate of 17.4 cases/100 000 employed workers.[23] Cases caused by animal allergens, or flours, grains and fodders accounted for 60% of the total.

The population burden of asthma attributable to occupational exposures has been estimated to be between 15% and potentially as high as 20%,[27] although studies using strict definitions of OA suggest attributable fraction closer to 4.7%.[24] In Australia, estimates of new cases of asthma caused by work range from approximately 1000 to 3000 per year.[28] There are limited data on the contribution of irritants to OA incidence. Survey data from New South Wales estimated a population attributable risk to new-onset asthma due to work of 9.5% overall and 0.2% for irritant exposures.[29] However, early data from Canada noted that IIA was relatively common among a sample of workers diagnosed with OA at a specialist occupational lung disease clinic (10/59).[17]

WEA has been noted to be a common condition.[30] An American Thoracic Society (ATS) consensus statement reviewed 12 general population or primary healthcare studies noting an average prevalence of 21.5% (range: 13–58%) of WEA among working asthmatic patients.[16] Other studies using more objective measures of asthma control (interviews, serial peak expiratory flow (PEF) measures and medication usage) identified WEA prevalence of 13–22% among all those with asthma.[31]

CLINICAL FEATURES

A relationship between asthma and exposures in the work setting should be considered in all people of working age with asthma, particularly if asthma develops during adult life or has been difficult to control.

A detailed history of clinical symptoms is required to determine if symptoms are consistent with asthma or an alternative diagnosis (Table 3). An OA screening questionnaire has been developed (OASQ-11) and has moderate discrimination for OA when used in a clinical setting.[36] Typical asthma symptoms include episodic breathlessness, wheeze, cough or chest tightness.[37] The presence of work-related dysphonia and cough has been noted to be more common with work-associated irritable larynx syndrome than asthma, especially when associated with sensory irritants including odours, perfumes, exhaust fumes and cleaning products.[35] Symptoms of occupational allergic rhinitis (nasal itch, rhinorrhoea and congestion) often precede symptoms of asthma especially related to HMW agents.[38] Asthma present before occupational exposure, but associated with worsening at the start of a new occupational exposure, suggests the presence of WEA.

Irritant-induced OA symptoms commence at the time of inducing workplace exposure. However, sensitiser-induced OA is characterized by a period of latency between first exposure to the occupational agent and development of asthma symptoms. This period may range from days to years. Subsequently, symptoms typically improve during times away from work, such as weekends and holidays, and worsen at work. This temporal association of symptoms lessens when asthma becomes more prolonged or severe.

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A detailed work exposure history should be obtained to identify likely exposure(s) known to cause WRA (Tables 1,2). The patient should be asked to provide a detailed description of his/her work schedule, tasks and exposures, and of possible exposures related to other activities in the environment. Details of control strategies including respiratory protection and ventilation should be obtained. The patient should request that their employer provide safety data sheets (SDS) relevant for their work environment. SDS are documents that provide critical information about hazardous chemicals. However, these sheets may be incomplete and not identify the potential of the agent to cause asthma.

INVESTIGATIONS

Clinical history alone is insufficient to accurately diagnose WRA.[39] Objective investigations are required to:

1. Confirm the presence of asthma (symptoms, variable airflow obstruction and/or non-specific bronchial hyperresponsiveness (NSBH)).
2. Evaluate the association between asthma and the workplace.
3. Demonstrate sensitisation to, or identify in other ways, the specific causal agent (wherever possible).

Investigations should be commenced as soon as WRA is suspected and should be performed when the worker is still in the role suspected to be associated with asthma. Relocation during the process of investigating WRA is only necessary if asthma is severe.

Given the individual limitations of investigations, an approach which includes clinical history and a combination of testing will increase diagnostic accuracy[1,4] (Table 4).

