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CME Review

Occupational exposure and asthma

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Key Messages

- Adult-onset asthma occurring as a direct result of occupational exposure (OA) is a common occurrence.
- Asthma caused by other factors (eg, seasonal allergic asthma) can be triggered by different occupational exposures and is known as work-related asthma (WRA).
- The number of occupational exposures that can adversely impact WRA is vast, varied, and sometimes initially vague.
- Identifying the specific occupational agents that affect WRA must be approached methodically with careful history, appropriate examination, and testing (laboratory, skin prick) as indicated to develop focused interventional strategies.
- Recognizing and mitigating asthma-exacerbating factors in the workplace requires cooperation and coordination among patient, allergist, and occupational representatives (eg, employers).

INSTRUCTIONS

Credit can now be obtained, free for a limited time, by reading the review article and completing all activity components. Please note the instructions listed below:

- Review the target audience, learning objectives and all disclosures.
- Complete the pre-test.
- Read the article and reflect on all content as to how it may be applicable to your practice.
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Overall Purpose

Participants will be able to demonstrate increased knowledge of the clinical treatment of allergy/asthma/immunology and how new information can be applied to their own practices.

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Learning Objectives
At the conclusion of this activity, participants should be able to:
- Describe the different clinical presentations of work-related asthma.
- Evaluate a patient with suspected occupational asthma using the most appropriate diagnostic test.
- Integrate occupational history as part of routine evaluation of working patients with asthma and/or rhinitis.

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Physicians involved in providing patient care in the field of allergy/asthma/immunology
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Introduction

Approximately 1 in 6 cases of adult-onset asthma are attributable to occupational exposure.[1] The overall estimated cost of work-related asthma (WRA; ie, the combination of occupational asthma [OA] and work-exacerbated asthma) is at least $1.6 billion annually.[2] Individuals with WRA experience more long-term disability, frequent health care use, loss of income, and unemployment compared with individuals who have asthma without WRA.[3]

Work-related asthma is a broad term covering several OA syndromes caused or triggered by different occupational exposures. WRA encompasses work-aggravated asthma (WAA) and OA.[4,5] WAA, also referred to as work-exacerbated asthma, refers to pre-existing asthma or concurrent asthma attributable to conditions outside the workplace (eg, seasonal allergic asthma) that is triggered or aggravated by some exposure or condition (eg, irritants, exertion) encountered at work. WAA has been estimated to have a median prevalence of 21.5% among adults with asthma.[3]

In contrast, OA is defined as asthma induced de novo by a specific agent or some other exposure encountered at work. OA encompasses (1) asthma induced by workplace sensitizers and (2) irritant-induced asthma caused by high-level exposure to irritating substances encountered at work. Respiratory sensitizers inducing OA are traditionally categorized as low-molecular-weight (LMW) chemicals (eg, diisocyanates) or high-molecular-weight (HMW) proteins of animal or protein origin (eg, wheat allergens, fungal enzymes, laboratory animals) encountered in the workplace. HMW allergens represent the largest number of sensitizers associated with induction of OA. The acute presentation of irritant-induced asthma is known as reactive airways dysfunction syndrome (RADS), characterized by lower respiratory symptoms (ie, cough, wheezing,

shortness of breath) that begin within 24 hours of a brief ambient high-level exposure to an irritant. RADS develops often after a single accidental exposure at work to a respiratory irritant in the setting of a spill or fire (eg, smoke inhalation, chlorine gas).[6,7]

Data from a recent survey suggest that current asthma in up to 48% of adults might be related in some way to work exposure.[8] This is likely an overestimate but suggests that WRA, be it WAA or OA, might be underappreciated by health care providers.

This review focuses primarily on exposure sources of HMW and LMW respiratory sensitizers that could lead to the development of OA. Conditions associated with WAA are discussed, although less is known about WAA due to the limited number of published studies relevant to this condition. A recent population-based study found that asthma exacerbations were associated with self-reported occupational exposure to gas, smoke or dust, organic dust, mold, cold conditions, and strenuous physical work.[9] An important limitation is that little is known or reported in the current OA literature regarding precise workplace exposure-response relationships including measurable exposure thresholds capable of inducing sensitization and OA.

