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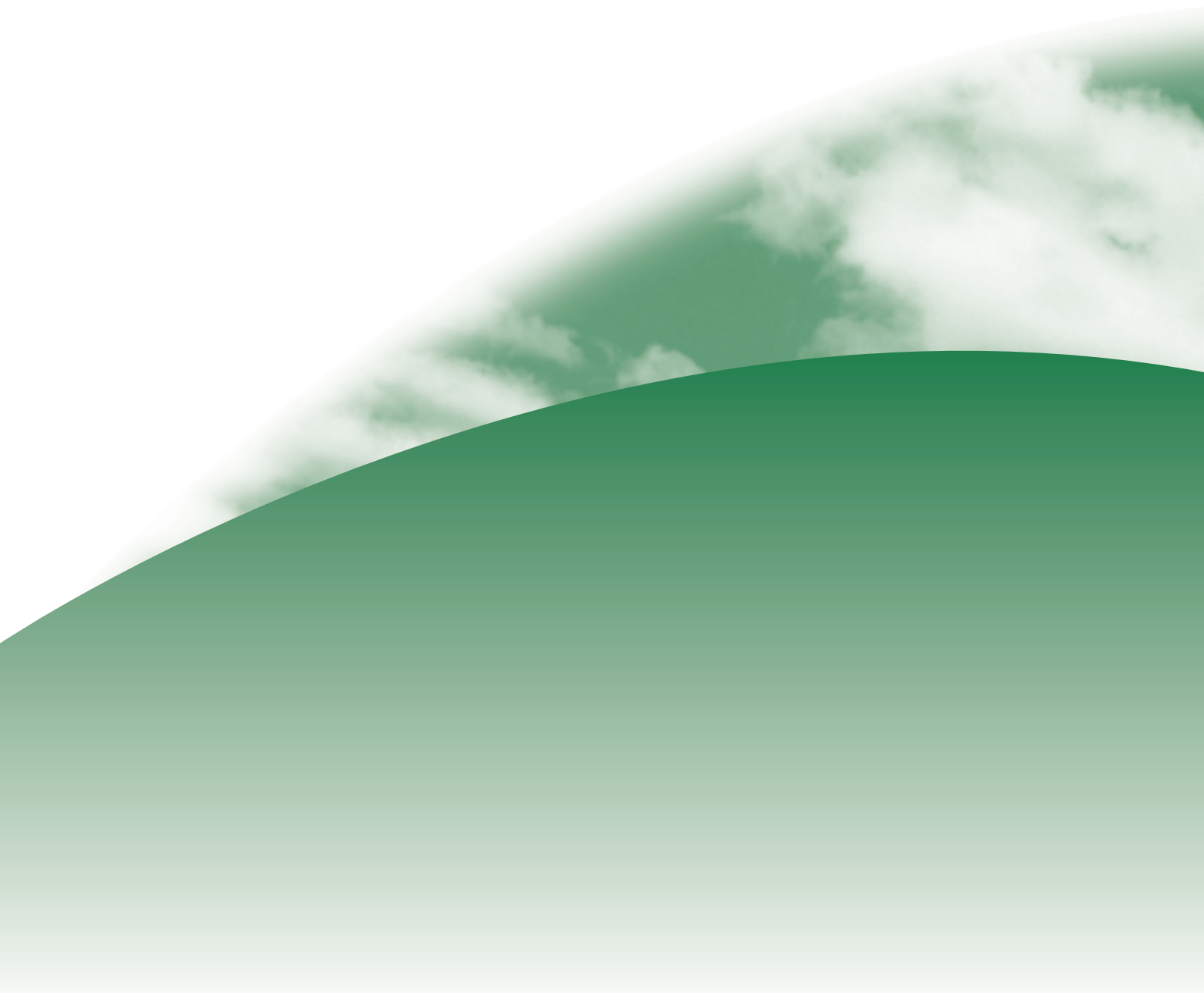
Asthma
and Air Pollution

A guide for health professionals



Asthma
and Air Pollution

A guide for health professionals

This publication is dedicated to the memory of Professor Ann Woolcock AO

The aim of this paper is to provide an up-to-date, evidence-based summary of the issues around asthma and air pollution, including practical advice. There is also a consumer brochure on this topic. These documents have been produced by the Australian Government Department of Health and Ageing in collaboration with the National Asthma Council.