The following are suggested:

1. Confirm the presence of asthma

Spirometry with bronchodilator reversibility assessment should be performed in every worker with suspected WRA in accordance with best practice guidelines to identify *variable airflow limitation*.[37,40] The presence of expiratory airflow limitation (forced expiratory volume 1 s/forced vital capacity (FEV_1/FVC) < lower limit of normal for age) and FEV_1 increase ≥200 mL and ≥12% from baseline in response to a β2-agonist is consistent with the diagnosis of asthma in this context.[37] However, normal spirometry at the time of initial assessment does not rule out the diagnosis of asthma. The quality of spirometry is important and may give clues to the possibility of other diagnoses.

If spirometry does not identify variable airflow limitation, then *bronchial provocation testing* should be considered to identify the presence of NSBH.

Bronchial provocation testing in the setting of OA has a high sensitivity (84%) and a high negative predictive value (75%),[41] such that a negative test or a lack of NSBH in a symptomatic individual, especially if performed within 24 h of work exposure, can generally be used to rule out active asthma.[1,42] Assessment for NSBH should be carried out when the patient is still exposed to the suspected offending agent, as airway hyperreactivity can return to normal rapidly once exposure ceases.[42] A negative bronchial provocation test is helpful in excluding active asthma, but due to low specificity and low positive predictive value, a single positive test should be interpreted in combination with other investigations and clinical aspects.[43]

Bronchial provocation testing can be done using either direct agents (methacholine or histamine) or indirect agents (mannitol). The latter is now commonly used in Australian laboratories and has been shown in a small study to be positive in patients with more active disease,[44] but there are more data on methacholine.

2. Evaluation of association between asthma and work exposure

Serial NSBH

Comparison of bronchial hyperreactivity at work and after a 10- to 14-day period away from the work exposure has shown moderate sensitivity and specificity for diagnosing WRA. A 2- to 3-fold change in the dose of methacholine or histamine needed for a positive test is considered significant.[1] There is only a slightly greater sensitivity with reduced specificity compared to using PEF measurements alone.

Serial PEF

The use of recording PEF during periods at and off work is helpful and can be evaluated visually by experienced respiratory and occupational physicians, although this method has been shown to have moderate between- and within-expert agreement.[45] If there are expert disagreements, computer evaluations using quantitative analysis of changes in mean PEF values can be used (OASYS-2; OASYS Research Group, Midland Thoracic Society, Birmingham, UK, http://www.occupationalasthma.com/occupational_asthma_pageview.aspx?id=4443).[43] Computer-based analysis has an equivalent sensitivity to visual inspection technique but greater specificity (91% vs 69%) and would be useful in confirming OA.[43]

PEF measurements should be recorded four times per day (on awakening, noon, at the end of working day and before bedtime) for a total of 4 weeks, including 2 weeks away from work.[1] Cross-shift PEF or FEV_1 seems to be less reliable than serial PEF testing. The cross-shift method has a high specificity (91%) but a low sensitivity (50–60%).[46]

Specific inhalation challenge

Specific inhalation challenge (SIC) involves exposing workers who are suspected of having sensitiser-induced OA to the presumed causative agent in a safe and controlled manner within an enclosed challenge room.[1,47] However, SIC testing requires a high level of expertise and is only performed in a few centres around the world. International guidelines recommend a 3- to 4-day protocol of testing and admission to hospital for the duration of the challenge test due to the risk of late phase excessive reactions.[47] At this time, SIC testing is not routinely available in Australia or New Zealand.

