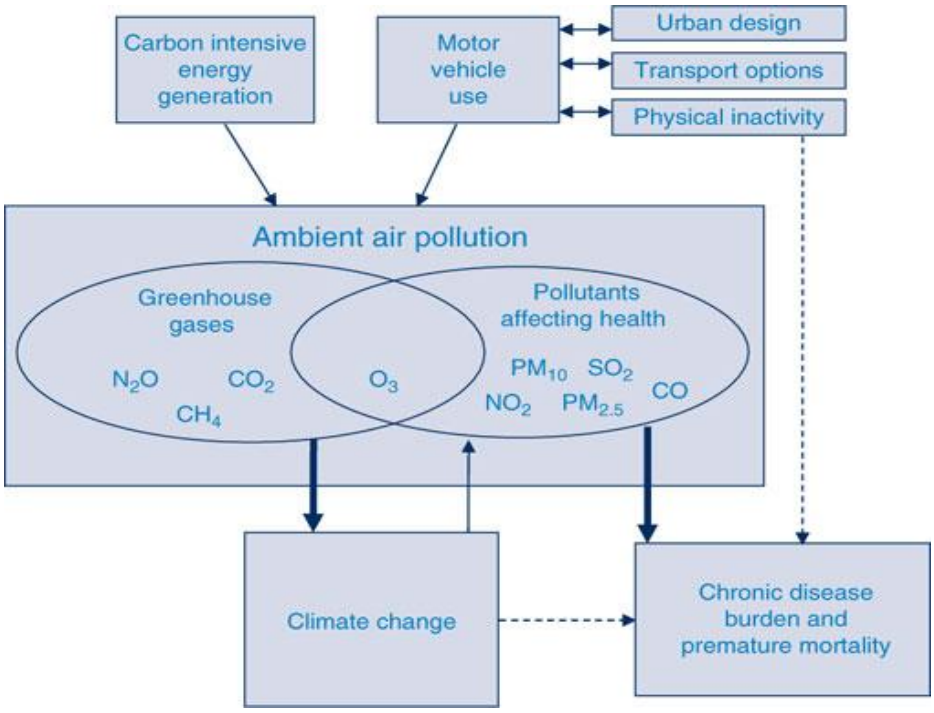
Ambient Air pollution

Ambient pollution* in Australia derives primarily from motor vehicle emissions, electricity generation from fossil fuels, heavy industry especially mining, bushfires, and home heating using wood and coal.[1, 2]

Air pollution is a mixture of thousands of pollutants in particle and gaseous phases which are involved in complex physicochemical processes with each other and affect human health directly or through enhancing climate change.[1, 3, 4]

Schematic representation of the interconnections between climate change, air pollution and chronic disease.[1]



* Ambient air pollution in this document refers to outdoor air. It does not include indoor air pollution, or exposure of workers on industrial sites.

Mortality from ambient air pollution

Air pollution has become one of the major causes of environmentally related mortality and morbidity. Recognising the seriousness of the problem, the United Nations Environment Assembly (UNEA) has called for action to improve air quality throughout the world.[5] Unlike lifestyle factors which individuals can control, exposure to air pollution is largely involuntary and outside of an individual's control.

Pollution has been linked to 7 million deaths annually, and outdoor air pollution has been ranked 11th out of a list of 79 risk factors contributing to the global burden of disease in 2010, leading to increased emergency department visits, hospitalisation and mortality.[6]

Already constituting a major risk, by 2060 outdoor air pollution is projected to cause 6 to 9 million premature deaths a year and cost 1% of global GDP unless action is taken.[7]

Exposure to one air pollutant, particulate matter in the 2.5 micron size class ($PM_{2·5}$) in 2015, caused 4.2 million deaths which was 7.6% of total global deaths.[8]

In Australia, it is estimated that urban air pollution contributes to approximately 3,000 deaths annually – more than double the deaths of the national road toll.[9]