Assessing Exposure and Taking a Complete Occupational History

The occupational history is an essential part of the medical history in all new patients presenting with asthma.[10] Patients with WRA may be aware of specific exposures at work that trigger symptoms. In general, symptoms begin and worsen on workdays and lessen at home including on weekends and long vacations. However, this is not necessarily the case in workers with sensitizer-induced OA in whom asthmatic symptoms can persist for weeks or months after leaving work. The clinician unfamiliar with evaluating OA can refer to the list of important questions pertaining to symptoms and work exposure in Tables 1 and 2. Additionally, a reliable questionnaire has recently been tested for screening workers for WRA.[11]

Table 1 lists essential questions regarding lower respiratory symptoms including their onset and duration related to work. Many patients regularly exposed to workplace sensitizers might not experience symptoms for months to years. This time of asymptomatic exposure is often referred to as the "latency period" of sensitization. The latency period of sensitization is quite characteristic of immunoglobulin E (IgE)–dependent asthma due to HMW allergens and some chemical sensitizers such as acid anhydrides (eg, trimellitic anhydride) and diisocyanates (eg, methylene diphenyl diisocyanate). Chronic bronchitis in current smokers can easily confound the diagnosis of WRA. The reporting of work-related nasal and eye symptoms (eg, itching, sneezing) associated with asthma at work supports the likelihood of IgE-dependent sensitization to an occupational allergen, usually an HMW protein. A known history of asthma medication use or asthmatic symptoms associated with outdoor or indoor aeroallergens should alert the clinician to WAA triggered nonspecifically at work, with the caveat that OA can be diagnosed and coexist in a worker with WAA.

Table 1
Occupational Respiratory History for Suspected Work-Related Asthma

1	While at your current job, have you had wheezing, cough, chest tightness, or shortness of breath?
2	If you answered yes, do these symptoms occur immediately after coming to work?
3	If you answered yes, do these symptoms begin hours after coming to work? If so, how many hours?
4	If you answered yes, do these symptoms continue after coming home from work? If so, within how many hours and how long do these last?
5	If you answered yes, do the symptoms decrease on weekends or vacations?
6	How long were you working at your current job before you first noticed respiratory symptoms?
7	Are you a current smoker, former smoker, or current smoker? If yes, record pack-years.
8	Have you ever been diagnosed with asthma, allergic rhinitis, chronic bronchitis, or chronic obstructive pulmonary disease? If yes, provide details.
9	Have you experienced nasal or eye symptoms (sneezing, itching of the nose or eyes) that begin or worsen at work? If yes, provide details.
10	If the patient does have asthma, list the required controller and rescue medications, frequency of exacerbations, and relation of these to work exposure.

Table 2
Occupational Environmental History for Suspected Work-Related Asthma

1	Have you ever been transferred from a job because of a health reason? If yes, provide details.
2	When did you start your current job?
3	What is your current job description? Provide details.
4	What is your current work area? Provide details regarding job, exposure to all substances encountered in the work area, and description of job processes. This might require requesting the employer for access to material safety data sheets.
5	What is your current work shift?
6	What percentage of time during the day is spent in the work area?
7	List all chemicals or substances used in a work area with details regarding how workers are being exposed (eg, airborne vs skin exposure). If possible, record specific date exposure started and stopped.
8	Has the worker experienced work-related respiratory symptoms with prior employment? If yes, provide details of exposures and related symptoms.
9	Have you ever inhaled or been exposed at work accidentally to a chemical spill or excessive amounts of fumes or smoke? If yes, provide details.