Table 4 Diagnostic criteria for forms of work-related asthma

OA			Work-exacerbated asthma
Sensitiser-induced		Irritant-induced	
Required criteria (need all for a definite diagnosis)	Supportive criteria	Required criteria	Required criteria
New-onset asthma or recurrence of previously quiescent asthma[1,4] Diagnosis of asthma made on the basis of BOTH: • Characteristic symptoms[4,32] • Lung function testing showing either variable airflow limitation or NSBH[4,32] Onset of asthma symptoms after a period of latency following initial exposure to a sensitiser in the work environment[4,32] Asthma symptoms occurring in association with work and exhibiting remission or improvement during periods off work[1,4,32] • Symptoms may occur at the beginning or end of the shift or in the evening after working hours[1,4] Objective association between asthma and the workplace.[4,32] The following criteria should be sought in all patients and at least ONE should be present for a diagnosis[1,4,32] • The occupational exposure preceding symptoms is a known asthma sensitiser. Specific immunological testing should be considered where available • In patients still working (or on return to work), serial testing to show at least ONE of: 1. Work-related worsening of PEF measurements 2. Work-related worsening of NSBH 3. Work-related worsening of airflow obstruction on spirometry	History of work in an at-risk occupation[1] Suggestive signs and symptoms (see section Clinical features) Evidence of work-related airway inflammation, such as FeNO measurements[1,33,34]	History of new-onset or recurrence of previously quiescent asthma while working[1,4] Symptom onset following one or more high-level exposures[4,32] Symptoms can begin ≤24 h and up to several days after exposure[4] Occupational exposure to gas, fume, spray or dust with known irritant properties[4,32] Symptoms persisting for ≥3 months[4,32] Physiological testing showing EITHER variable airflow obstruction OR NSBH[4,32]	Pre-existing asthma based on symptoms, medical history, variable airflow obstruction or NSBH on lung function testing or medication usage prior to occupational exposure[4,16,32] Presence of conditions at work that can exacerbate asthma (Table 2)[16,32] Demonstration of worsening of asthma after start of employment, change in work process or environment through at least ONE of the following[16,32]: 1. Worsening symptoms 2. Increased medication requirements 3. PEF diaries 4. Spirometry 5. Bronchial challenge testing OA is unlikely.[16] An exacerbation of OA due to the initial causative agent is considered an exacerbation of OA[16]

FeNO, fractional exhaled nitric oxide; NSBH, non-specific bronchial hyperresponsiveness; OA, occupational asthma; PEF, peak expiratory flow.

3. Demonstrate sensitisation to, or identify, the specific causal agent (where possible)

Only a few of the 300 known asthma-causing agents are commercially available for testing. *Skin prick tests* (SPT) and assessment of *serum allergen-specific IgE* (sIgE) antibodies are useful to demonstrate IgE-mediated sensitisation to many HMW and some LMW agents. Other than latex, cat and bee venom extracts, there is a worldwide relative lack of standardization and validation for other occupational agents. SPT with LMW agents should be performed with caution as

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allergenic extracts are not standardised and most of these agents are potentially irritant to the skin and may produce false-positive results with lower specificity.

Combination testing

Combining the presence of NSBH with a positive SPT or sIgE test markedly increased the specificity of NSBH assessment alone, while sensitivity was not consistently improved.[43,48] Assessment of indices of eosinophilic airway inflammation (fractional exhaled nitric oxide (FeNO) ≥ 25 ppb or a sputum eosinophil count ≥ 1%) has also recently been demonstrated to increase the sensitivity of evaluation when performed in combination with NSBH assessment.[33]

DIAGNOSIS

WRA should be suspected in all adults with asthma, but in particular those with new-onset or difficult to control asthma. Asking if asthma symptoms differ during times away from work such as weekends or holidays can be a useful initial screening question.[1] Those who answer yes will require more detailed evaluation for possible WRA. Due to the potential for the diagnosis to impact employment, it is important to utilize objective testing to confirm a diagnosis, as outlined in Table 4.

MANAGEMENT

The pharmacological treatment of WRA is the same as that for non-WRA.[1,37] A stepwise approach, using anti-inflammatory and bronchodilator therapy, should be used to achieve symptom control with subsequent dosage adjustment to achieve good symptomatic control at the lowest effective dose, as per existing guidelines.[37,49] For patients with difficult to control asthma symptoms, there should be consideration of referral to a specialist severe asthma clinic. Evaluation may include assessment of eligibility for access to monoclonal antibody therapy.

There is insufficient evidence that pharmacological management of sensitiser-induced OA with inhaled corticosteroids and long-acting β2-agonists is able to prevent the long-term deterioration of asthma in subjects who remain exposed to the agent causing OA.[50] One study showed that early treatment with oral corticosteroids may improve outcomes for patients with IIA; however, until confirmed this cannot be recommended.[51] Every opportunity should be taken to assist smoking cessation if relevant. The ATS has published a position paper on WRA,[16] and specific standards of care were developed by the British Thoracic Society and updated in 2012.[52] These contain very similar recommendations, and can be applied worldwide. The Australian Asthma Handbook (http://www.asthmahandbook.org.au) also has useful information.