Health effects of ambient air pollution

There is an extensive international body of literature on the health impacts of air pollution, reporting a wide range of adverse health outcomes, including exacerbation of chronic respiratory and cardiovascular disease, and premature mortality. Air pollution worsens asthma and chronic obstructive pulmonary disease and can increase the risk of cardiac arrhythmia, heart attack, stroke and lung cancer, and hinder lung development. This translates to increases in emergency department presentations and hospital admissions, as well as deaths.[2, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22]

Health effects occur even at exposure levels below current air quality guidelines, and for many pollutants it is unclear whether a safe threshold exists. Susceptibility to the effects of air pollution differs. The young and old and those with existing cardiac and respiratory disease are generally most at risk.[2, 10, 11]

Cardiovascular and respiratory effects have been postulated to be due to air pollutants inducing oxidative stress, inflammatory responses, and disturbances in cardiac autonomic control.[17]

The health costs associated with the effects of air pollution in Australia are estimated at between $11.1 billion and $24.3 billion annually solely as a result of mortality. The health cost of particle air pollution in the NSW Greater Metropolitan Area is $4.7 billion per year.[23] The health costs of PM_{10} emissions from road transport in Australia are estimated to be $2-7 billion per year.[23]

Individual pollutants and their health effects

The most common, so called air 'criteria pollutants', regulated by national standards, include particulate matter of varying size (PM), sulphur dioxide (SO_2), nitrogen dioxide (NO_2), ground-level ozone and carbon monoxide (CO).[1, 2, 10]

Particulate matter *(PM)* is generated from coal-fired power stations, mining, wood or vegetation combustion, bushfires, industry and motor vehicles. The size and composition of particles can influence the health consequences. Particulate matter may be coarse or fine (PM_{10}, $PM_{2.5}$: mass concentration of particles with aerodynamic diameter smaller than 10 and 2.5 μm, respectively) or ultrafine (particles smaller than 0.1 μm), and can aggravate chronic respiratory and cardiac disease, damage the lungs and increase the risk of premature death.

Fine particles are able to penetrate further into the lungs than coarser particles and also to enter the bloodstream via the lungs. According to the World Health Organization (WHO) *"Industries, households, cars and trucks emit complex mixtures of air pollutants, many of which are harmful to health. Of all of these pollutants, fine particulate matter has the greatest effect on human health. Most fine particulate matter comes from fuel combustion, both from mobile sources such as vehicles and from stationary sources such as power plants, industry, households or biomass burning".*[24]

In recent years, a large body of new scientific evidence has emerged that has strengthened the link between ambient PM exposure and health effects, particularly in relation to fine particles, which are strongly associated with mortality and other endpoints such as hospitalisation for cardio-pulmonary disease. Short-term PM exposure is linked to reductions in lung function and increased respiratory symptoms. Long-term PM exposure is linked to decrements in lung growth and premature death. Epidemiological studies have been unable to identify a threshold concentration below which ambient PM has no effect on health. Particulate matter has also been linked to adverse birth outcomes.[1, 3, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 25, 26, 27, 28, 29]

Sulphur dioxide *(SO_2)* Coal-fired power stations are a major source of sulphur dioxide. Exposure to sulphur dioxide creates an acute irritant respiratory response with cough and wheeze, especially in asthmatics. Short-term SO_2 exposure is associated with increases in mortality and respiratory and cardiovascular morbidity. It increases asthmatic episodes in children[30] and reduces birth weights.[31, 32] There is no threshold for health effects.[10, 11]

In the atmosphere, SO_2 condenses to form sulphate particles which are a substantial component of $PM_{2.5}$. Although coal fired power stations in Australia are located in regional areas outside capital cities, it is now recognised that gases and particles from coal fired power stations travel hundreds of kilometres and still form a substantial component of ambient air pollution in the large cities. In New South Wales, 87% of SO_2 emissions are derived from coal fired power stations.[33]

Many countries around the world have revised SO_2 standards downwards in recent years in the light of new evidence, for instance the current WHO standard for 1 day average SO_2 is 7.6 ppb, less than 1/10th the Australian standard.[34]

