Notes:

• please add details of the date, time, place and sponsorship of the meeting for which you are using this presentation in the space indicated;

• this is a large set of slides from which the presenter should select the most relevant to use in a specific presentation. These slides cover many facets of the problem. Present only those slides that apply most directly to the local or regional situation. Where relevant, adapt the information, statistics and photos within each slide to the particular context in which this module is being presented. For instructions on how to use this module visit: https://www.who.int/publications/i/item/WHO-CED-PHE-EPE-19-12-02;

• Ambient air pollution is one module from a larger training package focused on children’s environmental health. Consult these other modules where relevant. Throughout Ambient air pollution, a number of different modules are suggested that contain additional relevant information. To see the full package visit: https://www.who.int/teams/environment-climate-change-and-health/settings-populations/children/capacity-building/training-modules;

• Ambient air pollution is part of a selection of modules within the training package that discuss children’s health and air pollution. These include Childhood respiratory diseases linked to the environment, Household air pollution, Indoor air pollution and Second-hand smoke. Consult these modules for relevant additions;

• the World Health Organization (WHO) reference number for the module Ambient air pollution: training for health care providers, third edition is WHO/HEP/ECH/CHE/23.06;

• for more information on WHO’s work on children’s environmental health, please visit: https://www.who.int/health-topics/children-environmental-health.
This module is an introduction to child health and ambient air pollution.

At the end of this presentation, learners should be able to:
• describe the main sources of ambient air pollution;
• recognize major ambient air pollutants;
• identify health effects linked to ambient air pollution;
• recognize strategies to protect children’s health;
• identify methods of advocacy.

It is important to recognize that air pollution is variable, and that each community has unique problems based on its geography, climate, industries, traffic, socio-economic determinants, and a variety of other factors.

Photo:
• © Nick/Unsplash. Pollution from a power plant, Russia.
Note:
When selecting the slides to include in your presentation, please choose only those of relevance to the region and/or interests of your audience.

This training module includes the following sections:
• the magnitude of the problem and children’s special vulnerability to ambient air pollution;
• the main sources of ambient air pollution;
• major pollutants found in ambient air pollution;
• child health effects linked to ambient air pollution;
• interventions at local, national and international levels that can be taken to reduce ambient air pollution, and actions that health care providers can take to protect child health;
• an example of national policy measures to protect children’s health from ambient air pollution.

Photo:
• © WHO/ Yikun Wang. Children doing outdoor activities, China.
This module begins with the magnitude of the problem and some key definitions relevant to ambient air pollution. It also discusses children’s vulnerability and susceptibility to ambient air pollution.

**Photo:**
Air pollution can be defined as the presence in the atmosphere of one or more contaminants, such as dust, fumes, gas, mist, odour, smoke or vapor, in quantities and of characteristics and for durations such as to be harmful to human, animal or plant life (1,2).

There are two primary types of air pollution:

- **Ambient (outdoor) air pollution** refers to air pollution in the ambient environment, that is, in outdoor air, but able to enter the indoor environment (3);
- **Household air pollution** is air pollution in and around the home generated by the use of inefficient and polluting fuels and technologies for cooking, heating and lighting, leading to indoor air pollution and contributing to ambient air pollution (4).

Household air pollution is a type of indoor air pollution. Indoor air pollution is a broader term commonly used to discuss air quality within and around buildings and structures, especially as it relates to the health and comfort of building occupants (3).

**Note:** for more information on child health and air pollution please see *Household air pollution* and *Indoor air pollution*.

**References:**


**Photos:**

- **Top:** © WHO/ Diego Rodriguez. Traditional brick factory, Tunisia.
- **Bottom:** © WHO/ Yoshi Shimizu. A woman prepares lunch in a remote village in Vanuatu.
Particulate matter (PM) is used as a common indicator for ambient air pollution. PM is a complex mixture of solid and liquid particles from organic and inorganic substances suspended in the air (1).

Air quality is typically measured in hourly, daily or annual mean concentrations in micrograms per cubic metre (µg/m$^3$) of $\text{PM}_{10}$ and $\text{PM}_{2.5}$, particles with a diameter of 10 microns or less and 2.5 microns or less, respectively (1).

The map displayed on this slide shows the annual concentration of $\text{PM}_{2.5}$ in µg/m$^3$ in countries around the world in 2019. Countries coloured in darker green have higher annual concentrations of $\text{PM}_{2.5}$ (2). The map displays global disparities in the global concentrations of $\text{PM}_{2.5}$. Certain low- and middle-income countries (LMICs) in the WHO African, Eastern Mediterranean, South-East Asia and Western Pacific Regions had the highest annual concentrations of $\text{PM}_{2.5}$ in 2019.

**In 2019, 99% of the world’s population was living in countries where the World Health Organization’s (WHO) air quality guideline levels were not met** (3).

**Note**: find the annual concentration of $\text{PM}_{2.5}$ in 2019 in your country by visiting: https://www.who.int/data/gho/data/indicators/indicator-details/GHO/concentrations-of-fine-particulate-matter-(pm2-5).

**References**:

**Map**:
- © WHO.
Ambient air pollution is a major, global environmental health threat affecting people in low-, middle-, and high-income countries. Communities in both rural and urban areas are affected by ambient air pollution (1).

People living in low- and middle-income countries (LMICs) disproportionately experience the burden of ambient air pollution and the greatest burden of disease occurs in countries in the World Health Organization’s (WHO) African, South-East Asia and Western Pacific Regions (2). The latest ambient air pollution data reflect the significant role that air pollution plays in cardiovascular disease and related mortality (1).

The map on this slide shows the global ambient air pollution attributable death rate in 2019. Countries coloured in red have the highest death rate attributable to ambient air pollution. The map illustrates the higher death rate found in countries in the African, South-East Asia and Western Pacific Regions. When this map is compared to the map on Slide 6, it is evident that the areas with the highest annual concentration of fine particulate matter (PM$_{2.5}$) also have the highest mortality rates related to ambient air pollution.

Note: find the ambient air pollution attributable death rate in 2019 in your country by visiting: https://www.who.int/data/gho/data/indicators/indicator-details/GHO/ambient-air-pollution-attributable-death-rate-(per-100-000-population-age-standardized).

References:

Map:
• © WHO.
The International Agency for Research on Cancer (IARC) classifies both ambient air pollution and particulate matter (PM), a major component of ambient air pollution, as Group 1 carcinogens, causing cancer in humans (1). In addition to PM, concentrations of ozone (O\textsubscript{3}), nitrogen dioxide (NO\textsubscript{2}) and sulfur dioxide (SO\textsubscript{2}) are important measures of ambient air pollution (2).

In 2019, the World Health Organization (WHO) estimated that 99% of the world’s population was living in countries where the WHO air quality guidelines levels were not met (3,4). Worldwide and across all age groups, the WHO burden of disease estimates in 2019 found that:

- 4.2 million deaths globally were attributable to ambient air pollution (5);
- the overwhelming majority of these deaths (89%) occurred in low- and middle-income countries (LMICs), and the WHO South-East Asia and Western Pacific Regions were the most affected (3);
- almost 161 000 children under 15 years of age died globally from exposure to ambient air pollution due to acute lower respiratory infection, the majority of whom (more than 146 000) were under 5 years of age (6,7).

Environmental action presents an opportunity to reduce child mortality and illness linked to ambient air pollution. Interventions to improve air quality can prevent disease and premature death in children (8).

References:


Figure:
• © WHO.
Ambient air pollution places a considerable burden on the global economy. In 2019, the World Bank estimated that fine particulate matter (PM$_{2.5}$) in ambient air cost the global economy US$ 6.43 trillion due to health damages, including US$ 5.47 trillion in welfare loss due to increased mortality risk from ambient air pollution and US$ 0.96 trillion in lost income due to illnesses from ambient air pollution. This was equivalent to 4.8% of global gross domestic product (GDP) in 2019. Costs to national GDPs due to PM$_{2.5}$ in ambient air in 2019 varied considerably between countries (1).

The World Bank also found that in 2019 the costs of air pollution due to health damage were 40% higher in real terms than they were in 2013 (the previous estimate developed). This is due to changes in exposure-response functions, improvements in methodology and available data, and the inclusion of the cost of morbidity in global estimates (1).

Actions to reduce ambient air pollution will improve health and reduce health-related costs to the global economy (1,2).

References:

Photo:
- © WHO/ Kiana Hayeri. A boy plays with a kite on a hillside in Kabul, Afghanistan. Air pollution in the city below is clearly visitable.
Some common ambient air pollutants are also greenhouse gases and short-lived climate pollutants. These air pollutants may threaten the health of children and contribute significantly to atmospheric warming and, consequently, climate change. Some major air pollutants that also contribute to climate change include (1,2):

- **carbon dioxide**, the most significant air pollutant contributing to climate change. The primary source of carbon dioxide is the combustion of fossil fuels, for example for energy production and transport needs (3);
- **black carbon**, a powerful short-lived climate pollutant which warms the earth’s atmosphere by absorbing sunlight, thereby accelerating the melting of snow and ice. The most significant source of black carbon is fuel combustion for heating, cooking and lighting needs in residential and commercial buildings, and for transport (4);
- **methane**, another short-lived climate pollutant and a precursor to ozone pollution in ambient air. Methane is primarily produced in the agricultural and waste management sectors (4);
- **ozone**, especially relevant during high temperature days and can affect weather patterns. Ozone is not emitted directly, so precursor control measures are essential (ozone is discussed in more detail on Slide 23).

Climate change is having many effects on the environment. It is causing more extreme weather events, such as heatwaves and wildfires, droughts and sandstorms, air pollution events, and severe precipitation, flooding and thunderstorms. These events can contribute significantly to ambient air pollution levels, such as high levels of particulate matter from wildfires and sandstorms, and can exacerbate existing air pollution, such as heatwaves. Immediate solutions to some of the health effects linked with climate events, such as heatwaves and heat-related illness, are reliant on technologies that required intensive combustion of fossil fuels, such as the increased use of air conditioning. The use of these technologies in turn contributes to ambient air pollution, creating a vicious cycle. Additionally, climate change is affecting the distribution, quantity and quality of aeroallergens, such as pollen and spores, and ozone levels. For children with allergic diseases or asthma, there is evidence that climate change is exacerbating disease, causing more high pollen days, and consequently more symptomatic days, and reducing quality of life (5,6).

Interventions to reduce emissions of common air pollutants, including short-lived climate pollutants and greenhouse gases, will have multiple benefits to health and the environment. Reducing these emissions will improve air quality, consequently improving children’s health, and will help mitigate climate change.

**Note:** for more information, see the module *Global climate change and child health*.

**References:**


5. Egiluz-Garcia I, Mathioudakis AG, Bartel S, Vijverberg SJH, Fuertes E, Comberiati P et al. The need for clean air: the way air pollution and climate change affect allergic rhinitis and asthma. Allergy. 2020;75:2170-84.

It is important that health care providers recognize children’s vulnerability and susceptibility to ambient air pollution. Although ambient air pollution is an environmental threat to the health of people all over the world, not everyone is affected equally. Children constitute one group that is significantly more affected by ambient air pollution than others.

