Paediatric respiratory health

The importance of taking an environmental history

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With asthma and chronic respiratory disease increasingly prevalent in Australia, intervention in early life is imperative to reducing lifelong disease risk. Doctors who treat children should be aware of the consequences of important environmental exposures in childhood and ask about these when appropriate.

Key points

- **Modern Australian environments contain an increasing variety of chemicals and produce emissions that increase the risk of chronic respiratory disease, yet awareness of these risks is low.**
- **There is growing evidence that fetal and early-life exposure to air pollutants and other environmental contaminants increase lifelong risk of chronic disease**
- **Childhood exposure to toxicants can occur from the environment (e.g. contamination of air, water and soil), in the home and at school or childcare (e.g. cleaning and personal care products, candles and incense, and heaters), and ambient air (e.g. bushfires, motor vehicles and industrial emissions).**
- **Environmental history taking is key to identifying exposures that can increase the risk of chronic disease and exacerbate existing respiratory conditions in paediatric patients.**

The global pattern and major causes of disease have changed over recent decades. A recent Lancet Commission on pollution and health showed that pollution, in its broadest sense, was the largest cause of disease and premature death in the world.[1] Globally, early childhood deaths and deaths from communicable, maternal, neonatal and nutritional disorders have declined. By contrast, deaths from noncommunicable diseases (NCDs) are increasing, accounting for 70% of all deaths globally today.[2,3] A recent landmark decision from a UK coroner listed air pollution as a contributing cause of death in a 9-year-old asthmatic girl.[4]

The situation in Australia is no different, with a high incidence of chronic disease including obesity, type 2 diabetes, cardiovascular disease, neurobehavioural problems, asthma and chronic obstructive pulmonary disease (COPD). Thirty-one percent of people in Australia report having asthma or chronic respiratory conditions, with an economic cost of $9 billion per annum in direct and indirect costs.[5] As asthma and chronic respiratory disease become more prevalent in Australia and the Pacific region, the future costs of diagnosis and treatment will increase dramatically. To alter this trajectory, we need to intervene to reduce exposure to pollutants that cause adverse respiratory outcomes in early life and lifelong disease risk.

Sources of environmental toxicants

Modern Australian environments contain an increasing variety of chemicals and produce emissions that increase the risk of chronic respiratory disease. However, awareness of the risks and avoidable exposures is low, especially in environments in which children spend most of their time in early life (e.g. domestic, preschool care and school). Low awareness among the public, childcare workers, teachers and healthcare professionals contributes to human behaviours that perpetuate and even increase exposures to these pollutants.

RESPIRATORY MEDICINE TODAY 2021; 6(2): 26-28

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1. Common sources of toxicant exposure

Environmental exposures include air, water, soil and the food chain contaminated by pollutants emitted and discharged from:

- small and large-scale industries
- agricultural activities
- storm water discharges
- transport vehicles
- waste management practices

Modern household chemical exposures include:

- plastics and plasticisers, such as food packaging, food containers and mobile devices
- flame retardants, such as those used on furniture and household electronics
- pesticides, such as insect sprays and bombs
- cleaning products, such as those containing bleach
- personal care products, such as hair sprays and deodorants

Sources of particulate matter and irritant or oxidant gases inside homes include:

- the use of wood stoves or heaters, including slow-combustion types
- burning incense, candles and mosquito coils
- aerosolised air fresheners and cleaning products

Ambient air exposures include combustion-related products from:

- traffic-related air pollution
- wood smoke
- bushfires
- coal-fired power generation
- industrial emissions

2. Taking an environmental history

Questions to consider when taking an environmental history of a child include:

- Has there been any exposure to tobacco and other smoke, including vapour from electronic cigarettes?
- Has the child been exposed to incense burning, e.g. in religious altars?
- Is there frequent use of mosquito coils in the home?
- What type of heating is used at home/school/daycare: slow-combustion wood fires, open fires, unflued gas heaters?
- Do you use air purifiers with HEPA filters, which may reduce particulate exposure from wood smoke (internal or external)?
- Do you use strong smelling air fresheners or cleaning products, especially aerosol products at home?
- Have there been recent renovations or painting, new particle board furniture, new floor coverings in the home?
- Consider parent/guardian occupations – are contaminants brought into the house on work clothes?
- Are there any combustion sources in the backyard or immediate neighbourhood?
- Does the child live/go to childcare or school close to a busy road, especially one carrying heavy vehicles?
- Does the child spend significant time in another care situation? Do those carers smoke? What other exposures exist in that environment?

Most populations across Australia are exposed to varying amounts of environmental toxicants. Unlike in the USA and UK, Australia has no systematic assessment of environmental exposures and exposure pathways, or the health consequences of these exposures for our domestic population and for that of our regional neighbours. This means that, to some extent, we rely on overseas data. The problem with this is that exposures are very heavily influenced by the environment in which they occur and international data are not always relevant to local conditions.

Exposure to toxicants in childhood

Growing evidence indicates that fetal and early-life exposure to air pollutants and other environmental contaminants increase lifelong risk of chronic disease through mechanisms including endocrine disruption, epigenetic changes and disruption of innate immune defences.[6-8] Transplacental transfer, breastmilk, dermal transfer and non-nutritive ingestion result in unique exposure pathways during fetal development and in early life. Young children interact with the environment in their homes and in educational/childcare establishments through breathing air, consuming food and water and through 'mouthing behaviours' in which they put their hands, feet and fomites into their mouths, resulting in non-nutritive ingestion of toxicants. Because of their physiological differences, children get a higher 'dose' of toxicants from any contaminated environment than do adults.[9]

Exposures from the environment, modern household chemicals and ambient air are summarised in Box 1. Environmental exposures can potentially increase exposure to pollutants in communities living or recreating in affected areas, and adverse respiratory health effects from exposure to modern household chemicals have been reported.[10-13] Some sources of particulate matter (PM) and irritant or oxidant gases inside homes can emit small particles with mass median aerodynamic diameter below 2.5 microns ($PM_{2.5}$) that are associated with increased respiratory disease.[14-21] Air fresheners and cleaning products, especially those delivered as aerosols, can result in exposures to volatile organic compounds (VOCs) and $PM_{2.5}$.[20,22] Less obvious sources such as burning scented candles also increase VOCs and $PM_{2.5}$ in indoor environments.[19]

Children may also be exposed to toxicants in other environments in which they spend considerable time, such as childcare settings, kindergartens and schools. Family daycare may involve young children spending long periods each day in another home, with all the potential exposures encountered in homes. The use of unflued gas heaters has been a particular problem in some states and territories, and even those labelled 'low NOx' heaters, which supposedly emit lower levels of nitrogen oxides, can cause significant respiratory illnesses in exposed children.[23] Childcare environments may also have significant sources of VOCs and $PM_{2.5}$, resulting in increased exposure and poor respiratory health.[24] Longitudinal community studies of children exposed to toxic environmental exposures associated with living in the vicinity of the Hazelwood mine fires in Victoria highlight long-term health risks.[25]

3. Childhood respiratory conditions, environmental contributors and mechanisms of action

Respiratory conditions sensitive to environmental exposure

- Persistent asthma not responding to first-line therapy
- Recurrent respiratory infections, e.g. otitis media, rhinosinusitis, 'bronchitis', pneumonia
- Frequent respiratory exacerbations of cystic fibrosis
- Recurrent respiratory infections in children with cerebral palsy
- Frequent school absenteeism due to respiratory illnesses