Sensitiser-induced OA

Continued exposure will most likely lead to worsening symptoms, airflow limitation and airway hyperresponsiveness.[53,54] Conversely, complete avoidance will almost certainly result in improvement in asthma control, although symptoms may remain in two-third of cases.[55]

Optimal management of sensitiser-induced OA involves accurate identification of the sensitiser and early and complete avoidance of ongoing exposure.[50,56] The latter may involve:

- Control of exposure at the workplace, including substitution with an alternative.
- Effective engineering controls.
- Other means to reduce air levels, such as extraction ventilation or wetting the process for dusts.
- Redeployment to a job or work area with absence or reduction of the exposure.[5]
- Use of protective clothing, masks or independent air supplies, although low-level exposure may induce symptoms in established sensitiser-induced asthma despite protective equipment.[50]
- Communication with the employer (with patient consent) regarding recommendations to eliminate or reduce exposure.
- Seeking alternative employment.

Patients with confirmed or suspected sensitiser-induced OA who continue to have potential exposure to the sensitiser should be monitored closely by a specialist. A recommendation has been made for 3 monthly reviews for 1 year and then 6 monthly afterwards.[52] Workers need to be counselled regarding the risk of deteriorating asthma control and airflow obstruction posed by persistent occupational exposure.

If a worker leaves a workplace due to OA, even if based on medical recommendation, there is likely to be a significant negative socio-economic impact for that worker.[57] The diagnosis should therefore be objectively confirmed by a specialist with experience in investigating WRA, prior to making this decision. Workers who have left the workplace may have slow symptomatic and lung function improvement and should be monitored for a minimum of 3 years.[52]

Irritant-induced OA

Workers should be able to continue their job unless repetitive exposure to respiratory irritants is likely to occur. Employers should ensure control measures are in place to minimize the risk of exposure to respiratory irritants for all workers as far as practicable. For those with IIA, symptom control may be possible, whilst continuing their job, provided an effective reduction in trigger exposure can be achieved in the workplace.[18]

Work-exacerbated asthma

The literature regarding the natural history and optimal management of WEA is limited.[1,16] Identification of exacerbating triggers and reducing potential harmful exposures can minimize the risk of ongoing problems. Workers should be able to stay in the same job if control of exposure can be achieved, with close monitoring of their asthma control.

COMPENSATION AND IMPAIRMENT ASSESSMENT

Most jurisdictions in Australia, as part of their workers' compensation system, have produced lists of deemed diseases. These are conditions that are considered to be work related and the assumption is made that an exposed worker with WRA is deemed to have a work-related condition unless there is strong evidence to the contrary.[58] Therefore, it is important that the diagnosis of WRA is accurately confirmed by a specialist.

Persons suffering from WRA will commonly require periods of time away from the workplace. Most will consequently incur both social and financial costs, including loss of income, medical fees and costs of therapies. For these reasons, compensation will usually be sought and is appropriate.

Early referral to the employer's workers' compensation insurer is recommended to allow timely assessment of liability and institution of measures to address the worker's health. This may also expedite the process of reducing exposure for other workers.

In cases with ongoing respiratory impairment, lump sum compensation payments may be payable. An assessment of permanent impairment should be delayed until asthma symptoms have been stable for at least 12 months. In all states of Australia, the assessment of respiratory impairment is based on the *American Medical Association Guides to the Evaluation of Permanent Impairment*. In general, the fourth (third printing) and fifth editions are used and measured spirometric indices are applied to the relevant tables published in the guides. Requirements vary in the different editions but all require:

- Measurements of pre- and post-bronchodilator spirometry; predicted values as published in the guides.
- Determination that the lung function is stable (not expected to vary by more than 3% in the future).
- A record of medication requirements[59] including inhaled glucocorticoids.