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Contents

Disclaimer

The information contained in this paper has been expert reviewed and represents the available published literature at the time of review. It is not intended to replace professional medical advice. Any questions regarding a medical diagnosis or treatment should be referred to a medical practitioner.

Australian Government
Department of Health and Ageing

NATIONAL ASTHMA COUNCIL AUSTRALIA

Key messages

- There is no evidence that air pollution causes asthma, but it can trigger attacks in people who have asthma.
- Significant outdoor air pollutants for people with asthma are: airborne particles, sulphur dioxide, nitrogen dioxide and ozone.
- People with asthma in urban areas can be advised to remain indoors on smoggy days and, if outdoors, to avoid heavy exertion.
- Significant indoor air pollutants for people with asthma are: environmental tobacco smoke, formaldehyde, nitrogen dioxide and volatile organic compounds.
- Smoking by either parent – particularly by the mother – increases the risk of asthma in children. Doctor-diagnosed asthma is more common among non-smoking adults exposed to environmental tobacco smoke than those who are not exposed.
- People with asthma should avoid smoking and exposure to environmental tobacco smoke indoors and in confined spaces such as cars.

Introduction

Air pollution is often mistakenly thought to be a major environmental problem and a possible explanation for the high prevalence of asthma in Australia. While there is no evidence that air pollution causes asthma, it can trigger attacks in people who have asthma. Many studies have found a link between some air pollutants and the worsening of asthma symptoms.

The impacts of air pollution are especially severe when high levels of outdoor pollution are combined with high levels of indoor pollution.

Important outdoor air pollutants are: particles, sulphur dioxide, nitrogen oxides, ozone, carbon monoxide and lead.

Indoor air pollution arises from both outdoor pollution and indoor sources. Indoor air pollutants are either biological or chemical. Fungi, bacteria and allergens from house dust mites, cats and cockroaches are important indoor biological pollutants[1]. Significant indoor chemical pollutants are: environmental tobacco smoke, formaldehyde, nitrogen dioxide and volatile organic compounds.

[1] Information on indoor biological pollutants and their health effects can be obtained from the brochure, *Asthma and allergy: a guide for health professionals*, Australian Government Department of Health and Ageing, 2003.

Health effects of outdoor air pollution

While concentrations of individual outdoor air pollutants are generally low in Australian cities, the combined effect of the pollutants is complex and the health impacts are not restricted to the respiratory system.

The following table lists pollutants with known health effects on people with asthma.

Pollutant group (primary sources)	Known health effects	Other factors contributing to effects
Airborne particles (Combustion of fossil fuel and organic matter, tobacco smoke and exhaust fumes)	• Respiratory tract irritation and infection, allergies • Bronchitis, eye irritation • Exacerbation of respiratory and cardiopulmonary diseases • Asthma requiring hospital admission • Lung cancer	Sulphur dioxide, sulphuric acid, heat and humidity Smoking
Sulphur dioxide (and acid aerosols that form when sulphur dioxide reacts with moisture in air) (Fossil fuel combustion)	• Respiratory tract irritation, bronchitis, bronchoconstriction • Provocation of asthmatic episodes • Exacerbation of cardiopulmonary diseases	Exercise, particles, asthma
Nitrogen oxides (measured as nitrogen dioxide) (Biomass and fossil fuel combustion, tobacco smoke and exhaust fumes)	• Eye irritation • Respiratory tract infection (especially in children) • Exacerbation of asthma, irritation of bronchi • Asthma requiring hospital admission	Exercise, respiratory viruses, asthma
Ozone (Secondary pollutant – traffic, hydrocarbon release, fossil fuel combustion)	• Eye and respiratory tract irritation • Reduced exercise capacity • Exacerbation of asthma • Asthma requiring hospital admission	Exercise, respiratory viruses, asthma

Some of the scientific evidence for these health effects includes:

- A recent European study found that hospital admissions for asthma increase by 1 per cent for every 10 micrograms per cubic metre increase in particles with diameters less than 10 micrometres (known as PM_{10}).<LE III-3[2]>
- Associations between particles, ozone, nitrogen dioxide and asthma hospital admissions have been confirmed in Sydney, Brisbane and Melbourne.<LE III-3>
- A recent study in Darwin demonstrated an association between modest levels of PM_{10} from bushfires and emergency attendances for asthma.<LE III-3>
- Effects of particles on symptoms and lung function have not been confirmed in cohorts of children with asthma.<LE III-2>
- However, other studies involving cohorts of children with asthma have shown clear effects of nitrogen oxides and ozone.<LE III-2> With more sensitive techniques health effects of ozone are observed at ever-lower concentrations.<LE II, III-1>
- Prior exposure to ozone or nitrogen dioxide increases the response to allergens in people with allergic asthma.<LE II>
- Long-term effects of air pollution appear to be related more to bronchitis, chronic obstructive pulmonary disease (COPD) and lung cancer,<LE III-2> than to asthma.

Reducing exposure to outdoor pollutants

The following measures may help consumers to reduce their exposure to outdoor air pollutants:

Smog

- Remain indoors with external doors and windows closed on smoggy days.
- If outdoors, avoid heavy physical activity.<LE III-2>

Bushfires

- Remain indoors and close external doors and windows, unless advised to evacuate.
- If travelling in a vehicle through smoke, close windows and vents and use recirculated air to stop smoke entering the vehicle.
- Wear a dust mask if exposure to smoke cannot be avoided. The mask will need to firmly cover the nose and mouth to stop smoke entering from around the mask.
- Water down any dry dusty areas before trying to clean up after a fire.

[2] The levels of evidence ratings are listed on the back page. The evidence quoted is the highest level of evidence available.

Outdoor air pollutants

People with asthma have more sensitive airways and their lungs respond more to the effects of air pollutants such as particles, sulphur dioxide, nitrogen oxides and ozone. Outdoor pollutants not especially associated with asthma include carbon monoxide and lead. Carbon monoxide is more likely to affect people with heart disease than people with asthma. Lead has become much less of a problem as an air pollutant since most vehicles now run on unleaded petrol.

Airborne particles

Particles suspended in air are a complex mixture of solids and aerosols and their composition and size depends largely on their source, which can be natural (from pollens, bacteria and fungi) or man-made (primarily from combustion sources such as power stations, petrol-and diesel-powered motor vehicles, wood heaters, fireplaces and incinerators).

Respirable particles (PM_{10}, particles with diameters less than 10 micrometre) and fine particle ($PM_{2.5}$, particles with diameters less than 2.5 micrometres) have been attracting recent attention, largely because they can penetrate and be retained in the deepest structures of the lung.

Sulphur dioxide

Although natural sources such as volcanoes contribute to ambient levels of sulphur dioxide, the combustion of sulphur-containing fossil fuels is the primary source of this gas.

Nitrogen oxides

The major source of nitrogen oxides is the combustion of fossil fuels in power stations and motor vehicles. In sunlight, nitric oxide rapidly changes into the secondary pollutant, nitrogen dioxide, although high temperatures (for example, in power plants and gas heaters and stoves) can also lead to nitrogen dioxide being emitted directly.

Ozone

Ozone is a highly reactive gas formed in the lower atmosphere by chemical reactions between nitrogen oxides, oxygen and volatile organic compounds in the presence of sunlight. The pollutants produced are referred to as 'photochemical smog' and ozone is the most important pollutant in this group. Ozone in the upper atmosphere is protective by screening out ultraviolet rays.

Air quality standards

In 1998, the National Environment Protection Council made a National Environment Protection Measure (NEPM) for outdoor air quality which sets national air quality standards for the six major pollutants: particles (PM_{10}), sulphur dioxide, nitrogen dioxide, ozone, carbon monoxide and lead. These standards have been set to protect human health. Air quality is quite good in most Australian cities with only occasional incidences of exceeding the particle and ozone standards.

Air quality index

The Air Quality Index is calculated by converting the measured pollutant concentrations into index values. The lower the index is, the better the quality of our air. There are five categories in the index: Very Good (0-33), Good (34-66), Fair (67-99), Poor (100-149), Very Poor (>150).