In order to understand the risks faced by children related to ambient air pollution it is important to understand the concepts of **susceptibility** and **vulnerability**:

- **susceptibility** refers to innate or acquired physical predispositions which increase the relative risk of experiencing health effects due to air pollution exposure (such as a pre-existing condition or disease). A susceptible population may have an increased response to a concentration of air pollution, in comparison to the general population. Examples of children’s susceptibility to air pollution include their age and developmental status (1,2);
- **vulnerability** refers to people who have increased exposure to air pollution due to either external factors, such as place of residence, socio-economic status or type of occupation, or due to internal factors (3,4).

The next three slides will go into greater detail of the different and unique exposures that place children at increased risk to the adverse health effects of ambient air pollution.

**Note**: for more information, please see the **Children are not little adults** and **Why children** modules.

**References**:
As with many environmental hazards, children are often at increased risk from exposure for several reasons and air pollution is no exception.

Children have different and unique exposures to ambient air pollution when compared to adults. Some pollutants found in ambient air can cross the placenta, exposing the developing fetus to pollution experienced by the mother (1). Some studies have suggested links between prenatal exposure to certain pollutants in the air and adverse birth outcomes (2,3).

As children are small in stature, their breathing zone is closer to the ground where some air pollutants may be at their highest concentration (4).

Furthermore, older children in many cultures tend to spend significant amounts of time outside, often engaging in vigorous physical activity and play, which may increase their exposure to high levels of ambient air pollution (4). Time spent outside is influenced by many factors, including age, geographical region, climate, seasons, weather and industrial and agricultural activities. Whether an area is urban or rural can affect time spent outdoors and the pollutants present in the air, as can the economic development of the region (5). Social and cultural aspects may also influence outdoor activity, the amount of time that a child spends outdoors and the activities they undertake while outside (6).

Note: for more information, please see the Children are not little adults and Why children modules.

References:
5. Review of evidence on health aspects of air pollution: REVIHAAP project technical report. Copenhagen: World Health Organization Regional Office for Europe; 2021 (https://apps.who.int/iris/handle/10665/341712,

Photo:
• © WHO/ Alex Swanepoel. Lady Buxton Preschool group of 4-year-olds and teachers, South Africa.
Children are not little adults

**Dynamic developmental physiology:**
- Anabolic, rapidly growing
- Increased ventilation rate
- Mouth-breathing: by-passing nasal filtration
- Developing immune, respiratory and central nervous systems:
  - Smaller airway passages
  - Windows of vulnerability
  - May not recognize dangerous air pollution
  - Limited ability to move away from pollution

Due to their dynamic developmental physiology children are often subjected to higher levels of pollutants found in ambient air.

Because they are **anabolic and rapidly growing**, children breathe faster and breathe more air per unit of body weight than adults. **Children also have high rates of mouth-breathing**, by-passing nasal filtration, which can also expose them to higher levels of ambient air pollution, including fine particulate matter (PM$_{2.5}$).

Children have **immature immune, respiratory and central nervous systems** and are highly sensitive to environmental stimuli, including air pollution. The **immature respiratory system** is the primary target of air pollution. At birth, a newborn only has 30–50% of the alveoli that will be present in adulthood (3). Alveolar development occurs most rapidly during the first 18–24 months of life, although it may continue until 8 years of age (4). During this period, children have a higher ratio of lung surface area to lung volume than adults, as well as having larger lung surface area to body weight ratio relative to adults. All these factors facilitate increased absorption of particles from air pollution.

**Airway passages in children are smaller than those in adults.** Consequently, inflammation resulting from air pollution causes proportionately greater airway obstruction in children. Inflammation caused by air pollution that may produce only a small response in an adult can result in a potentially significant obstruction in a child’s airways (5).

**Windows of vulnerability** for permanent alternations in lung function persist throughout childhood. While alveolar development is substantially complete by 2 years of age, lung growth continues through adolescence and parallels somatic growth. It is thought to be complete by approximately 18 years of age in females and 20–23 years of age in males (3,4). Until adult systems are fully developed, exposure to air pollution may alter lung development and function in irreversible ways.

Finally, **cognitive immaturity also increases children’s exposure risk to dirty air.** Young children do not know to stay away from sources of air pollution and **may not recognize situations where there are dangerous levels of ambient air pollution**. Children are less likely than adults to cease activity when they begin to have respiratory symptoms, such as bronchospasm, and consequently may have prolonged exposure and become more acutely ill (6).

Adolescents may also engage in risk-taking behaviours that may place them at increased exposure to ambient air pollution (7).
Note: for more information, please see the *Children are not little adults* and *Why children* modules.

References:
Children have longer life expectancies than adults and consequently chronic conditions developed in childhood can affect the entire lifespan. Chronic illnesses can prevent children from attending school, which may affect academic achievement, future opportunities and economic possibilities in adulthood. Furthermore, health effects due to air pollution have time to manifest for diseases with long latency periods. Exposure to air pollution early in life may affect children’s health and development for years to come (1,2).

Finally, children depend upon adults to provide a safe environment in which to grow, develop and thrive. Pre-ambulatory children are unable to remove themselves from situations where high levels of ambient air pollution are present and children have limited choice in the locations where they live, play and learn. Children have limited agency to affect the political decisions made at local, national and international levels that may affect the air pollution levels in their environment. Children trust the adults in their lives to nurture and protect them through actions and decisions until they can protect themselves through their own individual, collective and political action (1,3).

Note: for more information, please see the Children are not little adults and Why children modules.

References:

Photo:
- © WHO/Alex Swanepoel. Lady Buxton Preschool group of 4-year-olds and teachers, South Africa.
The next section of this training module discusses the main sources of ambient air pollution.

**Photo:**
Sources of ambient air pollution are a global challenge and may differ significantly from region-to-region and from context-to-context.

There are seven primary sources of ambient air pollution (1,2):

- **Industry and energy supply**, which include the combustion of fossil fuels;
- **Transport**, such as planes, lorries and personal vehicles using fossil fuels;
- **Waste management**, especially open burning practices;
- **Household combustion devices and polluting fuels**, used for heating, cooking and lighting in homes;
- **Agricultural practices and livelihood**, which may include controlled burning of biomass and uncontrolled forest and savannah fires;
- **Dust and dust storms**, which can contribute significantly to concentrations of particulate matter (PM) in the air (3);
- **Wildfires**, which can release significant amounts of hazardous pollutants and greenhouse gases into the atmosphere, including PM$_{2.5}$ and carbon dioxide (4).

Sources of ambient air pollution may differ significantly between regions and between urban and rural areas. However, crossover effects link all types of air pollution. Air pollution levels are closely linked to human activities, the climate, weather events and topography. Some examples include:

- episodes of heightened air pollution can be particularly problematic if the affected area is in a valley surrounded by mountains, which can have the effect of trapping air pollution within the area;
- surfaces, such as roads that are made of gravel, dirt and asphalt, can generate air pollution when cars and lorries drive on them, contributing to ambient air pollution (5);
- in arid regions, windblown soil and dust caused by dust storms can significantly increase PM concentrations in the air (3);
- in areas where waste management is poor, open burning practices are frequently used to dispose of unwanted waste, including hazardous waste such as electrical and electronic waste (e-waste), lead-acid batteries and plastics. Burning hazardous waste can cause the release of many toxicants into the air (6);
- the use of polluting fuels and technologies for household cooking, heating and lighting is a major contributor to local air pollution levels (1).

**Note**: highlight the major sources of ambient air pollution in your community or region.

**Note**: for more information, please see the Household air pollution module.
References:

Figure:
• © WHO.
In urban settings, fossil fuel combustion and waste management are the most common sources of ambient air pollution. This slide discusses these sources of ambient air pollution however, it is important to note that sources differ from region-to-region and that pollutants in the air can travel significant distances from their point of origin (1).

**Fossil fuel combustion in urban areas** occurs primarily due to (2,3):
- transport needs for personal cars, lorries and other vehicles;
- industrial energy supply, for example burning coal to produce electricity;
- household cooking, heating and lighting needs.

**Biomass combustion** also pollutes ambient air and is primarily for (3):
- household cooking, heating and lighting needs.

**Waste** becomes an air pollution issue when management techniques and infrastructure are inadequate to safely dispose of unwanted items. Waste burning contributes significantly to the presence of many chemical pollutants in the air, including dioxins and lead (4). In many low- and middle-income countries (LMICs), open burning activities are often practised to manage biomass waste as well domestic, municipal, industrial, hazardous and other wastes. In 2016, the World Bank estimated that over 90% of waste in LMICs was openly dumped or burnt, contributing an estimated 1.6 billion tonnes of carbon dioxide equivalent greenhouse gas emissions into the atmosphere. In 2016, this was about 5% of global carbon dioxide emissions (5). Additionally, if waste containing hazardous chemicals is inappropriately dumped or discarded in landfill, these chemicals can remobilize by volatilization, consequently contributing to ambient air pollution (6).

**Note on terminology:** “carbon dioxide equivalent” is a measure that incorporates the effect on global warming over a given time of different greenhouse gases, using carbon dioxide as a reference. It allows for a single metric to be presented (and compared) when an intervention affects emissions from multiple climate forcing agents (7).

**Note:** add any available urban air pollution data or information relevant to your context and discuss the main sources of urban air pollution in your community here.

**Note:** for more information, see the Household air pollution module.

**References:**

1. [Reference 1](#).
2. [Reference 2](#).
3. [Reference 3](#).
4. [Reference 4](#).
5. [Reference 5](#).
6. [Reference 6](#).
7. [Reference 7](#).


Photo:
• © WHO/ Kiana Hayeri. Traffic on the street in Kabul on a polluted day, Afghanistan.
In rural settings, household fuel combustion, agricultural practices and anthropogenic or natural processes are common sources of ambient air pollution.

**Household fuel combustion**, the use of polluting fuels and inefficient technologies for cooking, heating and lighting, contributes significantly to ambient air pollution in rural areas. In 2020, the World Health Organization (WHO) estimated that 52% of the global rural population relied on polluting fuels and technologies for cooking, compared with 14% of the global urban dwelling population (1,2).

Polluting fuels and technologies used for household cooking, heating and lighting may include (3):
- kerosene
- biomass and coal
- open fires
- candles
- oil, gasoline or kerosene lamps
- polluting and inefficient stoves.

There are many **agricultural practices** that contribute to ambient air pollution in rural areas including (4,5):
- biomass waste burning;
- slash and burn practices;
- excessive use of fertilizers, which can release ammonia pollution into the air;
- pollutants from pesticides;
- livestock waste;
- animal fodder preparation.

In some countries, opening burning of agricultural waste is prohibited or restricted, but often appropriate policies and regulations are not implemented or enforced, and open burning practices continues (6). In many countries, farmers and agricultural workers have few other options than to continue open burning activities.

**Natural or anthropogenic processes** can also lead to significant levels of ambient air pollution in rural areas, such as (4,7):
- wildfires, which may start naturally through hot and dry conditions or lightning. More frequently, however, wildfires are started accidentally or on purpose through human actions, such as unattended or uncontrolled fires, backburning or arson;
- fog, which traps air pollutants at ground level;
• sand and dust storms, which contribute significantly to particulate matter (PM) levels.