The workplace must be investigated for tasks or processes that involve regular use of known sensitizers. Material safety data sheets must be provided by employers on request and can help identify potential sensitizers, although in some cases these might not be complete. An occupational hygienist can be quite helpful in identifying a suspect causative agent or asthma trigger.[12] Table 2 lists key questions useful in characterizing exposure to sensitizers in the workplace. These questions seek to identify prior problems at previous job sites, current and past exposure to known causative workplace sensitizers, exposure characteristics of the immediate and adjacent work areas, and by what route specific exposures can occur (ie, skin and/or respiratory). It is essential to query about prior accidental exposures to chemical spills, fumes, and smoke inhalation. Such events can precede development of OA caused by an irritant (ie, RADS) or chemical sensitizer (eg, isocyanates). Failure on the part of the worker to follow safety rules when handling hazardous substances at work can lead to inadvertent cutaneous or inhalational exposure to respiratory sensitizers. Specific exposure information can be obtained from workplace managers and/or safety officers who sometimes can clarify relevant exposures of an individual worker and, if available, provide quantitative exposure data that might have been collected in immediate and adjacent work areas.

Diagnostic Approach

Evaluation of Irritant-Induced Asthma or RADS

The diagnoses of RADS is retrospective and based largely on a history of acute high-level exposure to an irritating substance at work followed by the onset of lower respiratory symptoms (cough, dyspnea) within 24 hours after the exposure event. Confirmation of the diagnosis requires demonstration of bronchial hyperresponsiveness by a positive methacholine test.[7] The impact of chronic low-level irritant exposure on development of irritant-induced asthma is controversial.

Stepwise Evaluation of OA Due to a Workplace Sensitizer

Step 1: Establishing Asthma Diagnosis

The following diagnostic approach is recommended for objective confirmation of OA (Fig 1). The first step in the diagnostic workup is to obtain a clinical and occupational history[10] as described earlier. If a worker reports work-related lower respiratory symptoms consistent with possible WRA, the next step is to objectively confirm asthma by showing reversibility in forced expiratory volume in 1 second (FEV_1) after inhaled bronchodilator. Simple spirometry testing should be performed before and after 2 to 4 inhalations of albuterol delivered by a metered-dose inhaler. An increase in FEV_1 of at least 12% after bronchodilator treatment confirms asthma but alone is not sufficient to establish a diagnosis of OA. If reversibility in FEV_1 cannot be demonstrated, methacholine challenge testing is recommended. The methacholine test is performed by having the patient inhale nebulized saline, which is followed by inhalation of incremental doses of methacholine (0.125–25 mg/mL) every 5 to 10 minutes until a 20% decrease from the post-saline FEV_1 is observed or until all challenge doses have been delivered without any decrease in FEV_1.[13] The provocative concentration eliciting an FEV_1 decrease of 20% is referred to as the methacholine PC_{20}, with a positive test reaction defined as PC_{20} no higher than 16 mg/mL. As shown in Figure 1, a negative methacholine test reaction ($PC_{20} > 16$ mg/mL) performed when the worker is actively exposed and symptomatic excludes asthma and OA with a high degree of certainty.[14]

Step 2: Determining Workplace Connection

Once asthma is confirmed, a decrease in lung function during the work shift concomitant with exposure to a suspect causative agent is required for confirming OA. The preferred approach is to perform a specific inhalation challenge (SIC) in a specialized laboratory. The SIC is considered the diagnostic gold standard for OA, but specialized laboratories performing this controlled procedure are not available in the United States, with limited availability worldwide. Such facilities have developed challenge chambers that can reliably generate, measure, and regulate exposure concentrations of chemical and HMW challenge agents so that SICs can be performed safely.[3,10,14] Thus, serial measurement of peak expiratory flow rate (PEFR) during work and away from work exposure is the alternative approach for confirming OA from an occupational sensitizer. Serial PEFRs should be performed by workers every 4 hours (or at least four times per day) during waking hours for a period of 2 weeks at work followed by 2 weeks of serial recordings away from the workplace. OA is confirmed by consistent decreases in PEFR on days at work while exposed to a suspect causative agent that increases on days away from work. Compared with the SIC as the gold standard, workplace monitoring of PEFR has a sensitivity of 81% and a specificity of 74% for correctly identifying OA.[15] Falsification of abnormal readings can be ruled out by showing a decrease in methacholine PC_{20} at the end of 2 weeks of monitoring PEFRs during active work exposure.