Nitrogen dioxide *(NO_2)* Short-term increases in nitrogen dioxide concentrations have been associated with increases in asthma, hospital admissions and emergency department presentations for respiratory symptoms and increased cardiovascular and respiratory mortality. Long-term exposures to NO_2 are linked to changes in lung growth in children and respiratory symptoms in asthmatic children.[10, 11, 35] The 2012 Australian Child Health and Air Pollution Study examined lung function in 2860 children with various levels of NO_2 exposure and found reduced lung growth in children with higher NO_2 exposure even though all study locations were well within the Australian NEPM standards. This is strong evidence that the NO_2 standard should be revised downwards.[36]

Ground-level ozone *(O_3)* is a secondary pollutant which is formed by reactions of oxides of nitrogen (NOx) and volatile organic compounds (VOC) in the presence of sunlight. Motor vehicles and coal fired power stations are the main sources of these pollutants and in the Sydney Greater Metropolitan Area the latter contribute 52% of NOx.[33] Ozone even affects healthy lungs, causing inflammation, reduced lung function and increased respiratory symptoms. Exposure to ozone is linked to increases in mortality, hospital admissions and emergency department attendances mainly for respiratory causes. There is no evidence of a safe threshold for ozone exposure.[1, 3, 10, 11, 37]

Carbon monoxide *(CO)* is linked to premature death and worsening of cardiovascular disease. Australian studies have found associations between CO at current levels and increases in mortality and hospital admissions for cardiovascular disease. The strongest effects are in the elderly and those with pre-existing heart disease.[10]

The current Australian NEPM standards are shown below, along with the dates they were established or revised.

Pollutant	1 Year	1 Day	8 Hour	4 Hour	1 Hour	Units	Date set or revised
PM_{10}	25	50				$\mu g/m^3$	Dec 2015
$PM_{2.5}$	8	25				$\mu g/m^3$	Dec 2015
SO_2	20	80			200	ppb	1998
NO_2	30				120	ppb	1998
O_3				80	100	ppb	1998
CO			9.0			ppm	1998

Vehicle emissions

The size of the Australian vehicle fleet is increasing with a disproportionate number of diesel cars following a European trend.[38]

The financial cost of the health burden imposed by vehicle pollution in Australia has been estimated at US$5.8 billion (AU$7.7 billion).[39]

Improvements in ambient air quality in Australian cities over the last century were mostly achieved by more stringent vehicle emissions standards and by removing lead from petrol. Further improvement has been delayed.

Australia's standards for vehicles lag well behind European and US standards and are the worst in the OECD, particularly with regard to sulphur which interferes with emission control devices as well as being a pollutant in its own right.[40] In general, Australia has adopted European standards with a lag period of 5 to 10 years to allow the Australian car producers time to adapt. This has at times resulted in the sale of vehicles in the Australian market that would not be acceptable in Europe. The emissions' standards only apply to new vehicles and there are no standards for vehicles in use unlike the UK or California where exhaust standards are checked at annual vehicle inspections. This will be increasingly important as the diesel vehicle fleet ages.

With the cessation of car production in Australia, there is no reason to continue Australian standards that lag those in the rest of the world. Increases in population and vehicle ownership put Australia on a path to worsening air quality unless stricter standards are rapidly adopted, and vehicle km per person per year reduced. Many countries have exhaust emission standards for annual registration checks to remove highly polluting old vehicles from the road.

Detrimental health effects have been documented for people living near busy roads, and public policy to avoid locating schools or child care centres on busy roads would protect child health.

Diesel vehicles

Diesel vehicles have greater emissions of particulates and nitrogen dioxide than petrol cars even when their particulate filters perform optimally.[41] This is especially worrying when vehicles are left idling close to schools, as children's lungs are sensitive to these pollutants. Some countries have already introduced anti-idling laws in urban areas or in proximity to schools and some European cities are taking action to prevent diesel vehicles entering city central areas.

Diesel is classified as a Class 1 carcinogen[42] and may increase the risk of lung cancer and also possibly bladder cancer.