**Note:** add any available local rural data relevant to your context and discuss the main sources of rural air pollution in your community here.

**Note:** for more information, please see the *Household air pollution* module.

**References:**


**Photo:**

• © WHO / Nigel Bruce. Smog lingering in a mountain village in the Alps, Switzerland.
Ambient air pollution is transboundary, and many pollutants can travel significant distances from their source of origin. Particulate matter (PM) and nitrogen dioxide from vehicle emissions, desert dust and sand, pesticide residues and mercury from coal-fired power plants have been observed to travel significant distances from points of pollution (1).

Ambient air pollution can move from urban to rural areas and vice versa, may travel across a country, between neighbouring countries, across entire regions and can even travel from one continent to another. Some air pollutants can circulate around the world, depositing on land and in water bodies far from their sources (1).

Air pollution is strongly affected by meteorological conditions and pollutants are primarily distributed by air patterns and winds. Rainfall can also move air pollutants from one area and deposit them in another. Some major air pollutants discussed in this module can travel significant distances, including:

- **PM**: the transport of PM over long distances depends on chemical composition, the size of particles, climate conditions and the sources of pollution. PM$_{2.5}$ can remain in the atmosphere for days or weeks and is more likely to be transported across long distances than coarse PM (2). This primarily occurs during pollution events, such as biomass burning, wildfires or dust storms (1). Rainfall and wet weather can cause PM pollution to disperse over a wide area (2). For example, the west coast of the United States of America can be affected by plumes of PM originating in the World Health Organization (WHO) South-East Asia and Western Pacific Regions due to prevailing winds and dry conditions (1);

- **Ozone and precursor emissions**: many precursor emissions have lifetimes that allow them to travel long distances in the atmosphere. This can lead to ozone formation in locations that may be hundreds or even thousands of kilometres away from the source of precursor emissions. In the WHO European Region, research has suggested that background ozone levels are associated with emissions from across the entire northern hemisphere (3). Ozone pollution is often observed downwind of major industrial regions (1). In the WHO European Region, research has found that ozone levels are often higher in rural areas surrounding populated areas, rather than in urban areas or roadside locations due to the movement of precursor emissions (3);

- **Sulfur dioxide**: has anthropogenic (such as combustion of coal for energy needs) and natural sources (such as volcanoes), and concentrations have changed significantly over time in different locations depending on activities from these sources (4). Sulfur dioxide has an atmospheric lifetime of about 10 days, and it can travel thousands of kilometres from its point of origin (5). For example, in 2022 a volcanic eruption in Tonga led to a significant sulfur dioxide plume over Australia 3 days later. This plume had travelled more than 7000 kilometres (6).

Due to the ability of some air pollutants to travel significant distances from their point of origin, efforts to improve

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<td>• Meteorological conditions</td>
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| Air pollutants can travel:           | Mitigation efforts must be broad in scope:           |
|                                       | • Urban → Rural                                       |
|                                       | • Rural → Urban                                        |
|                                       | • Internationally                                       |
|                                       | • Trans-continentally                                   |
|                                       | • Local policies may not be sufficient                  |
Air quality must be broad in scope. Local air quality policies are important to protect human health, however they may not be sufficient if air quality is affected by international emissions. International and regional conventions and agreements exist to reduce emissions of long-range air pollutants (see Slide 56 for more detail).

References:


The next section of this module discusses major pollutants that can be found in ambient air pollution, and their primary sources. The following slides give a brief overview of each major pollutant and include key information for health care providers. For more detailed information about these pollutants please see the *WHO global air quality guidelines* (1) and relevant *Toxicological Profiles* (2).

**References:**

**Photo:**
• © WHO/ Yikun Wang. Children doing outdoor activities, China.
Five pollutants found in ambient air are considered the major air pollutants. They are also referred to as “classical” or “criteria” air pollutants. These are:

- particulate matter (PM)
- ozone
- nitrogen dioxide
- sulfur dioxide
- carbon monoxide.

These five are considered major air pollutants due to their global importance and evidence illustrating their adverse effects on human health (1). In some countries, these pollutants are routinely measured, and governments may set standards for them that aim to reduce emissions and protect health. This slide discusses each of these pollutants and the main sources of their emissions.

PM is a complex mixture of solid and liquid particles (aerosols) of organic and inorganic substances suspended in the air. Its common components are sulfates, nitrates, ammonia, sodium chloride, black carbon, mineral dust and water. Some significant sources of PM in ambient air are (1,2):

- open burning of waste or biomass;
- coal fires;
- power plants, especially those which use fossil fuels;
- roads and vehicle traffic, especially unsealed roads;
- residential biomass;
- wildfires, dust storms and pollen.

Ozone is a secondary pollutant and is not emitted directly (this will be discussed in greater detail on Slide 23) (1).

Nitrogen dioxide in the ambient atmosphere results from high temperature combustion of fossil fuels, including coal, oil or diesel fuel, such as (2,3):

- in transportation vehicles, including cars, trucks and buses;
- power plants and power generation.

Sulfur dioxide is mainly emitted through the combustion of fossil fuels, especially coal, for (2,4):

- power generation and household energy needs;
- industrial facilities;
- maritime shipping.
Sulfur dioxide can also cause ambient air pollution through volcanic activity.

**Carbon monoxide** is produced by the incomplete combustion of carbonaceous fuels such as wood, oil, coal, natural gas and kerosene (2). The predominant source of carbon monoxide in ambient air is from motor vehicles and certain industrial processes (2,5).

The following slides discusses the five major ambient air pollutants and their characteristics in greater detail.

**Note:** highlight the major air pollutants in your area and their main sources.

**Note:** for more information, please see the *Household air pollution* module.

**References:**
Particulate matter (PM) is a common proxy indicator used globally to measure levels of air pollution (1). It is a complex mixture of solid and liquid particles from organic and inorganic substances suspended in the air. Some particles are emitted directly, while others are formed through reactions in the atmosphere. The main components of PM include sulfates, nitrates, ammonia, sodium chloride, black carbon, mineral dust, and water (1,2).

The composition of PM depends on many factors including (2):
- the time of day
- season
- location
- sources.

PM that is transported from elsewhere may also be an important factor to local ambient air quality.

Some particles are big or dark enough to be visible to the naked eye. However, other particles are so small they can only be seen using a microscope. There are two common classification types of PM discussed in this training module due to their significant effects on human health (3,4):
- **PM\(_{10}\)**: refers to particles that are between 10 and 2.5 microns (\(\mu\)m) in diameter. These are sometimes referred to as coarse particles, they can be inhaled and are small enough to enter the respiratory tract;
- **PM\(_{2.5}\)**: refers to particles that are equal to or less than 2.5 \(\mu\)m in diameter. Also referred to as fine PM, these particles are an especially important source of health risks, as they can penetrate deep into the lungs, enter the bloodstream, and travel to organs causing systemic damage to tissues and cells. PM\(_{2.5}\) is the best indicator for the health effects of air pollution.

**Ultrafine particles (PM\(_{0.1}\))** (particles that are equal to or less than 0.1 \(\mu\)m in diameter) are a cause for growing concern. These particles are so fine that they may reach, and be absorbed into, circulation. Depending on their chemical characteristics, PM\(_{0.1}\) may also have systemic toxicity (3,5). PM\(_{0.1}\) is difficult to track and measure, and epidemiological evidence is limited. PM\(_{0.1}\) makes up a portion of PM\(_{2.5}\) measurements.

**Note:** if possible, highlight local features of PM in your area or region, for example, times of the day or year when PM concentrations are at their highest and why.

**References:**


Tropospheric, or ground-level, ozone is a secondary pollutant. It is not emitted directly, but is produced when methane, carbon monoxide or other volatile organic compounds are oxidized in the atmosphere in the presence of nitrogen oxides and sunlight. Methane, carbon monoxide, volatile organic compounds and nitrogen oxides are also referred to as “ozone precursors.” The precursors that contribute most to the formation of ozone are nitrogen dioxide and non-methane volatile organic compounds. Methane is most significantly involved in ozone formation over oceans and remote land areas (1,2).

Industrialization has caused significant increases in ozone precursor emissions, leading to increases in tropospheric ozone concentrations worldwide (3). Some estimates suggest that ozone concentrations may be 30–70% higher than during preindustrial times and may be even higher in some regions (4). Ozone is a primary contributor to “smog,” as visible in the photo on the slide.

Tropospheric ozone pollution is usually at its highest concentration on warm and sunny days. It is an air pollutant of global concern, however human exposure depends upon several factors, including (1):
- local sources of precursor emissions, which are strongly linked to levels of ozone in the air;
- meteorological conditions, particularly sun, high temperatures, rainfall and wind.

Tropospheric ozone concentrations are most likely to be at their highest on warm, dry and sunny days, with only a light wind (5). Additionally, unlike particulate matter (PM) and some of the other major air pollutants discussed in this module, ozone formation often occurs downwind of urban areas (1).

Note: this slide discusses ozone pollution in the troposphere, which is harmful to human and plant health. This should not be confused with ozone in the stratosphere, the upper layer of the atmosphere, which plays a vital role in absorbing ultraviolet light.

References:

Photo:
• © WHO/Yikun Wang. City covered in smog, China.
Nitrogen dioxide (NO$_2$) is a reddish-brown gas with a distinctive, pungent odour (1,2). It is often used as an indicator for the wider group of nitrogen oxides (NO$_x$), including nitric acid (3). Nitrogen dioxide plays a key role in ambient air pollution levels globally and is also associated with numerous human health outcomes, especially asthma and other respiratory outcomes (4).

Nitrogen dioxide can absorb visible solar radiation, consequently contributing to impaired atmospheric visibility. It is also plays a key role in global ozone concentrations (as discussed on Slide 23) and the formation of other secondary pollutants, such as sulfate particles, that contribute to concentrations of particulate matter (PM) (1,2).

Exposure to nitrogen dioxide in ambient air is strongly linked to mobile sources, such as cars, trucks and other combustion vehicles. Unlike PM or ozone, nitrogen dioxide shows a distinct urban-rural gradient and the **highest concentrations are usually found in densely populated urban areas** (1). Due to the development and enforcement of air quality standards, average nitrogen dioxide concentrations have decreased in many high-income countries (HICs), especially in North America and Europe. However, in many low- and middle-income countries (LMICs), trends in nitrogen dioxide concentrations have dramatically increased due to rapid urbanization and industrialization. This is especially evident in some east Asian countries (1).

**Note:** nitrogen oxides (NOx) are a family of poisonous, highly reactive gases. They form when fuel is burnt at high temperatures. Seven nitrogen oxides can be found in ambient air including nitric oxide, nitrogen dioxide, nitrous oxide and nitrous acid. Nitric oxide and nitrogen dioxide are the two main nitrogen oxides associated with combustion sources (5).

**References:**
Sulfur dioxide is a colourless gas with a strong odour. It dissolves easily in water and concentrations in ambient air are strongly linked to the combustion of fossil fuels, especially coal and oil. Sulfur dioxide can also pollute the air through natural methods, such as volcanic eruptions, however human exposure is overwhelmingly associated with anthropogenic sources (1–3).