Utility of Allergy Testing for OA

Whenever appropriate, specific IgE testing with HMW occupational allergens should be conducted with skin prick testing and/or serum specific IgE. It should be emphasized that specific IgE determines sensitization status, but alone does not establish or exclude an OA diagnosis. A positive skin test or serum specific IgE assay reaction can assist in establishing causation of OA especially if allergen exposure to that substance is associated with work-related decreases in PEFRs. Specific IgE tests also can be useful to identify a clinically relevant allergen in workers concurrently exposed to several workplace allergens. However, commercial skin test allergens are not available for performing prick skin testing for many substances (eg, natural rubber latex, microbial enzymes), compelling some clinical allergists to prepare their own extracts from natural sources. Serum specific IgE immunoassays are commercially available for proteinaceous workplace allergens (eg, natural rubber latex) and some chemicals sensitizers (eg, diisocyanates). Except for diisocyanate and natural rubber latex, diagnostic sensitivity or specificity for most commercial specific IgE assays have not been evaluated.[16,17] Measurements of serum specific IgG4 have not been validated for evaluating OA.[18]

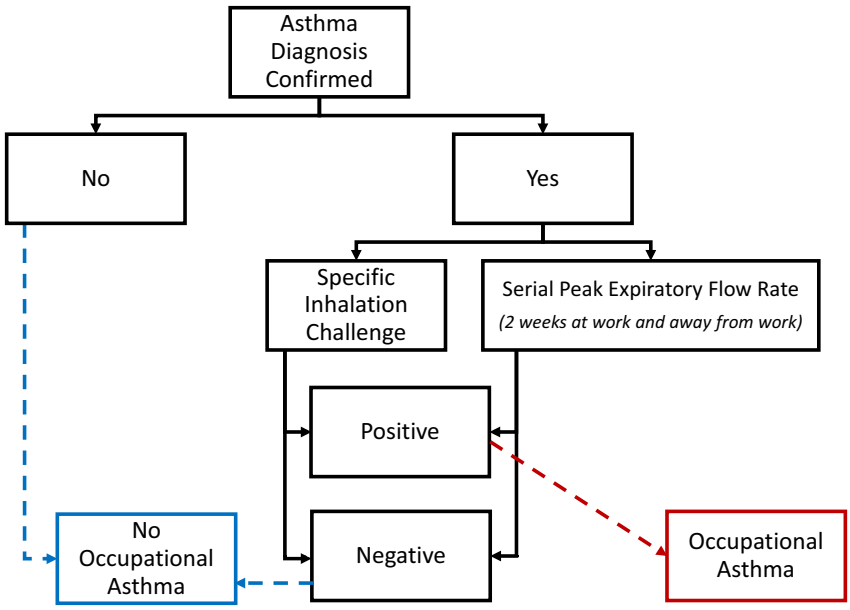

Figure 1. Stepwise approach to evaluating the worker with work-related lower respiratory symptoms. Asthma is confirmed by reversibility in forced expiratory volume in 1 second (FEV_1) or with methacholine testing. If asthma is present, then occupational asthma (OA) is confirmed by a positive specific inhalation challenge (if available) or serial monitoring of peak expiratory flow rate for 2 weeks at work and 2 weeks away from work.[6]

Reactive Airway Dysfunction Syndrome

Reactive airway dysfunction syndrome was first described by Brooks et al[7] in 1985 noting that acute exposure to a high concentration of an irritant at work led to acute respiratory symptoms. Typically the exposure is due to incidents causing accidental release of irritants such as vapors, gases, fumes, or with smoke.[18] Smoke inhalation and acute chlorine exposure are amongst the more common causes of RADs.[6,19,20] A possible example is first responders at the World Trade Center disaster who developed persistent airway hyperresponsiveness that was strongly associated with the exposure intensity, although it is uncertain if those cases fit the definition of RADS.[21] Not all acute exposures result in RADS as persistent nasal symptoms have been associated with acute chlorine exposure independent of development of RADS.[22] In a longitudinal study of workers exposed to chlorine, chlorine "gassing" incidents were associated with increased airway hyperresponsiveness confirmed over a 2-year period.[23] Overall, RADS symptoms can be transient and resolve in less than 12 weeks or persist for years.[24]