Health effects of indoor air pollution

Indoor pollution is characterised by a high concentration of specific pollutants that are of indoor origin. During recent decades, concern about possible health effects resulting from indoor air pollution has increased as the concentration of indoor pollutants in modern buildings has risen to relatively higher levels. Environmental tobacco smoke and mould growth are consistently associated with asthma, but the associations between other indoor pollutants and asthma have not been confirmed.

Indoor air pollution is significant to the health of building occupants from three perspectives:

- Australians, in common with most Western populations, generally spend more than 90 per cent of their time indoors in homes, schools, offices and public buildings.
- Occupants are exposed to outdoor pollution from outdoor air that has entered the building as the result of natural air flow or ventilation systems
- Emissions from sources such as building materials and appliances can cause additional pollution of indoor air.

Environmental tobacco smoke

Environmental tobacco smoke (ETS) is probably the most important indoor pollutant, especially around young children:<LE III-1>

- Smoking by either parent, particularly by the mother, increases the risk of asthma in children.<LE III-2>
- The outlook for early childhood asthma is less favourable in smoking households.<LE III-2>
- Children with asthma who are exposed to smoking in the home generally have more severe disease.<LE III-1>
- Many adults with asthma identify ETS as a trigger for their symptoms.<LE III-1>

Doctor-diagnosed asthma is more common among non-smoking adults exposed to ETS than those not exposed. Among people with asthma, higher ETS exposure is associated with a greater risk of severe attacks.<LE III-2>

Formaldehyde

Formaldehyde is an irritant to the eyes and the upper and lower respiratory tract. Symptoms are temporary and, depending upon the level and lengths of exposure, may range from burning or tingling sensations in eyes, nose and throat to chest tightness and wheezing.<LE III-2>

- Higher formaldehyde exposure levels are more likely to result in more frequent symptoms.<LE III-2>
- Formaldehyde causes an inflammatory response in the airways of healthy children, which may be responsible for respiratory symptoms and declines in lung function.<LE IV>

Nitrogen dioxide

The major source of indoor nitrogen oxide is unflued gas appliances, wood stoves and fireplaces. As a result of tightly closed homes during winter, wood stoves and fireplaces, even when vented to the outside, may cause high concentrations of indoor air pollutants including nitrogen dioxide.<LE III-2> This is likely to happen due to leaks and poor chimney design.

- High indoor nitrogen dioxide exposure causes cough, wheezing and asthma attacks. The magnitude of the effects depends on the concentration and duration of exposure.<LE III-2>
- There is an association between secondary heating sources, such as home fireplaces, heating stoves and kerosene heaters, and respiratory symptoms in infants.<LE III-2>
- High exposure to nitrogen dioxide in the week before the start of a respiratory viral infection is associated with a more severe attack of asthma in children.<LE III-2>
- Replacement of unflued gas heaters with flued gas or electric heaters is associated with significant reductions in symptoms of asthma.<LE III>

Volatile organic compounds

Volatile organic compounds (VOCs) can cause irritation of the upper respiratory tract and airways.

- An Australian study has shown that VOC-free paint causes fewer respiratory symptoms among people with asthma than conventional acrylic paint.<LE II>

Reducing exposure to indoor air pollutants

The following measures may help consumers to reduce their exposure to indoor air pollutants. Where possible:

- Avoid tobacco smoke indoors or in enclosed spaces such as cars.
- Consider using electricity instead of wood fuel or gas for heating and cooking.
- When building or renovating, use natural timber products or wood panels that are certified to emit low levels of formaldehyde.
- Use building materials, paint and furniture that are certified to emit low levels of VOCs.
- Leave several windows open for up to six months following construction or renovation to reduce levels of formaldehyde and VOCs from new materials within the building.

Indoor air pollutants

Environmental tobacco smoke

ETS is a complex mixture that includes some carcinogens and respiratory irritants such as sulphur dioxide, formaldehyde and ammonia.

Formaldehyde

Formaldehyde, a pungent gas, is found in buildings with high quantities of particleboard, fibreboard and plywood (for example, mobile buildings and caravans). It is found in many households and offices in wood-based panels, furniture, glues, dyes, permanent-press clothes, markers, paints and cigarettes.