Historically, sulfur dioxide has been a primary component of air pollution, and a significant amount of research has focused on its effects on human health (2). At very high concentrations (more than 100 parts per million (ppm)), sulfur dioxide can be fatal to humans. However, exposure to sulfur dioxide at such high levels is rare and is unlikely to occur outside an occupational setting (3). However, exposure to sulfur dioxide has been associated with increased all-cause mortality and respiratory mortality, even at low-levels (4).

Levels of sulfur dioxide in ambient air are linked to the intensity of industry, development and urbanization. The highest levels are usually found in urban areas and areas where there is intensive industry activities. Children living near industrial sources, such as power plants that burn coal, or contaminated waste sites are at the highest risk to sulfur dioxide pollution in the air. While concentrations in ambient air are often at their highest during winter months, children often have greater exposure during summer months due to greater time spent outdoors (2,3).

Note: sulfur oxides (SOx) are a group of compound pollutants containing both sulfur and oxygen molecules. Sulfur oxides are primarily produced through burning fossil fuels and include sulfur monoxide, sulfur dioxide and sulfur trioxide. Sulfur dioxide is considered the most prevalent and dangerous to human health. Interventions that target sulfur dioxide are generally considered to protect human health from other sulfur oxides (5).

References:
4. Orellano P, Reynoso J, Quaranta N. Short-term exposure to sulphur dioxide (SO2) and all-casue and respiratory...


Photo:
• © Thijs Stoop/ Unsplash. Smoke, New York.
Carbon monoxide (CO) is a colourless, odourless, tasteless and non-irritant gas. It is combustible and can form explosive mixtures in the air (1,2).

Carbon monoxide in ambient air is primarily due to the incomplete combustion of fossil fuels in motor vehicles, including cars and lorries. Consequently, children living in urban areas with heavy traffic are at the highest risk of exposure to carbon monoxide in ambient air. Carbon monoxide is very harmful to human health. Once inhaled into the human body, carbon monoxide is dissolved in blood where it competes with oxygen to bind to haemoglobin. This process reduces oxygen availability for tissues and can lead to numerous health effects. At very high levels, carbon monoxide can quickly lead to death. However, carbon monoxide concentrations in ambient air tend to be very low. High concentrations of carbon monoxide and adverse health outcomes are generally considered a risk in contexts of household air pollution (2–4).

**Carbon monoxide is not detectable by humans by sight, smell or taste** (2). Therefore, other means of detecting carbon monoxide levels in the environment are required, such as carbon monoxide detectors.

**Note:** for more information on carbon monoxide, please see the modules *Household air pollution* and *The paediatric environmental history.*

**References:**

**Photo:**
• © WHO/ Yikun Wang. Smoke coming from car exhaust, China.
Other ambient air pollutants

- Polycyclic aromatic hydrocarbons (PAHs)
- Volatile organic compounds (e.g. formaldehyde)
- Heavy metals (e.g. lead)
- Benzene

There are many other pollutants that can be found in ambient air. The presence and concentration of these pollutants changes from location-to-location depending upon many factors, such as local industries and human activities. For example, the United States of America’s Environmental Protection Agency (USEPA) monitors outdoor concentrations of 188 different hazardous air pollutants that are known or suspected to cause cancer or other serious health effects, such as birth defects (1,2). The photo on this slide shows a burning pile of waste next to a passenger train. Open burning of waste can cause the release of many different toxic chemicals into the air.

This slide gives some examples of hazardous pollutants that can be found in ambient air:

- **Polycyclic aromatic hydrocarbons (PAHs)** are widespread in the environment and can come from natural or anthropogenic sources. PAHs are primarily associated with industrial processes and incomplete combustion of carbon-based products, especially coal. Tobacco also contains high levels of PAHs. PAHs can cross the placenta and some PAHs have been linked to a variety of adverse health outcomes in children (3–5). The International Agency for Research on Cancer (IARC) has classified benzo(a)pyrene, a common PAH, as a Group 1 carcinogen, causing cancer in humans (3).

- **Volatile organic compounds (VOCs)** are hydrocarbons, oxygenates, halogenates and other carbon compounds that are present in the atmosphere as vapours. They mainly contribute to air pollution through pressurized system leakage, such as methane or natural gas, or from evaporation of liquid fuel. They can also arise from incineration processes, fossil fuel combustion, paints and adhesives. Formaldehyde is a common VOC and can be found in many everyday items, including building materials and motor vehicle exhaust. Formaldehyde is classified by the IARC as a Group 1 carcinogen, causing cancer in humans (6,7).

- **Heavy metals** can also be a component of ambient air pollution. Lead is one of the most well-known ambient air pollutants due to its toxic characteristics. Lead has historically been used in vehicle fuel, and while this source has been eliminated in every country in the world, it is often still used in aviation fuel, which can lead to increased concentrations in areas close to airports. Lead can also be released into the air via burning of materials that contain lead, such as during mining and smelting processes, waste incineration, e-waste and lead-acid battery recycling activities, and through the stripping of leaded paint. Lead can be found in dust and in particulate matter (PM), and current exposures may be caused by historic emissions (8,9). The USEPA considers lead as one of its “criteria” pollutants and it is included in the country’s air quality monitoring activities (10). Other heavy metals found in ambient air pollution can include mercury, cadmium and chromium (11).

- **Benzene** is a highly volatile chemical and exposure is common around the world. In ambient air it comes from combustion of benzene-containing fuel. Benzene is classified as an IARC Group 1 carcinogen - carcinogenic to humans. Exposure to benzene has been linked to leukaemia in children (12). Benzene is considered one of the 10
chemicals of public health concern (13).

Note: for more information, please see the modules *Electrical/electronic waste and children's health*, *Indoor air pollution*, *Lead*, *Mercury* and *Second-hand smoke*.

References:

Photo:
- © WHO/ Anna Kari. Train passes through next to burning garbage, Jakarta, Indonesia.
The fourth section of this module discusses child health outcomes linked to ambient air pollution. The health outcomes discussed here are primarily linked to the major pollutants discussed in section three of the module.

**Photo:**
The pathways of human exposure to air pollution include inhalation and dermal absorption, as well as ingestion. The primary pathway of exposure is **inhalation**, as is illustrated on the slide. Pollutants in ambient air reach different parts of the respiratory system depending on several factors. These include (1,2):

- characteristics of pollutants, for example particle size or water solubility of gases;
- physiological factors of an individual, for example presence of disease, age or level of activity and exercise.

Particles larger than 10 microns (µm), or large coarse particles, are too large to be inhaled beyond the nasal passages and are deposited in the nose and throat. Particles between 10 and 2.5 µm, or coarse particles (PM$_{10}$), are small enough to reach the trachea, bronchi and bronchioli, where they can cause irritation and consequently coughing. Both particles less than 2.5 µm, or fine particles (PM$_{2.5}$), and ultrafine particles, less than 0.1 µm (PM$_{0.1}$), can enter the lung, cross the lung barrier and can be absorbed into circulation where they may travel to other organs and have systemic effects (3–5).

When considering gas pollutants present in ambient air, there are several factors influencing their penetration of the respiratory system such as water solubility, concentration in the air and oxidizing power. For example, the less soluble a gas is; the deeper it can penetrate the lung. Sulfur dioxide is very soluble in water and can damage the upper airways. Nitrogen dioxide and ozone are less soluble in water and can therefore penetrate further into the respiratory system, irritating the bronchiolar tract (1).

**Note:** the illustration on the slide highlights key aspects of the upper and lower respiratory tracts including the nose, throat, trachea, bronchi, bronchioli and pulmonary alveoli. Pulmonary tissue and the circulatory system are not shown in the illustration. Additionally, the circle on the illustration highlights in greater detail the bronchiole and alveoli that are found throughout the lungs.

**References:**


5. Integrated science assessment (ISA) for particulate matter (final report, December 2019). Research Triangle Park: United States Environmental Protection Agency; 2019

**Figure:**
- Reproduced with permission of the © ERS 2023.
Multiple mechanisms of action have been suggested through which breathing in air pollution leads to health damages (1). These mechanisms are briefly described below:

- **Oxidative stress** is considered the primary mechanism of action through which air pollution exerts adverse health outcomes on humans (2). Many different pollutants found in the air can give rise to oxidative stress in the respiratory system. Oxidative stress is often described as an excess of free radicals within the body, a decrease in antioxidant defences, or a combination of both. This can lead to cell injury, tissue damage and an increase in inflammatory cells to injury sites. An increase in inflammatory cells can lead to additional oxidative stress as these cells also generate and release free radicals (3). Oxidative stress underlies many adverse health effects associated with air pollution including lung damage, decreases in lung function and negative cardiovascular outcomes. Additionally, both local and systemic inflammatory responses are mediated through oxidative stress (2–4).

- **Inflammation** is a commonly recognized mechanism of action through which air pollution exerts effects on the human body. Inflammation has been implicated in several diseases and health outcomes strongly linked to air pollution exposure. Air pollution is associated with local and systemic inflammation in humans. Inflammation linked to markers of air pollution have been associated with various adverse health outcomes on the respiratory, cardiovascular and immune systems (2). Local inflammation is usually linked to acute exposures and is associated with short-term health outcomes such as exacerbation of asthma symptoms and enhanced airway responsiveness (2). Air pollution has been also linked to biomarkers of systemic inflammation in a variety of chronic health effects that are strongly associated with exposure to particulate matter (PM) and other pollutants, including chronic obstructive pulmonary disease, cardiovascular disease, stroke and possibly neurological diseases (2,5,6). For example, research suggests that air pollution can cause pro-inflammatory signals originating in peripheral tissues and organs, including the lung and cardiovascular system. This can give rise to systemic-induced cytokine response, which has been linked to neuroinflammation. Studies on biomarkers of systemic inflammation have largely been based on adult study groups. However, some research also suggests that children are particularly vulnerable to the inflammatory impacts of air pollution on the central nervous system, and that inflammatory effects may accumulate across a lifetime (7).

- Other mechanisms of action associated with exposure to ambient air pollution include immunosuppression (8), which can cause children to become more susceptible to diseases such as respiratory infections, and **mutagenicity in cells**, which can cause mutations to DNA and may be associated with increased risk of some chronic diseases, including cancer, in adulthood (9).
References:
This section discusses the health effects in pregnancy and children that have been associated with ambient air pollution. Ambient air pollution has been linked to a diverse range of child health outcomes. There is robust evidence linking some ambient air pollutants to:

- adverse birth outcomes, including preterm birth, reduced fetal growth and low birth weight;
- childhood respiratory effects, including acute lower respiratory infections such as pneumonia, changes to lung function and development, and exacerbation of asthma.

Other emerging health outcomes in children that are being studied, but for which there is currently limited, mixed or inconclusive research include:

- infant mortality;
- adverse maternal health outcomes, such as gestational diabetes and hypertension;
- childhood cancer;
- obesity;
- developmental effects;
- increased risk of childhood and lifelong conditions, including childhood overweight and obesity, lung cancer and cardiovascular disease.