Exposures increasing the risk of respiratory conditions

- Tobacco smoke, electronic cigarette vapour
- Combustion sources inside the home including incense, wood stoves, slow-combustion wood heaters, mosquito coils, candles
- Volatile organic compounds (VOC) from paints, particle board furniture, air fresheners, household cleaning chemicals, nitrous oxide from gas cooking
- Penetration of ambient air pollution inside the house, school or daycare including traffic-related air pollution and industrial exposures, e.g. volatile organic compounds from petroleum refineries
- Smoke from bushfires or planned burning activities, backyard fire pits, incinerators or other combustion sources
- Unflued gas heaters in schools
- Ambient air pollution in the playground

Mechanisms

- Direct irritation of respiratory epithelium increasing epithelial permeability
- Induction of oxidative stress
- Impairment of innate immune responses increasing susceptibility to respiratory infections
- Neutrophilic inflammation

Susceptibility to toxicants in childhood

Not all children are equally susceptible to the health consequences of adverse environmental exposures. The lungs have well-developed defences against irritant and oxidant stimuli, especially those inhaled from the external environment. Many components of the antioxidant defences are under genetic control and low or null-function mutations are relatively common. Individuals with such mutations are more susceptible to the adverse health effects of oxidant particles and gases such as those contained in traffic-related air pollution.[26,27] There is some evidence that breastfeeding and dietary or supplemental antioxidants can decrease the adverse respiratory effects of traffic-related air pollution.[28] However, much of this evidence is not of sufficient strength to actively advocate the widespread use of antioxidants in all patients.

Environmental exposure history

Given this background, what is the relevance for GPs and what should they do in everyday practice? GPs are already aware of the importance of asking patients about cigarette exposure, especially when dealing with children with respiratory disease. This is one simple example of taking an 'environmental exposure' history, as outlined in Box 2. As should be evident from the discussion above, taking an environmental exposure history needs to go further than simply asking about smoke exposure.

Although most children presenting with respiratory illnesses may not have a significant environmental contribution to the illness causation, an awareness of when to be on alert is helpful. Box 3 outlines circumstances in which doctors caring for children should consider an environmental contribution to the presentation and take an environmental exposure history. A real-life case scenario of a child with sudden onset of severe asthma is presented in Box 4.

4. Case scenario. A 6-year-old with acute severe asthma

Georgia (not her real name), a 6-year-old girl, was admitted to intensive care in February 2019 (when she was 4 years of age) with a sudden onset of severe asthma requiring intensive treatment with oxygen, intravenous salbutamol and corticosteroids. She responded well to treatment and her acute asthma settled over 12 hours and she was asymptomatic on discharge two days later. She recovered from her acute asthma well and was completely asymptomatic with a normal chest examination one month later on no asthma medication.

The following February, Georgia again developed acute severe asthma requiring admission to intensive care, supplemental oxygen and intravenous salbutamol and corticosteroids. Again, she responded quickly to treatment and was discharged from hospital asymptomatic two days later.

Georgia has a history of mild episodic wheeze that is worse in summer, but no severe attacks before 2019. She had mild wheeze on two previous occasions – both with an obvious upper respiratory tract infection during winter that responded to inhaled salbutamol delivered via a spacer.

An environmental history reveals that Georgia lives with her parents on a farm growing table grapes. Her father is responsible for managing the vineyard and uses sulphur powder to prevent mildew on the grapes. The day before both acute asthma episodes, Georgia had been in the shed with her father watching him prepare the sulphur for use. The family are counselled about the irritant effects of sulphur and Georgia is now banned from the shed. She has not had any further episodes of acute severe asthma.

Conclusion

Although the management of respiratory conditions in children is usually straightforward, when first-line management is not working clinicians should question whether adverse environmental exposures may be playing a role. Taking an environmental history is simple and should not add much time to a consultation. However, the pay-off may be large. When children with asthma are exposed to sources of pollution that the family can not reduce, such as ambient air pollution, adherence to preventive treatment regimens becomes even more important for maintaining good respiratory health. **RMT**

References

A list of references is included in the online version of this article (www.respiratorymedicinetoday.com.au).

COMPETING INTERESTS: None.

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