Specific Causative Agents of OA

Although there are hundreds of agents used in the workplace that can cause OA, 50% to 90% of reported cases have been associated with exposure to flour, diisocyanates, latex, persulfate salts, aldehydes, animals, wood dusts, metals, and enzymes.[25] Table 3 lists common etiologic agents divided by HMW and LMW agents.[26] HMW allergens are proteins larger than 10 kDa and are complete allergens. These can be grouped as animal proteins, cereals, plant protein, and enzymes. Of these, laboratory animal allergens and microbial enzymes have the strongest evidence for inducing OA.[27]

In contrast, LMW reactive chemical agents are too small to induce sensitization alone but form allergenic determinants by conjugating with protein carriers in vivo.[28] Occupational exposure limits for causative reactive chemicals are largely unknown and, as mentioned earlier, there is a lack of quantitative exposure data that can define dose-response effects.[29–31] Certain HMW agents such as flour, latex, α-amylase, and isocyanates have sufficient data for regulatory agencies (eg, Occupational Safety and Health Administration) to establish permissible limits of exposure.[32] However, exposure to the agents at the permissible limits do not prevent sensitization to occupational allergens. Even if exposures are tightly controlled by industrial hygiene, sensitization can occur from intermittent exposures including inadvertent skin exposure or higher than normal ambient exposures during maintenance procedures, spills, or accidents. The exception to this is the detergent industry that successfully implemented exposure control measures to decrease ambient enzyme exposure from an established limit of 60 ng/m^3 to a safer level of 5 to 15 ng/m^3, which successfully eliminated work-associated respiratory symptoms and decreased sensitization.[33–36]

Diisocyanates

Diisocyanates have been ranked among the top 10 reported causes of new cases of WRA in the United States.[37] Individuals who work with plastics, polyurethane, paints, adhesives, sealants, and foam coating can be exposed to diisocyanates, including toluene diisocyanate, methylene diphenyl diisocyanate, and hexamethylene diisocyanate.[8,27,38] A descriptive study found that 21% of participants working in plants that manufacture toluene diisocyanate met symptom or lung function criteria prompting an evaluation.[39] However, rigorous studies of diisocyanate exposure indicate 5% to 10% prevalence of OA.[28] The risk of developing OA can be associated with increased cumulative toluene diisocyanate exposure.[40] Isocyanate oligomer-derived triamines detected in the urine of exposed automobile workers exposed to hexamethylene diisocyanate paints have recently been developed as a biomarker for monitoring isocyanate-exposed workers.[41]

Cleaning Agents

Cleaning agents have been reported to cause 5% of new cases of WRA in the United States.[37] Gotsev et al[42] noted a general decrease in new cases of OA in manufacturing workers while there was an increased number of new cases attributable to cleaning agents and dust among employees in health care and education over 15 years in their Canadian occupational clinic. Available evidence suggests that exposure to cleaning agents can trigger WAA and can cause OA. The use of disinfectants (formaldehyde, glutaraldehyde, hypochlorite bleach, hydrogen peroxide, and enzyme-based cleaners) has been associated with worse asthma control in nurses[43] and regular cleaning with bleach has been associated with asthma in young adults.[44] Regular use of hypochlorite bleach has been associated with bronchial hyperresponsiveness and chronic cough in women with nonallergic asthma.[45] Another study determined that cleaners are at increased risk of developing WRA, confirmed in 46% of those with respiratory symptoms, of whom one-third were considered to have WAA and 20% were considered to have OA.[46] Exposure limits for cleaning chemicals are not known, but low levels of measured exposure to hydrogen peroxide, peracetic acid, and acetic acid have been associated with ocular and respiratory symptoms in cleaners.[47] Although unproved, possible product misuse by inappropriately mixing bleach and acid could play a role in respiratory illness among cleaners.[48,49]

Exposure to Laboratory Animals

A recent surveillance study estimated that approximately 12% of workers are exposed to animals, fish, and/or shellfish.[50] Laboratory animal allergens are strong sensitizers.[27] Simoneti et al[51,52] reported that the likelihood of laboratory animal sensitization was significantly associated with duration of exposure exceeding 2.85 years. Laboratory workers who left the workplace had a higher mean exposure to mouse antigen compared with those who continued to work, although it was unknown whether those leaving did so because of work-related symptoms.[51,52]