It is important to note that assessing whether a particular pollutant is linked to a certain child health outcome is difficult. Air pollution is always a mixture of chemicals and particles and therefore children are likely to be exposed to multiple pollutants at one time. Continued research on the effects of exposure to air pollutant mixtures, as well as modifying influences such as genetics and nutritional status, is still needed.

The following slides discuss each of these health outcomes, associated air pollutants and the strength of evidence in greater detail.

**Note:** this section uses underlining on the slides (for example, particulate matter) to identify pollutants for which robust evidence is available linking a particular pollutant to child health outcomes.

**Note:** this training module deals only with ambient air pollution and associated health outcomes in children. For training on health outcomes in adults please see reference (3).

**References:**
Maternal exposure to ambient air pollution has been linked to several adverse birth outcomes and evidence is continuing to grow. There is robust evidence linking maternal exposure to fine particulate matter (PM$_{2.5}$) and the following adverse birth outcomes:

1. **Low birth weight** and **small for gestation age** can be be used to assess the possible effects of ambient air pollution on healthy **fetal growth**. In a pooled analysis comprising multiple studies and examination of multiple pollutants, birth weight decrements of approximately 10–30 grams (odds ratios of 1.05–1.10 for low birth weight) were observed in relation to representative concentrations of higher carbon monoxide, nitrogen dioxide, coarse particulate matter (PM$_{10}$), and fine particulate matter (PM$_{2.5}$) (1). There is a significant evidence base linking an association between maternal exposure to PM$_{2.5}$ and negative effects on fetal growth, as measured by low birth weight and small for gestational age. One recent study has estimated that globally in 2019, more than 920 000 low birth weight infants were associated with maternal exposure to ambient PM$_{2.5}$ (2). More research is needed to confirm the associations between fetal growth parameters and other ambient air pollutants (2,3).

2. **Preterm birth** is defined as birth before 37 completed weeks of gestation, and it is the leading cause of death in children under 5 years of age (4). In 2019, preterm birth complications were responsible for approximately 900 000 deaths in children under 5 years of age globally (4,5). There is growing evidence that maternal exposure to ambient air pollution increases the risk of preterm birth. Most studies have investigated links between PM$_{2.5}$ and preterm birth. In 2019, one study has estimated that almost 2 million preterm births globally were associated with maternal exposure to ambient PM$_{2.5}$. The most affected populations were in the World Health Organization’s (WHO) African and South-East Asia Regions (2). Evidence on maternal exposure to other ambient air pollutants and the risk of preterm birth is growing. For example, an analysis of 1 million births in Canada, between 1999 and 2008, found an association between preterm birth and ozone exposure in the week prior to birth (6). Studies have also investigated links between residential proximity to traffic-related pollutants, especially carbon monoxide, nitrogen dioxide and PM, and found an increased risk of preterm birth (1,3).

Greater research is needed to confirm the effects of exposure to ambient air pollutants during **specific vulnerable windows of pregnancy** and adverse birth outcomes, including both fetal growth and preterm birth. Additional research is needed to understand the role of pollutants in ambient air and links to other adverse birth outcomes, including stillbirth and congenital anomalies (2,3).

Finally, low birth weight, small for gestational age and preterm birth complications are linked to increased risk of
neonatal mortality and infant mortality. Low- and middle-income countries are the most affected (2,4).

References:

Photo:
• © WHO/ Ala Kheir. Medhne with her child Aron in Um Rakuba Refugee camp in eastern Sudan.
The adverse effects of air pollution on children’s respiratory health have been acknowledged for decades and the vulnerability of children’s respiratory systems to air pollutants is well recognized (1). This table highlights some of the major ambient air pollutants previously discussed, and some of the effects that have been observed on children’s respiratory health in epidemiological studies. This table is not exhaustive.

It is important to note that none of these pollutants are present alone. All exposures are mixed and many of the effects may be additive or synergistic (2,3). The following slides discuss some of these pollutants and their effects on children’s respiratory health in greater detail.

**Note:** for more information on children and respiratory health please see the modules *Childhood respiratory diseases linked to the environment* and *Household air pollution*.

**References:**
Upper respiratory infections are the most frequently occurring illness in childhood. In 2019, an estimated 17.2 billion (95% UI: 15.4–19.3) upper respiratory infections occurred globally. Upper respiratory infections include cough, acute nasopharyngitis, sinusitis, pharyngitis, tonsillitis, laryngitis, tracheitis, epiglottitis, rhinitis, rhinosinusitis, rhinopharyngitis, and supraglottitis. Children under 5 years of age had the highest overall incidence, followed by a steady decline throughout all age groups (1). In 2019, the World Health Organization (WHO) estimated there was more than 10 000 deaths globally due to upper respiratory infections. The majority of these occurred in children under 5 years and adults over 70 years of age (2). Upper respiratory infections can decrease quality of life, may lead to more serious infection and can interfere with important activities, such as education.

Multiple environmental exposures have been associated with increased risk of developing upper respiratory infections. In particular, studies have found associations between childhood exposure to particulate matter (PM), both PM$_{2.5}$ and PM$_{10}$, and an increased risk of developing an upper respiratory infection (3). A study of emergency department visits in three hospitals across a city in China found that short-term exposure to ambient air pollution, especially sulfur dioxide and carbon monoxide, was associated with an increased risk of hospitalization due to upper respiratory infection, especially during winter months (4). Another study conducted in Atlanta, United States of America, between 1993 and 2010 investigated air pollution and emergency department visits of children under 5 years of age for respiratory infections, including upper respiratory infections. This study found that exposure to the carbon fraction of PM$_{2.5}$ may be linked to an increased risk of upper respiratory infection in children under the age of 5 (5).

Note: for more information on children and respiratory infections please see the module *Childhood respiratory diseases linked to the environment.*

References:

Almost all children will experience otitis media, an inflammation of the middle ear, during childhood. Young children are particularly vulnerable anatomically due to their shorter, smaller and more horizontal eustachian tubes, and their smaller middle ear chamber. Children also have frequent upper respiratory infections, which are often the antecedents to otitis media. Common consequences of otitis media include acute pain and suffering and secondary infections. Rare consequences of otitis media include mastoiditis, meningitis, brain abscess and death (1,2). Prolonged or frequent bouts of otitis media during early life-stages may cause impairment of hearing and difficulties with language and other cognitive development (1,2).

There is consistent and increasing evidence of an association between ambient air pollution exposure and the occurrence of otitis media in children (3). Possible associations between increased risk of otitis media and exposure to sulfur dioxide, ambient particulate matter (both PM<sub>2.5</sub> and PM<sub>10</sub>) and traffic-related air pollution have been identified, however greater research is needed to confirm these associations. Studies completed in the Republic of Korea have found that an increased concentration of ambient fine particulate matter (PM<sub>2.5</sub>) was associated with a relative risk increase of otitis media in children under 2 years of age. However, other factors such as recent upper respiratory infection and warm weather also affected the risk of otitis media (4,5). A case-crossover study conducted in the United States of America found that preterm infants exposed to PM<sub>2.5</sub> were at increased risk of otitis media, but term infants were not (6). In a systematic review, increased risk of otitis media was associated with exposure to nitrogen dioxide, but findings with other ambient air pollutants were inconsistent (1). Research conducted in Germany found a link between improving ambient air quality and a reduction in the prevalence of otitis media in children (7).

The majority of research on otitis media and ambient air pollution has been conducted in high-income countries (HICs). Research on the associations between ambient air pollution and otitis media in low- and middle-income countries (LMICs) with high levels of air pollution is largely missing from the evidence base.

**Note:** for more information on children and respiratory infections please see the module *Childhood respiratory diseases linked to the environment.*

**References:**


Photo:
• © WHO/ Blink Media – Gareth Bentley. Nurse Carol treats memory, 3 (held by her mother Alice), for a severe ear infection at the Lukomba Rural Health Centre in Kapiri Mposhii District, Zambia.
Acute lower respiratory infections, including pneumonia, bronchitis, bronchiolitis and other acute respiratory diseases, are the second leading cause of child mortality worldwide. In 2019, an estimated 740,000 children under 5 years of age died from acute lower respiratory infections globally. Low- and middle-income countries (LMICs) carry the highest burden of childhood mortality from lower respiratory infections, particularly countries in the World Health Organization’s (WHO) African and South-East Asia Regions. Together, these two regions accounted for 76% of the global burden of child mortality from acute lower respiratory infections in 2019 (1). Acute lower respiratory infections are strongly correlated to environmental risks, including ambient, household and indoor air pollution, crowded living conditions, parental smoking and poor access to safe water, sanitation and hygiene services (2). In 2019, more than 146,000 children under the age of 5 years globally died from acute respiratory infections associated with ambient air pollution (3).

Ambient air pollution can greatly increase the risk of contracting an acute lower respiratory infection, complicate its course and increase the risk of poor health outcomes in children. Exposure to ambient air pollution, even for a short time has been associated with the exacerbation of acute lower respiratory infections. A substantial amount of research has investigated exposure to ambient air pollution and risk of childhood acute lower respiratory infections, with a strong focus on links between particulate matter (PM) exposure and pneumonia (4). Research on other major ambient air pollutants is growing.

A systematic review and meta-analysis found that short-term increases in particulate matter (both PM_{2.5} and PM_{10}), sulfur dioxide, nitrogen dioxide and ozone were associated with increases in paediatric hospital admission due to pneumonia (5). An analysis of 10 birth cohorts conducted in Europe found consistent evidence of association between traffic-related air pollution (nitrogen dioxide, nitrogen oxides, PM_{2.5} and PM_{10}) and pneumonia incidence during the first year of life (6). However, another birth cohort study conducted in Europe could not repeat these results and found only a weak link between zinc in PM_{10} (a marker of traffic pollution) and pneumonia in children under 2 years of age (7).

An 18-year time-series study conducted in Atalanta, United States of America, found that emergency department visits for pneumonia in children under the age of 5 were associated with short-term increases in ozone and PM_{2.5}, nitrogen dioxide and carbon monoxide. In particular, this study observed that the carbon fraction of ambient PM_{2.5} may be a risk for pneumonia in children (8). A study of hospitalizations for acute lower respiratory infections in children in 25 cities across China observed similar findings to the study conducted in Atlanta. This study found that short-term exposure to gaseous ambient air pollutants - carbon monoxide, nitrogen dioxide, ozone and sulfur dioxide - was linked to paediatric admission to hospital for pneumonia. However, the study also notes that evidence
on the association between exposure to carbon monoxide and ozone in ambient air pollution and acute lower respiratory infections in children is inconsistent across other studies (9).

A small amount of research has found suggestive links between maternal exposure to ambient air pollution, especially PM and traffic-related pollution, and the risk of developing acute lower respiratory infections in early childhood (10,11).

In conclusion, ambient air pollution is a well-established environmental risk factor for acute lower respiratory infections in children. Ambient air pollution is linked to a substantial percentage of deaths in children under the age of 5 years due to acute lower respiratory infections annually. Greater research is needed to confirm the risk of individual major ambient air pollutants in childhood acute respiratory infections and links between maternal exposure and incidence of childhood acute respiratory infections. Additionally, the majority of research has been conducted in high-income countries (HICs). Greater research is needed in LMICs, where both the burden of childhood mortality from acute lower respiratory infections and levels of ambient air pollution are highest.