Nitrogen dioxide and carbon monoxide

These gases are present indoors where unflued gas appliances and wood stoves and heaters with indoor leaks are used.

Volatile organic compounds

VOCs cover a broad spectrum of organic compounds, ranging from about 20 to several hundred in any given sample of indoor air. They are found in new buildings and cars (usually for the first 6 to 12 months following construction).

VOCs are released from most materials, whether synthetic or natural. Highest emissions occur when products are new, and especially if the products are applied wet, such as paints, adhesives or sealants. Long-term emissions, greater than several months, occur from thick materials such as plastic floor coverings and furniture.

Cleaning agents and office equipment are some other indoor sources of VOCs. High indoor VOC levels have been observed in new or renovated buildings and houses with attached garages. Some wool carpets have also shown to produce VOCs.

VOCs are generally present in indoor air at concentrations greater than outdoor air. However, concentrations in homes and offices are generally much lower than in industrial buildings.

Levels of indoor pollutant

Within buildings there are many items, appliances and activities that emit air pollutants. Some air pollutants in buildings come from outdoors. Many outdoor pollutants do not remain airborne when they enter buildings because they become attached to indoor surfaces (called a 'sink process') from which they may or may not be later released. Potentially, indoor air pollutants can greatly exceed outdoor levels. It is important that people with asthma consider this when they seek to use their homes or other buildings as refuges from the effects of outdoor pollution.

Typical ratios for levels of pollutants indoors to outdoors are presented in the following table and show the importance of indoor pollutant sources.

Pollutant	Indoor/outdoor ratio of pollutant levels (range low to high)
Sulphur dioxide	0.1:1 to 1:1.0
Ozone	0.1:1 to 0.7:1
Nitrogen dioxide	Approximately 1:1 (no unflued gas appliances) >1:1 to 5:1 (with unflued gas appliances)
Particles	0.1:1 to 5:1 (depending on indoor particle generation)
Formaldehyde	5:1 to 30:1
VOCs	2:1 to 100:1 (highest ratios in first few months after construction)

The impact of indoor emissions on air quality depends directly on ventilation and air mixing. Traditionally, ventilation rates have been set at levels sufficient to prevent stuffiness and odours from occupants, not to remove indoor emissions. This practice, together with recent efforts to conserve energy, has led to a situation in developed countries where the rate of exchange of indoor and outdoor air has been reduced, particularly in colder climates. Under such conditions, even low emission rates in houses can result in concentrations of indoor pollutants at levels of concern.

Air quality standards

Studies on indoor air quality in Australian buildings have established that people with asthma are likely to experience asthma symptoms where the goals for indoor air pollutants have been exceeded. For example:

- Nitrogen dioxide levels in buildings with unflued gas appliances are estimated to exceed the National Environment Protection Measure (NEPM) standard set by the National Environment Protection Council in 1998.
- Levels of particles (PM_{10}) in most buildings where there is tobacco smoking or wood heating are likely to exceed the NEPM standard.
- Formaldehyde levels in new homes using reconstituted wood-based panels (particleboard, medium density fibreboard, plywood) and in new and established mobile buildings (caravans, mobile homes, offices) have been found to exceed the National Health and Medical Research Council (NHMRC) indoor air goal.
- Levels of VOCs in new and renovated buildings and new cars have been found to exceed the NHMRC goal, decreasing initially, then increasing, but not reaching goals for several weeks to months.

Current issues

Air cleaning devices

Air cleaning devices are available in Australia, especially as stand-alone devices for rooms, and are often marketed with little evidence to support their effectiveness. Such devices need to be able to demonstrate two key factors:

- That they can remove a range of pollutants from air, both gaseous and particulate, with a level of efficiency that is known and maintained over time.
- That they actually treat a sufficiently large volume of room air to cause a significant reduction in pollutant levels. For example, a high-efficiency device will need to treat more than four room volumes per hour if it is to reduce pollutant levels to about 20 per cent.