In Victoria, the *Impairment Assessment in Workers with OA* is used as an extension of table 10 of the AMA 4th Edition guides and also takes into account clinical symptomatology and exercise capacity.[60]

PREVENTION

All occurrences of WRA are potentially preventable. Because a new diagnosis of OA is a sentinel event, the managing clinician has an ethical responsibility to communicate with the workplace and facilitate measures that protect co-workers. These may involve the accurate identification of the causative exposure, a review of workplace control measures, the introduction or modification of a health surveillance programme to screen other co-workers as well as optimizing case management.[61] Involvement of an occupational physician to address some of these issues may be warranted. Ideally, a positive workplace culture will facilitate workers to report safety concerns and potential early symptoms of asthma.[52]

Elimination, substitution and enclosure

Elimination of the agent is strongly recommended as the primary preventive method.[62] An example has been the substitution of powdered latex gloves by latex-free gloves and powder-free, protein-poor natural rubber latex (NRL) gloves minimizing occupational allergy and asthma in health care.[63]

Exposure reduction

This is the next favoured approach if elimination is not possible. Exposure levels are kept as low as feasible through partial substitution, partial segregation and/or optimization of ventilation by engineering controls and/or automation of some work practices.[64]

Respiratory protective equipment as a preventive measure is ranked lowest in the hierachy of controls.[61,62] If used, it must be appropriately selected for the exposure (such as isocyanate-containing spray paints),[65] and adequate training of the workers must be provided. Respiratory protection must be regularly fit tested and well maintained. Powered or air supplied respirators may be required to ensure a suitable degree of protection is obtained.

Health surveillance

Although exposure reduction may lessen the progression of subclinical asthma and sensitisation, this strategy also requires careful monitoring of workers for the potential emergence of disease. Workplace surveillance using questionnaires, followed by the investigation of suggestive symptoms by a specialist clinician, is recommended.[62] Serial spirometry, serological testing and/or SPT as part of a more comprehensive medical surveillance programme differ between industries and/or individual workers and jobs within an industry. Specific IgE (or SPT) surveillance is strongly recommended for ongoing potential exposure to HMW agents such as animal care workers, bakers dust, enzyme and latex exposures.[66] It is also used for occasional LMW allergens such as complex platinum salts.[1] Although the evidence to support surveillance programmes is considerable,[61] optimal monitoring frequency and efficacy of individual components have not yet been established.

Pre-placement assessment

Testing of workers for specific sensitisation to HMW allergens before employment is strongly recommended for high-risk industries.[62] Workers should be made aware of the common sensitisers, existing control measures and typical symptoms of occupational rhinitis and asthma that suggest a need for further evaluation following commencement of work. For prospective employees with pre-existing asthma and/or atopy, results from screening investigations (such as spirometry and/or assessment of allergen-specific IgE) may be used as a starting point for surveillance and health education.[66] While such applicants might consider avoiding 'at-risk' employment, employer selection based on these common predisposing conditions is not useful as many workers will never develop WRA.[14,66]

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CONCLUSION

The development of asthma from an occupational exposure is an important, preventable factor which has substantial negative health and socio-economic implications for an individual. The worsening of asthma control due to workplace conditions is also common and requires careful management. Diagnosis of WRA can be challenging and requires a thorough approach with objective measures of respiratory function. The influence of work on asthma should be considered as part of routine asthma care, and if WRA is suspected, early referral to a specialist for further evaluation and management is usually required. Diagnosis of WRA should also lead to evaluation of a workplace's prevention measures to minimize the risk to other exposed workers.[3]

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Abbreviations: ATS, American Thoracic Society; CT, computed tomography; FeNO, fractional exhaled nitric oxide; FEV_1, forced expiratory volume 1thinspaces; HMW, high-molecular weight; Ig, immunoglobulin; IIA, irritant-induced (occupational) asthma; LMW, low-molecular weight; NSBH, non-specific bronchial hyperresponsiveness; OA, occupational asthma; PEF, peak expiratory flow; RADS, reactive airway dysfunction syndrome; SDS, safety data sheet; SIC, specific inhalation challenge; sIgE, serum allergen-specific IgE; SPT, skin prick test; WEA, work-exacerbated asthma; WRA, work-related asthma

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