Note: for more information on children and respiratory infections please see the modules Childhood respiratory diseases linked to the environment, Household air pollution and Second-hand smoke.

References:
Asthma is a common chronic, noncommunicable childhood disease. Asthma is a diffuse, obstructive lung disease with hyper-reactivity of the airways to a variety of stimuli and a high degree of reversibility of the obstructive process, which may occur either spontaneously or as a result of treatment. Symptoms can be continuous or intermittent and can change over time. There are multiple phenotypes, and the causes of asthma in individuals are multifactorial, including genetic predisposition, gene environment interactions especially early in life, infections, and exposure to allergens and various environmental conditions and triggers (1,2). The Global Initiative for Asthma (GINA) defines asthma as (3):

- “a heterogeneous disease, usually characterized by chronic airway inflammation. It is defined by the history of respiratory symptoms, such as wheeze, shortness of breath, chest tightness and cough, that vary over time and in intensity, together with variable expiratory airflow limitation.”

The global burden of disease from asthma is significant. In 2019, an estimated 262 million people were affected by asthma, causing an estimated 455,000 deaths and 21.7 million disability-adjusted life-years (DALYs) globally (4-6). There are many environmental factors and exposures linked to exacerbation of asthma symptoms. These include (2):

- diet
- urbanization and industrialization
- poverty and other social determinants of health
- environmental risks such as ambient and household air pollution, microbial exposures, second-hand smoke, pollen and animal allergens.

Additionally, some research has suggested associations between exposure to air pollution during prenatal and early life, and childhood asthma development. There is some initial evidence that exposure to fine particulate matter (PM$_{2.5}$) may influence the development of childhood asthma. However, these associations are not completely understood (2,7).

It is essential that health care workers can recognize the common symptoms of asthma in children. **Common symptoms that children may present with at health clinics include (8)** (please see Slides 49 and 50 for more details on asthma symptoms, diagnosis and management):

- wheeze
- difficulty breathing
- chest tightness
- cough
- symptoms that vary in intensity and over time.
Recently, the prevalence in high-income countries (HICs) has leveled off or, in some cases, slightly decreased. Meanwhile, asthma trends and prevalence of asthma symptoms in low- and middle-income countries (LMICs) have shown evidence of changing, and in some cases are increasing (9,10). Countries in the African and South-East Asia Regions have seen significant rises in asthma cases, but children in these regions suffer a disproportionately high burden in terms morbidity and mortality due to under-and mis-diagnosis of asthma symptoms, and inadequate access to preventative and treatment medications (10,11).

The following two slides explore the links between ambient air pollution and asthma exacerbation in children. It should be noted, however, that there are many other triggers for asthma exacerbation in indoor and outdoor environments that are not discussed here. Children who have asthma, their parents and health care providers should explore all possible triggers for asthma exacerbation.

**Note**: DALYs for a disease or health condition are the sum of years of healthy life lost due to disability and years of life lost due to premature mortality.

**Note**: for more information on childhood asthma and possible environmental triggers please see the modules *Childhood respiratory diseases linked to the environment*, *Household air pollution*, *Indoor air pollution* and *Second-hand smoke*.

**References**:

Children with asthma are highly vulnerable to some major pollutants found in ambient air pollution. Pollutants can lead to exacerbation of asthma symptoms, leading to increases in emergency visits, hospitalization, sick days and use of medication. “Exacerbation” is an acute deterioration in asthma symptoms, usually characterized by worsening cough, wheeze or difficulty breathing (1).

In particular, asthma exacerbation is strongly linked to:

- **Ozone**, which is a powerful respiratory irritant and can penetrate deep into the lungs. The effect of ozone on the respiratory tract has been called “sunburn of the lungs.” Exposure to ozone has a consistent and measurable effect on heightened asthma symptoms and increases in doctor visits and hospitalizations. In one meta-analysis, days of elevated ozone concentration were associated with increases in emergency room visits or hospitalizations for asthma exacerbation (2). Children with asthma appear to be more susceptible to the effects of ozone than adults with asthma (3);

- **Nitrogen dioxide** is another powerful respiratory irritant with the ability to penetrate deep into the lungs. It can induce coughing, wheezing, shortness of breath and bronchospasm. Research in children has suggested that exposure to even low levels of nitrogen dioxide can cause asthma symptoms, reduced lung function and exacerbate asthma (3). A systematic review of ambient air pollutants found strong associations between nitrogen dioxide and moderate to severe exacerbations of asthma (4);

- **Sulfur dioxide**, is a well-established respiratory irritant (5). A systematic review found a relationship between exposure to sulfur dioxide and moderate to severe asthma exacerbation in children (3). Another systematic review found that short-term exposure to sulfur dioxide was correlated with an increase in hospital admission and emergency departments visits across all age groups. This study also found that children with asthma were more susceptible to the effects of air pollutants than adults with asthma (6);

- **Particulate matter** (PM) has been linked to numerous outcomes in children with asthma. Short-term exposure to PM has been linked to asthma symptoms, school absence, emergency department visits and hospitalizations (3). There is also growing evidence that PM exposure could be associated with reduced asthma control in children (7).

There are many other ambient influences that can influence asthma symptoms and exacerbation, including weather changes and pollen count (8).

Additionally, there is some evidence that exposure to air pollution, especially traffic-related nitrogen dioxide and PM, during early and late childhood may increase the risk of asthma incidence (9).
Note: for more information on childhood asthma and possible environmental triggers please see the modules Childhood respiratory diseases linked to the environment, Household air pollution, Indoor air pollution and Second-hand smoke.

Reference:
The image on this slide illustrates the complex relationship between ambient air pollution, asthma and socio-economic outcomes. The top of the illustration shows the major sources of air pollution that can affect asthma outcomes, including wood and coal fires, power plants, traffic-related air pollution and tobacco smoke. These sources of air pollution are associated with numerous health outcomes including:

- increase in asthma symptoms
- increase in asthma exacerbation and hospitalizations
- decrease in lung function
- increase in medication use
- increase in respiratory disability.

These health outcomes can cause social and economic effects on individuals and their families. This can include increased health care-related costs due to more visits to doctors, hospitals and use of medication. Additionally, parents and caregivers may take more time off work, consequently earning less money, to take care of sick children. These health outcomes can affect quality of life due to more time spent sick, restrictions on activities such as sport and social events, and more time spent away from school and education. Missed schooling can affect a child for the rest of its life through reduced academic achievement and employment opportunities (1,2).

Note: for more information on childhood asthma and possible environmental triggers please see the modules Childhood respiratory diseases linked to the environment, Household air pollution, Indoor air pollution and Second-hand smoke.

References:

Figure:
- Tiotiu AI, Novakova P, Nedeva D, Chong-Neto HJ, Novakova S, Steriopoulous P et al. Impact of air pollution on asthma outcomes. Int J Environ Res Public Health 2020;17(17): 6212. This file is licensed under Creative Commons Attribution 4.0 International license (CC BY 4.0; https://creativecommons.org/licenses/by/4.0). This graphic has been adapted to highlight children’s vulnerability. The original version of this graphic also indicated that elderly groups are vulnerable to air pollution and asthma.
Lung function is a measure of how effectively the lungs move air in and out of the body in order to exchange oxygen with blood and remove carbon dioxide. Lung function indicates how well a person breathes. Windows of vulnerability for permanent alterations to lung function persist throughout childhood. While alveolar development is substantially complete by 2 years of age, lung growth continues through adolescence and parallels somatic growth. It is thought to be complete by approximately 18 years of age in females and 20–23 years of age in males (1,2). Until adult systems are fully developed, exposure to ambient air pollution may alter lung function and development in irreversible ways.

Many studies have documented the harmful effects of a wide variety of air pollutants, during prenatal and childhood periods, on lung function and development.

- **Changes to lung development and growth** are associated with ambient air pollution exposure during prenatal and postnatal windows. In one review article, prenatal exposure to air pollution was linked to impaired organogenesis and lung growth (3), although specific pollutants and windows of exposure varied across the studies. Epidemiological studies have found associations between exposure to particulate matter (PM) during early childhood and decreased development in certain measures of lung function, such as forced vital capacity (4,5). Exposure to PM$_{2.5}$ and ozone during prenatal and early childhood periods have been reported to reduce growth of the tracheobronchial tree (6,7). Long-term exposure to air pollution, especially ozone, has been linked to airway remodeling, which may predispose children to respiratory diseases later in life (7). Changes to lung development and growth during childhood may lead to lifelong respiratory issues.

- **Reduced lung function** during childhood and associations with ambient air pollution has been the focus of many studies. Reduced lung function has been associated with childhood exposure to ambient PM$_{2.5}$ and PM$_{10}$ (8,9). In a meta-analysis of 13 studies, increased levels of nitrogen dioxide from traffic pollution were associated with a higher prevalence of children with abnormal lung function (measured in terms of forced expiration volume in 1 second) (10). Ozone levels are strongly associated with reduced lung function especially in children with asthma, as well as in children who do not have asthma particularly during times of physical exertion, such as sporting activities (6).

Additionally, there is evidence that improved air quality is significantly associated with improved lung function and growth in children (11).

Finally, there is a paucity of research on children’s exposure to ambient air pollution and lung function in low-and middle-income countries (LMICs). For example, a recent systematic review found only 14 studies conducted in sub-
Saharan African countries, with the majority of those studies completed in South Africa. Countries in sub-Saharan Africa are experiencing rapid urbanization, population growth and increases in ambient air pollution. Greater research is needed in these countries to understand the effects of these environmental changes on children’s health, and public health interventions that will effectively protect their respiratory system from damage (12).

Note: for more information, please see the modules Childhood respiratory diseases linked to the environment and Household air pollution.  

References:

Photo:
© WHO/ Nazik Armenakyan. Paediatricians Dr Ghazaryan and Dr Harutyunyan examine the lungs of 9-month-old Nare who has bronchiolitis, at Wigmore Clinic in Yerevan, Armenia.
A growing body of research is investigating possible associations between prenatal and early childhood exposure to ambient air pollution and adverse neurodevelopmental outcomes (1).

Several studies have evaluated the relationship between prenatal exposure to air pollution and neurodevelopment in children. These studies suggest that air pollution can negatively affect their cognitive and motor development, however study findings are inconsistent. For example, one study conducted in Spain found that prenatal exposure to fine particulate matter (PM$_{2.5}$) and nitrogen dioxide was associated with decreases in cognitive and motor development in children at the age of 15 months (2). Another study conducted across six European birth cohorts found no association between cognitive development and prenatal exposure to any air pollutant (3). Systematic reviews have suggested links between prenatal exposure to ambient air pollution and reduced attention and executive functions, learning and memory, and language and numerical ability in preschool and school-aged children (4) and changes in fine psychomotor skills, behavioural changes and reduced intelligence quotient (IQ) (5).