Bakers Exposed to Flour-Related Antigens

Those who work in food industries (pasta factories, pizza bakeries, cake and cookie factories, restaurant kitchens, or malt factories), animal feed plants, and agriculture are exposed to flour dust. In 1994, DeMers and Oris[53] reported relatively high mortality among US bakers with asthma-like symptoms. Cereal proteins in larger particles and fungal α-amylase can induce sensitization leading to the development of OA and rhinitis.[54] Less is known about the effects of the smaller flour particles, which can reach the alveolar region, possibly contributing to allergic alveolitis.[55] A recent Finnish study characterized the finer particles and found that the breathing zone of bakers contained 9% to 15% of fine nanoparticles that are inhalable. The large particles consisted mainly of phosphorous, potassium, nitrogen, sulfur, carbon, and oxygen, whereas the smaller particles contained mostly carbon with small amounts of silicon or sulfur.[56]

Modifying Exposure in the Work Environment and Managing of the Worker With WRA

In the individual patient with moderate or severe WRA, avoidance of the cause or trigger at work is the primary treatment. For severe asthma associated with chemical or protein sensitizers, this could require leaving the workplace or relocating to an area lacking

Table 3
Major Causes of Occupational Asthma and Rhinitis[a]

Agent type	Source	Workers/occupations at risk
High-molecular-weight agents		
Animals	laboratory animals (mice, rats)	laboratory workers
	cows, swine	farmers
	chicken	poultry worker
Arthropods	locust, fruit fly, grasshopper	laboratory workers
	silkworm	silk workers
Seafood	crustaceans	seafood processors, fisherman
	red soft coral	fish handlers
Acarian	mites (grain, fowl, tree)	farmer, grain-store worker, flour handler
Flour	wheat, rye, soya, barley, buckwheat	bakers, food processor, millers, pastry makers, dock workers
Pollens	bell pepper, cauliflower and broccoli, chrysanthemum, rose, *Helianthus annuus*	greenhouse worker, vegetable planter, processing worker, culture of roses
Plant protein, derived products	grain dust, coffee bean, soybean, tea	grain elevator, food processor
	flowers	flower industry
	weeping fig	plant keeper
	latex	glove manufacturer, health professional
Enzymes	*Bacillus subtilis,* Esperase	Detergent industry
	α-amylase, phytase, amyloglucosidase, and hemi-cellulase	bakers, baking products manufacture, technician food industry
	lactase	pharmaceutical industry
	empyreanase	hospital personnel
	vegetable gum (acacia, guar)	printer, carpet manufacturer
Low-molecular-weight agents		
Diisocyanates	toluene diisocyanate (TDI)	plastics, varnish
	diphenylmethane diisocyanate	foundry
	methylene diphenyl diisocyanate (MDI)	polyurethane
	hexamethylene diisocyanate (HDI)	spray painter
	combination of diisocyanates	chemical manufacturing, paint
Anhydrides	phthalic anhydride	production of resins, plastics
	trimellitic anhydride	epoxy resins, plastics
	methyl tetrahydro-phthalic anhydride (MTHPA)	electrical plant
	hexahydrophthalic anhydride (HHPA)	chemical workers, electrical plant
Aliphatic amines	ethylene diamine	shellac hardener
	ethylene diamine tetraacetic acid (EDTA) and sodium salt	cleaners and health care professional
	hexamethylene tetramine	lacquer handler
	aromatic polyamine	chemical factory
	monoethanolamine	beauty culture
	3-(dimethylamine)propylamine (3-DMAPA)	ski manufacturer
	piperazine hydrochloride	pharmaceutical, chemist, chemical plant
	N-methylmorpholine	chemical manufacturing
	paraphylene diamine	dye (fur and hair)
Fluxes	colophony	electronic worker, manufacturer solder
Wood dust and bark	fernambouc	bow making, furniture/cabinet, carpenter
	cinnamon (*Cinnamomum zeylanicum*)	store
Metals	platinum	platinum refinery, hard metal grinder, diamond polisher
	cobalt	metal welder
	chromate and nickel	hard metal plant (metal alloy production
Drugs	penicillin	pharmaceutical
	cephalosporin	pharmaceutical
	phenyl-glycine and chloride anhydride	pharmaceutical
	psyllium	laxative manufacturer, pharmaceutical, health personnel
	spiramycin	pharmaceutical
	ipecacuanha	pharmaceutical
	opiate compounds	pharmaceutical
Reactive dyes	reactive dye	reactive dye manufacturer, textile dye house
	carmine	dye manufacturer
Biocides	glutaraldehyde	health care worker (endoscopy unit)
	chloramine	chemical manufacturer, cleaner, brewery
Chemicals	polyvinyl chloride	meat wrapper
	persulfate salts (ammonium, potassium, sodium)	hairdresser
	diazonium salt	fluorine polymer precursor manufacturer
	azobisformamide	plastics, rubber
Miscellaneous	formaldehyde	hospital staff
	methyl-acrylate and cyanoacrylate	adhesive
	ethoxylated-2-bisphenol-adiacrylate	autobody shop
	triacrylate (unspecified)	printing