Off-road diesel engines in bulldozers, locomotives and mining machinery are substantial sources of fine particles that are often generated in residential areas. The NSW government has adopted a policy that all equipment purchased under government contracts from 2018 must meet the US Tier 4 standards.[43] As this equipment is not manufactured in Australia,

and we are a small part of the world market, the only sensible approach is to adopt an international standard either from Europe or the US for all off-road diesel equipment in Australia.

Shipping emissions

Ships are a small but important source of fine particle and SO_2 pollution.

Even with new international fuel sulphur rules set for 2020 ship fuel will contain 500 times more sulphur than on-road diesel. As a result, SO_2 and sulphate emissions rise substantially in ports, and along coastlines when onshore winds prevail. Requirements for ships to burn low sulphur distillate fuels in port, or use onshore power would lead to significant sulphate and soot particle reductions.[44, 45] In Newcastle, shipping contributes 2-4% of fine particles and residents near to shipping berths are subject to high levels of pollutants.[46]

Shipping emissions have been regulated in Australia but the regulations are weaker than many other developed countries. Currently the average sulphur content of shipping fuels in Australia is 2.7%. In 2020 the requirement will be a sulphur content of 0.5%. This is still above the MARPOL regulations of 0.1% which are already in place in many jurisdictions. Use of distillate fuels in Australian waters is a low-cost measure[47] which can be easily regulated under the Marine Pollution MARPOL convention.[48]

Bushfires

The highest particulate air pollution readings in Australian cities occur during bushfires, which are becoming more frequent and intense under climate change. Hazard reduction burning is a part of bushfire management, but smoke from this activity can also impact upon human health.[49] Hazard reduction burns should be planned so that the smoke carried to major population centres is minimised.

The Australian Ambient Air Quality standards

The Australian Ambient Air Quality National Environment Protection Measure (AAQ NEPM) sets national benchmarks for air quality monitoring and action by the states. The AAQ NEPM in 1998, set standards for six criteria air pollutants: PM_{10}, ozone, CO, NO_2, SO_2, and lead. The NEPM was varied in 2003 to include advisory reporting standards for $PM_{2.5}$. A review of the NEPM commenced in 2005.

In December 2015, Australia's Environment Ministers established the National Clean Air Agreement to address the impacts of air pollution on human and environmental health.[50]

The agreement's 2-year work plan included strengthening the reporting standards for particles and undertaking a review of the ozone, nitrogen dioxide and sulphur dioxide standards, with a view to strengthen these standards. A mid-term report on progress was produced in November 2016.[51] The SO_2, NO_2 and Ozone standards are now 19 years old and do not reflect current scientific understanding of health effects. Revision is long overdue.

An updated AAQ NEPM PM standard was introduced in February 2016. The amendment included:

- Amending the status of the 8 $\mu g/m^3$ annual average and 25 $\mu g/m^3$ 24-hour average $PM_{2.5}$ 'advisory reporting standards' to 'standards'
- Including an annual average PM_{10} standard of 25 $\mu g/m^3$
- Including an aim to move to annual average and 24-hour $PM_{2.5}$ standards of 7 $\mu g/m^3$ and 20 $\mu g/m^3$ by 2025
- Initiating a nationally consistent approach to reporting population exposure to $PM_{2.5}$

- Replacing the five-day exceedance form of the 24-hour $PM_{2.5}$ and PM_{10} standards with an exceptional event rule.

Currently not all Australian states have the same reporting standards for PM. Victoria and the ACT have set a more stringent annual average PM_{10} standard of 20 $\mu g/m^3$. This reflects World Health Organization guidelines and the recommendations of the National Environmental Health Standing Committee.

Legislative mechanisms to reduce pollution

The transition to a low emissions economy is underway in many developed and developing countries. Doctors for the Environment Australia supports market mechanisms to reduce carbon emissions. The options to bring transition via market mechanisms are a carbon tax, which Australia abolished, or an emissions intensity scheme which was ruled out by the government in 2016. A further option is to extend the renewable energy target.