A limited number of studies have investigated the possible links between exposure to ambient air pollution, especially traffic-related air pollution, during early childhood and adverse neurodevelopmental outcomes. These studies have investigated associations between PM$_{2.5}$ and nitrogen dioxide and have indicated possible links to increased risk of anxiety and depression, impaired cognitive function, reduced IQ and reduced attention span (6,7).

A small number of studies have investigated links between prenatal and early childhood exposure to PM$_{2.5}$ and nitrogen dioxide in ambient air and risk of autism spectrum disorder and attention-deficit hyperactivity disorder (ADHD). Evidence is not consistent across studies or exposure windows and greater research is needed before any conclusion can be drawn (8).

Studies on the associations between ambient air pollution and adverse neurodevelopmental effects in children is an area of growing interest. The limited number of studies is one constraint. Findings across current studies have not been consistent and greater research is needed to define specific vulnerable windows of exposure during pregnancy and early childhood, specific pollutant risks and protective factors (8).

Research from current studies warrants further investigation on the risks of ambient air pollution to children's neurodevelopment.

**Note:** for more information, please see the modules *Children and neurodevelopmental behavioural intellectual disorders (NDBID): training for health care providers*, *Household air pollution* and *Second-hand smoke*.
Reference:
Studies have investigated many other health effects in children. Evidence is still emerging for associations between ambient air pollution and the following adverse health outcomes in children:

- **Infant mortality** has been the subject of research investigating air pollution exposure immediately prior to an infant’s death. A study of 1 million births across sub-Saharan Africa found that infant mortality increased by 9% with a 10 micrograms per cubic metre (µg/m³) increase in fine particulate matter (PM$_{2.5}$) (1). A systematic review in Canada found that ambient air pollution may lead to increased respiratory symptoms in infants and consequently contribute to infant mortality (2). Greater research on links between ambient air pollution and infant mortality is needed, especially on vulnerable windows of exposure and the influence of specific pollutants, as well as pollutant mixtures.

- **Maternal health** has investigated several outcomes but have primarily focused on gestational hypertension, gestational diabetes and preeclampsia. Pregnancy-associated hypertension is a leading cause of perinatal and maternal mortality and morbidity. A large body of research on the general population has linked changes in blood pressure to ambient air pollution. A systematic review of the effects of ambient air pollution on gestational hypertension and preeclampsia found some evidence of an association, particularly between exposure to particulate matter (PM), ozone and nitrogen dioxide and pregnancy-induced hypertension and preeclampsia (3). A systematic review on links between ambient air pollution and gestation diabetes found a significant positive association, especially exposure to PM, sulfur dioxide and nitrogen dioxide during preconception and the first trimester of pregnancy (4). Current evidence warrants further research on ambient air pollution and maternal health outcomes.

- **Childhood cancer** and links to ambient air pollution, especially childhood leukaemia, is a topic of concern and associations have been suggested, particularly to traffic-related air pollution. In 2015, the International Agency for Research on Cancer (IARC) evaluated both particulate matter and ambient air pollution as Group 1 carcinogens – carcinogenic to humans (5). However, research on associations between childhood leukaemia and ambient air pollution have been inconclusive. A systematic review found that exposure to benzene was associated with an excess risk of childhood leukaemia in children under 6 years of age, and that disease subtype, windows of exposure and child age may modify this risk. No association between childhood leukaemia and other ambient air pollutants was found (6).

- **Obesity** in childhood and environmental exposure is an area of growing interest. However, the relationship between obesity and environmental exposure is complex and multifactorial. Ambient air pollution may have both direct and indirect influences on childhood obesity. Additionally, a limited number of studies on ambient
air pollution and childhood obesity have been conducted, and there is not enough current research to draw any conclusions (7).

- **Chronic diseases in adults**, such as cardiovascular disease, lung cancer and chronic lung disease, are strongly linked to exposure to ambient air pollution and make up a considerable burden of air pollution-related mortality and morbidity (8). Links between exposure to ambient air pollution during childhood and increased risk of cardiovascular disease, lung cancer and chronic lung disease later in life have been suggested. However, too few studies have been conducted to draw any conclusions. Greater research is needed to identify key windows of exposure, and whether hypertension and insults to the developing lung associated with air pollution exposure during childhood can persist into adulthood, affecting the onset of some chronic adult diseases (7,9).

References:
In the next section we discuss interventions at local, national and international levels that can help reduce children’s exposure to ambient air pollution. This section also discusses actions that health care providers can take to reduce children’s exposure to ambient air pollution.

**Photo:**
Health professionals should have a high index of suspicion for ambient air pollution exposure in children given its ubiquity in their environments. From a clinical perspective, it is important to include ambient air pollution as an environmental etiology in differential diagnoses. For example, unexplained respiratory symptoms, repeated respiratory infections or exacerbated asthmatic episodes (1).

Health professionals can reduce children’s exposure to air pollution by:

1. **Identifying children at high risk of ambient air pollution**. Health professionals can identify air pollution-related risk factors by asking pertinent questions about the child’s or pregnant mother’s environment. For example, asking about the location of the home or child’s school and any heavy traffic or polluting industries in the area (see Slide 45 for some example questions). Additionally, health professionals should be aware of patients who are particularly susceptible to ambient air pollution, for example children with asthma or pregnant women. These groups may be at higher risk to the effects of ambient air pollution. Additionally, health care clinics, centres and hospitals can identify ways to reduce air pollution from their own practices. For example, replacing sources of air pollutants, such as mercury thermometers, and evaluating and improving work practices to save energy and reduce emissions (1,2);

2. **Familiarizing themselves with common sources of air pollution and linked symptoms and diseases**, for example, asthma and exacerbated asthmatic episodes or repeated respiratory infections. Children with asthma and their family may require support to identify sources of ambient air pollution in their environment and methods to reduce exposure. If children are suffering from unexplained symptoms that may be associated with ambient air pollution, for example respiratory infections, health professionals should recognize the role that exposure may have (1,2);

3. **Diagnosing and treating children** who are affected by ambient air pollution and associated diseases;

4. **Educating and communicating** with patients and family, colleagues and students about sources, risks and prevention;

5. **Advocating** for local, national and international policies and regulations that will reduce levels of ambient air pollution. Health professionals are well positioned to share their knowledge with decision-makers. Health professionals can also convey the health burden of ambient air pollution to decision-makers, conduct health-based assessments, support improved standards and policies to reduce harmful exposure, advocate for monitoring, and emphasize the need to protect children’s health (1).

**References:**

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Photo:
• © WHO/ Olivier Asselin. A health worker examines a young girl at the Kara polyclinic in Kara, northern Togo.
Health professionals can ask their patients and families key questions that may help in detecting exposure to ambient air pollution and identifying at-risk children or pregnant women. Key questions can help to build a paediatric environmental history, assess whether a child is suffering from symptoms related to air pollution and how to avoid exposure to high levels (1,2). These questions must be context specific to each patient.

**Examples of questions that can be asked include (3–6):**

- Are there sources of smoke, smog, fog, or dust close to your home? Examples may include fires from burning waste, smoke, smog or dust from surrounding industrial or agricultural activities.
- Does your child play outdoors in areas near busy roads or highways? What time of the day do they engage in these activities?
- How often do lorries, or other heavy vehicles such as machinery or buses, pass through the street where you live? What is the distance from your house to the nearest busy road?
- Is your child’s school or day care located close to any major sources of pollution, such as traffic, power plants or factories?
- Does your child have any unexplained respiratory symptoms, such as wheezing or whistling in the chest, coughing, shortness of breath, tight chest? If so, how often? Have they been diagnosed with any respiratory condition? Medication?
- If your child has respiratory symptoms, do they become worse after time spent outside? Do symptoms become worse at night or early morning?

**Note:** if you have examples of questions that have been useful in your context or region they can be used here.

**Note:** for more information on completing a paediatric environmental history please see the module *The paediatric environmental history*.

**References:**


There are suggestions that health professionals can make to children, pregnant women, their families and communities to reduce their exposure to ambient air pollution. Adapt these actions to the specific context of each patient.

**Examples of actions that can be suggested include (1):**

- if available, consult the use of a local air quality index to assess daily ambient air quality. Use this information to decide on outdoor activities for the day. If a local air quality index is not available, suggest a global accessible alternative, such as OpenAQ (2) (see Slides 53 and 59 for more information);
- follow associated health recommendations of local air quality indexes, especially if a child has any respiratory illness, such as asthma;
- if possible, avoid travelling during times of heavy traffic or high air pollution;
- avoid strenuous sports or activities during times of high air pollution in your location;
- avoid sports or activities in locations near heavy traffic;
- adapt the time and locations of sporting activities so that ambient air pollution exposure is reduced. If possible, pay particular attention to ozone levels and temperatures when making these decisions;
- cease sport or activities if coughing or other respiratory symptoms occur, and seek medical review;
- if possible, stay inside during times of high ambient air pollution;
- take prescribed medication as directed by a health professional;
- report any changes in respiratory symptoms to your health professional.

**Note:** if you have examples of successful suggestions that have been used in your context or region they can be mentioned here.

**References:**

This slide summarizes the World Health Organization’s (WHO) key suggestions on the use of personal face masks to protect against ambient air pollution (1,2):

- **Currently, the WHO does not recommend the use of personal face masks or respirators in the general public to protect against ambient air pollution.** Currently, available research does not indicate that face mask or respirator use in the general public or susceptible populations is effective to protect against air pollution hazards;

- **During extreme air pollution events**, for example wildfires, volcanic eruptions desert dust episodes or clean-up after a disaster, approved personal face masks or respirators may be recommended to protect against inhalation hazards under well-controlled procedures and for short periods of time. Additionally, people with respiratory and cardiovascular diseases must be cautious as face masks or respirators can increase dead space, airway resistance and psychological stress.

There are five factors that ensure the effective use of face masks and respirators (1,2):

1. Putting the face mask or respirator on correctly;
2. Ensuring that it fits properly;
3. Ensuring continuous use during exposure;
4. Replacing the respirator or air filter when it becomes saturated;
5. Ensuring that the face mask or respirator is approved to remove at least 95% of particles from the air. There are a wide variety of face masks and respirators that are available to the public but do not provide respiratory protection to the wearer.

As of 2023, there are no commercial face masks or respirators that are designed specifically to fit children’s faces and protect them against ambient air pollution hazards.

**References:**

This slide summarizes the World Health Organization’s (WHO) key suggestions on the use of portable air filters to protect against ambient air pollution (1,2):

- Some research has found that certain portable air filters can efficiently reduce indoor fine particulate matter (PM2.5) in real-world conditions (as opposed to laboratory or occupational settings). Studies have indicated some health improvements, primarily in healthy adults. Research on efficiency and health outcomes associated with portable air filters is limited to short-term time frames, largely with a small number of healthy participants, and further studies are needed;
- **WHO conditionally recommends the use of portable air filters as a protective measure.**

This recommendation is based on three primary reasons (1,2):

1. Lack of information on effectiveness in the real world;
2. Potential adverse indoor and environment effects;
3. High cost

Air filters could be proposed for people with pre-existing health conditions (1,2).