[a]Adapted from CNESST, Quebec, Canada.[26]

exposure to the offending substance. Complete remission of diisocyanate asthma is possible with an early diagnosis and timely elimination of exposure.[57] For RADS, affected workers can continue to work provided that adequate measures to prevent future accidental high-level irritant exposures are in place.[10]

In work environments where known sensitizers are used in industrial processes, exposure control measures can be implemented. Substitution of an alternative agent with less potential for sensitization is a preferred option. For example, substitution of hexamethylene diisocyanate with an epoxy paint process might

be effective in preventing or decreasing new cases of OA. In modern plants engaged in metal painting, use of robotics in ventilated paint booths has eliminated or significantly decreased human exposure to diisocyanates. In the manufacture of detergents using allergenic microbial enzymes (eg, fungal amylase), new cases of enzyme sensitization and OA have been substantially decreased by substituting powdered enzymes with liquid or encapsulated enzyme ingredients, thereby eliminating biologic skin and respiratory exposure in detergent workers.[58] Most enzyme-sensitized detergent workers reportedly had persistent asthma after leaving the workplace.[59] The widespread substitution of powdered latex gloves with low-protein non-powdered gloves has been highly effective as a primary prevention measure in eliminating natural rubber latex allergen sensitization, contact urticaria, and OA in health care workers.[60,61] In fact, Heederik et al[62] conducted a systematic review of 29 primary prevention studies and concluded that exposure elimination of a causative agent is the most effective intervention for lessening the burden of OA.

Strategies aimed at decreasing exposure in people who work with laboratory animals include the use of personal protective equipment that has been shown to alleviate symptoms. Even with these protective measures, it is often impossible to entirely avoid exposure in this work setting, because workers might still have intermittent exposure to animal allergens when removing exhaust filters from ventilated cages or might decide not to adhere to safety practices.[63,64] Of note, minimizing measures have been found to alleviate symptoms but have not been shown to have a significant effect on lung function.[65]

Protection of individual workers who must work with LMW chemicals is challenging. Air-supplied respirators and respiratory masks can leak and many workers cannot tolerate uncomfortable protective equipment during an entire work shift. In a cohort of workers exposed to an acid anhydride chemical sensitizer, Grammer et al[66] reported a lower incidence of chemical sensitization and OA in workers using respiratory protection devices vs those who did not.

A recent systematic review evaluated 52 published studies on management and outcomes of WRA, concluding that complete avoidance of exposure is more effective than partial mitigation; persistent exposure is likely to lead to worsening asthma; and personal protective equipment does not provide complete protection. Any intervention meant to decrease exposure requires careful medical monitoring to ensure that worsening asthma can be promptly detected.[65]

Conclusion

This review highlights the need for allergists to incorporate an occupational history as part of the routine evaluation of all working patients with asthma and/or rhinitis so that new cases of WRA can be evaluated and managed appropriately.

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