Accordingly, Doctors for the Environment Australia has proposed a pollution licensing system which will primarily reduce pollution from coal fired power stations and concomitantly reduce their greenhouse emissions.[52]

As there is no threshold below which air pollutants have no effect, the regulation of polluting industries should include financial incentives for cleaner production rather than just setting a cap for the maximum emissions. Regulatory arrangements that drive emissions lower over time will have increasing health benefits. Such systems have been effective overseas, and currently NSW, SA and WA have pollution license systems that impose a fee based on the amount of each pollutant discharged to air or water, but the fees have been set so low as to be ineffective. Increasing these fees to match the health externalities of production would maximise community benefit.[53]

Monitoring and reporting of air quality

Current monitoring and reporting practices for air quality appear inadequate to fully protect public health. Outside of large cities and major regional centres there may be difficulty obtaining independent air quality assessment.[10, 54]

The NSW EPA, for example, has a network of monitoring stations for ambient air that publishes results online in near real time. This is of great benefit to communities concerned about their air quality and can be used to generate public health alerts for people with sensitive medical conditions. There would be public health benefits in extending this model across Australia to all cities, and to smaller communities that host polluting industries.

Action on climate change has the potential to reduce levels of ambient air pollutants, resulting in significant public health gains. Air pollutants that harm health and greenhouse gases frequently stem from common sources. There are a number of 'natural intervention' events which demonstrate health gains that can occur when fossil fuel combustion is reduced e.g. reductions in ozone and asthma events with traffic restrictions during the Atlanta Olympic Games; the ban on coal sales in Dublin reducing particle pollution and mortality from cardiovascular disease and respiratory disease.[1, 55, 56, 57, 58, 59]

Summary

Globally, air pollution is an increasingly important public health problem. Nationally, ambient (outdoor) air pollution contributes significantly to morbidity and mortality. Reductions in fossil fuel combustion to mitigate climate change have the potential to also benefit health by reducing concentrations of air pollutants which contribute to respiratory and cardiovascular disease and premature mortality.

Policy
DEA recommendations are

In relation to air pollution generally:

1. Timely updating and strengthening of national air quality standards in keeping with current scientific and medical evidence. Updating of the NEPM SO_2 standard by the end of 2017 and the NO_2 standard by the end of 2018. Ideally requirements for regular updating of the standards in line with current science and best practice should be embedded in legislation.
2. Uniformity of application of standards across all states and territories so that all Australians have stringent standards to protect health from air pollution.
3. Improved monitoring and public reporting of criteria pollutants, not only in cities but also in communities affected by polluting industries such as coal-fired power plants and coal mining.
4. The results of air quality monitoring should be made public in real time and accessible to communities in a user-friendly format.
5. A uniform national load based licensing fee system that creates a financial incentive for cleaner production processes by imposing substantial costs on industrial polluters in proportion to the quantity of each pollutant released.

In relation to vehicular pollution:

6. Adoption of Euro 6 standards for new light vehicles and Euro VI standards for new heavy vehicles.
7. Vehicle testing under real world driving conditions for all new vehicles, and pollution standards for annual registration inspections.
8. Adoption of strict emissions standards such as the US Tier 4 or the European equivalent for off road diesel equipment including locomotives and mining equipment.
9. Excise on diesel fuel to reflect the health costs imposed by diesel vehicles and/or higher duty paid on new diesel vehicles.
10. Intersectoral policies should be supported that aim to reduce motor vehicle use and increase the use of public transport and active transport.
11. Raising public awareness of air pollution risks and introduction of anti-idling laws around schools.
12. Improve monitoring of pollution for populations at risk (schools, hospitals, aged care centres.
13. Introduction of fiscal measures: stamp duty and registration costs based on greenhouse gas emissions and emissions of toxic pollutants, as in the ACT.

In relation to shipping pollution:

14. Declaration of Emissions Control Areas under Annex VI of the MARPOL convention on marine pollution, mandating the use of low sulphur fuel (0.1% sulphur) within 200 Km of any Australian city.

In relation to pollution from bushfires and controlled burns:

15. Policies which increase controlled burning operations to reduce bushfire risk should encompass health risk assessment to minimise impacts on human health.

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