Gas heaters

Manufacturers of unflued gas heaters have been reducing nitrogen dioxide emissions for several years, producing 'low-nitrogen oxides' heaters for the Australian market. However, even these heaters will lead to nitrogen dioxide concentrations in buildings which are above health-based air-quality guidelines under circumstances where:

- the building ventilation rate is low, or
- the heating capacity of the heater is high relative to the building volume.

Additionally, some of these 'low-nitrogen oxides' heaters have been found to emit formaldehyde as a product of inefficient gas combustion.

Building materials

Wood-based panels use several types of resin in their manufacture which can emit formaldehyde gas for years after manufacture. Homeowners should consider keeping several windows open for the first six months after construction or renovation to counter the emissions of formaldehyde and VOCs from new materials.

Many countries now specify VOC emission limits for building materials and contents resulting in the availability of several hundred low-VOC products. However, this strategy has yet to be instigated by Australian industry.

Information resources

Outdoor air: websites

European Air Quality Guidelines
www.euro.who.int/document/e71922.pdf

An American Guide to Air Quality and Your Health
www.epa.gov/airnow/aqi_cl.pdf

European Union
www.europa.eu.int/comm/environment/air

British Department for Environment
www.defra.gov.uk/environment/airquality/airpoll/index.htm

Health & Clean Air Newsletter
www.healthandcleanair.org

National Environment Protection Council
www.nepc.gov.au/

Indoor air: websites

State of Knowledge Report on Air Toxics and Indoor Air
www.ea.gov.au/atmosphere/airtoxics/sok/index.html

Indoor Asthma Triggers, US Environmental Protection Agency
www.epa.gov/iaq/asthma/triggers

Residential air cleaners
www.epa.gov/iaq/asthma/pubs/airclean.html

Unflued gas heaters
www.dhs.vic.gov.au/phd/0005108/0005108.pdf

Building research in Australia
www.cmit.csiro.au

National Asthma Council

The National Asthma Council website contains information and publications on asthma and has links to other asthma sites.
www.NationalAsthma.org.au

Asthma Foundations of Australia

For further information on asthma and patient materials, contact your local Asthma Foundation on **1800 645 130**, or visit their websites:

www.asthma.org.au
www.asthmasa.org.au
www.asthmatas.org.au
www.asthmaqld.org.au
www.asthmansw.org.au
www.asthmawa.org.au
www.asthmant.org.au
www.asthmaaustralia.org.au

Australian Government

www.health.gov.au/pq/asthma

HealthInsite

www.healthinsite.gov.au

Healthy Homes

www.nphp.gov.au/enhealth/council/pubs/pdf/healthyhomes.pdf

Australasian Society for Clinical Immunology and Allergy

Reliable and up-to-date information on allergy and asthma:
www.allergy.org.au

Levels of evidence

I	Evidence obtained from a systematic review of all relevant randomised controlled trials
II	Evidence obtained from at least one properly designed randomised controlled trial
III-1	Evidence obtained from well-designed pseudo-randomised controlled trials (alternate allocation or some other method)
III-2	Evidence obtained from comparative studies with concurrent controls and allocation not randomised (cohort studies), case-control studies, or interrupted time series with a control group
III-3	Evidence obtained from comparative studies with historical control, two or more single-arm studies, or interrupted time series without a parallel control group
IV	Evidence obtained from case series, either post-test or pre-test and post-test

These levels of evidence ratings have been adapted from *US Preventive Services Task Force (1989), Guide to clinical preventive services: an assessment of the effectiveness of 169 interventions* (ed. M Fisher), Williams and Williams, Baltimore, Appendix A, p 388.

Source: NHMRC
A guide to the development, implementation and evaluation of clinical practice guidelines.

This series on Asthma Topics for Health Professionals comprises eight separate titles:

1 Asthma and Allergy
2 Asthma and Lung Function Tests
3 Asthma and Pain Relievers
4 Asthma and Air Pollution
5 Asthma and Complementary Therapies
6 Asthma and Infant Bedding
7 Asthma and Diet in Early Childhood
8 Asthma and Wheezing in the First Years of Life

To access these documents log on to: www.NationalAsthma.org.au or contact the Department of Health and Ageing on **1800 500 053**.