Portable air filters could be proposed for people with pre-existing health conditions, such as chronic respiratory or cardiovascular diseases, who need to stay indoors and protect themselves from air pollution exposure (1,2).

**References:**
Asthma is a common chronic illness among children and treatment is available allowing affected people to lead active lives. In 2019, however, asthma caused an estimated 455,000 deaths, most of which were in low- and middle-income countries (LMICs) where underdiagnosis and access to treatment is a challenge (1,2).

Under- and mis-diagnosis of children with asthma may be due to unawareness among parents, carers, teachers and health care workers of the main symptoms of asthma. The key symptoms of asthma in children are (3,4):

1. Wheeze
2. Shortness of breath
3. Chest tightness
4. Cough

Some of these symptoms are also associated with other common childhood diseases, such as respiratory infections. Other factors when considering common asthma symptoms include:

- **Episodic** or **seasonal** symptoms
- Symptoms may vary over time and in intensity
- Worse during night or early morning
- Worse after exercise
- Symptoms can be mild or severe
- Symptoms may come and go over time

Slide 50 discusses the World Health Organization’s (WHO) key suggestions for asthma assessment and management.

References:

This slide summarizes the World Health Organization’s (WHO) key suggestions to assess a patient for asthma in low resource settings and five key suggestions to manage asthma.

Key suggestions for assessing a patient presenting with cough, difficult breathing, chest tightness and wheezing symptoms (1,2):
1. Is there a previous diagnosis of asthma?
2. Has the patient had symptoms since early childhood?
3. Is there any history of hayfever, eczema or allergies?
4. Are symptoms intermittent with asymptomatic periods in between?
5. Do symptoms become worse at night or during early morning?
6. Are symptoms triggered by respiratory infection, exercise, weather changes or stress?
7. Do symptoms respond to salbutamol (a bronchodilator)?

If the patient answers yes to these questions, a diagnosis of asthma is likely, and children should be regularly checked by their health care provider to ensure symptoms are being effectively managed (1,2).

WHO suggests five key tips for managing asthma (1,3):
1. Be aware of asthma symptoms: cough, wheeze and difficulty breathing are all signs that your asthma is not well controlled;
2. Identify and avoid asthma triggers: common asthma triggers include smoke, fumes, viral infections, pollen, changes in the weather, animal fur and feathers, and strong fragrances. Triggers can differ from person-to-person;
3. Know about asthma inhalers: a reliever inhaler (also called a bronchodilator) is used when a patient has asthma symptoms. It opens the small airways and improves airflow in and out of the lungs;
4. Use a spacer: a spacer is a plastic chamber that can help inhaled medicines reach the small airways in the lungs and work better. It connects the inhaler at one end, to your mouth via a mouthpiece or mask at the other end;
5. Take back control: discuss asthma, its symptoms and treatment, and prevention medication with your health care provider and family members.

Note: for WHO’s recommendations on asthma assessment, diagnosis, treatment and management please see references (1,2). To check if your country has developed national asthma management guidelines, please see reference (4). For additional asthma resources please see reference (5). For the list of WHO recommended asthma prevention and treatment medications, please see reference (6).
References:
The points on this slide give some examples of actions that local councils or governments can take to reduce local sources of ambient air pollution and help improve air quality. Local governments can reduce exposure to ambient air pollution and related health risks by (1,2):

- **Supporting local air quality monitoring** projects and community initiatives;
- **Developing local warning systems** that alert people to hazardous air quality, e.g., via text message;
- **Promoting the use of air quality indexes** and making them accessible;
- **Improving municipal waste management**, such as collection methods, recycling and waste separation;
- **Eliminating open waste burning**;
- **Engaging local schools and communities** in air pollution initiatives, such as tree planting and walk or bike to school days;
- **Working with communities to find solutions**;
- **Promoting the use of public and active forms of transport**;
- **Creating green spaces**, such as parks, gardens and car free areas.

Local governments can reduce local ambient air pollution by (1,2):

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<th>Reducing ambient air pollution:</th>
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<td>• Improve municipal waste management</td>
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**Note:** if you have examples of national policies, regulations or measures to reduce ambient air pollution that have been developed or used in your context they can be mentioned here.

**References:**
Examples of national actions

- Set and enforce air quality standards in line with WHO air quality guidelines
- Invest in air quality and health risk monitoring
- Reduce and prevent open burning practices
- Improve waste management
- Invest in green energy
- Ensure access to clean fuels and technologies for domestic cooking, heating, lighting
- Build green cities and green spaces
- Encourage walking, cycling and public transport
- Implement vehicle emissions and standards

At the national level, governmental action is vital to reduce levels of ambient air pollution. Actions must be broad in scope and work with stakeholders across governmental, nongovernmental and private sectors including environment, health, transport, industry, waste and energy.

National governments can take many actions to help protect their citizens from hazardous ambient air pollution, including (1,2):

- **setting and enforcing air quality standards** in line with the World Health Organization’s (WHO) global air quality guidelines (3);
- **investing in air quality and health risk monitoring** that aims to protect the most vulnerable from hazardous air pollution (see Slide 53 for more detail on air quality indexes and their uses);
- **reducing and preventing open burning practices and improving waste management** by supporting appropriate waste collection, reduction, separation, recycling and reuse or reprocessing;
- **investing in green energy solutions**. This may include transitioning away from fossil fuel combustion for large-scale energy production and increasing the use of low-emission fuels and renewable sources of energy;
- **providing universal access to clean and affordable fuels and technologies** for domestic cooking, heating and lighting;
- **building green cities and green spaces** by improving energy efficiency of homes and other buildings through insulation and passive design principles, such as natural ventilation and lighting. Additionally, special attention should be paid to the location of residential areas, schools and day care centres, and the proximity of heavy traffic;
- **encouraging active forms of transport** such as walking and cycling and public transport by building safe pedestrian and cycle-friendly networks, and affordable and accessible public transport (4);
- **implementing strict vehicle emissions and efficiency standards** and enforcing mandatory inspection and maintenance for vehicles (5).

**Note**: if you have examples of national policies, regulations or measures to reduce ambient air pollution that have been developed or used in your country they can be mentioned here.

**References**:


Figure:
• © WHO.
An air quality index summarizes the air quality conditions in a particular location (for example, a city or even a specific area within a city) into a single number or category. They provide information about air quality in real time, interpreting and transmitting information from monitors almost instantly. According to the United Nations Environment Programme (UNEP), only 27 per cent of countries in 2021 used air quality indices to communicate in real time the state of the air quality to the public (1).

What is an air quality index (1,2)?
- Air quality indices monitor variations in ambient air pollutant concentration levels over the short-term (e.g., hours).
- They often provide health messages to encourage individuals to adjust their behaviours to reduce short-term exposure to elevated levels of air pollution and its associated health risks.

What are the functions of an air quality index (1–3)?
1. Share information with the general public about current and forecast ambient air quality conditions.
2. Protect the general public and at-risk population groups (susceptible or vulnerable) from experiencing short-term adverse health effects caused by elevated levels of air pollution.
3. Educate and raise awareness among the general public, at-risk population groups, and government decision-makers about the links between air pollution and human health.

The following two slides illustrate examples of two different types of air quality indices.
Note: for more information about the use of personal protective equipment, please see reference (3).

References:
AirNow is the national air quality index tool used in the United States of America to communicate daily air quality. It uses a colour-coded index to illustrate health risks, measured between 1 and 500, and is accompanied by information for general and at-risk populations. AirNow indicates a primary pollutant that is the current highest in ambient air in a specified area. AirNow is aimed at the public, health professionals, teachers and students and weather forecasters (1). The website also includes (1):

- current and forecast air quality maps and data for more than 500 cities across the United States of America;
- current and historical data for some United States of America Embassies and Consulates around the world;
- current fire conditions;
- air quality data for Canada and Mexico.

**Note:** if an air quality index is used in your country, discuss it here.

**References:**

**Figure:**
This slide shows the Air Quality Health Index used in Canada. In contrast to the air quality index used in the United States of America, this index uses a combination of all air pollutants calculated to reflect the potential compounded health risks of multiple pollutants in a single value (1,2). As of 2023, Canada is the only country with an Air Quality Health Index. Additional features of the Air Quality Health Index include (1):

• measurements of air quality on a scale from 1 to 10 (see image on the left of the slide);
• provides health messages and advice customized to each category for both the general and at-risk populations (see image on the right of the slide);
• current hourly readings and maximum forecast values for the day, the evening, and the following two days;
• tips and actions to improve the air you breathe.

Note: if an air quality index is used in your country, discuss it here.

References:

Figure:
Reducing ambient air pollution: International actions and initiatives

- **WHA Resolution 68.8 – Health and the environment: addressing the health impact of air pollution**
- **Roadmap for an enhanced global response to the adverse health effects of air pollution**
- **Regional conventions on Long-range Transboundary Air Pollution**
- **Stockholm Convention on Persistent Organic Pollutants**
- **Clean Air and Climate Coalition**
- **BreatheLife Campaign**
- **International Day of Clean Air for blue skies**
- **World Asthma Day**

Ambient air pollution is an international environmental problem threatening the health of children across the world. Actions to improve air quality must be global in scope and inclusive of stakeholders in high-, middle- and low-income countries. This slide includes some international actions and initiatives that aim to improve air quality and protect public health:

- **World Health Assembly (WHA) Resolution 68.8**: in 2015, the Sixty-eighth WHA adopted a landmark resolution, “Health and the environment: addressing the health impact of air pollution”. This resolution urged Member States to research, publicize and minimize the health effects of air pollution (1);
- **Roadmap for an enhanced global response to the adverse health effects of air pollution**: in 2018 at the Seventy-first WHA, the Director-General of the World Health Organization (WHO) announced the road map, including a proposed monitoring and reporting framework with indicators and objectives to track progress (2);
- **Convention on Long-range Transboundary Air Pollution**: this Convention was the first international, legally-binding instrument to address air pollution on a regional level. It sets targets and technical emission standards with the goal of reducing the health and environmental impacts of air pollution. Since its establishment in 1979, it has grown to consist of eight protocols that identify specific measures to cut emissions of air pollutants, such as sulphur dioxide, nitrogen oxides, volatile organic compounds and particulate matter (3);
- **Stockholm Convention on Persistent Organic Pollutants (POPs)**: requires parties to eliminate production, and restrict the import and export, of POPs. As of 2023, there are 186 parties to the Stockholm Convention and it eliminates, restricts or requires the reduction, where possible, of 35 different POPs (4);
- **Clean Air and Climate Coalition**: a global, voluntary partnership of governments, intergovernmental organizations, businesses, scientific institutions and civil society organizations. The Coalition aims to improve air quality and protect the climate through actions to reduce short-lived climate pollutants and encouraging action by providing knowledge, mobilizing support for action through advocacy, increasing access to financial resources and enhancing scientific knowledge (5);
- **BreatheLife Campaign**: an initiative formed by WHO, United Nations Environment Programme (UNEP), the World Bank, and the Climate and Clean Air Coalition to address the effects of air pollution on human health and the planet. The global campaign provides a platform for cities to share best practices, including monitoring, solutions and education, with the goal of bringing air quality to safe levels by 2030. It also provides information tailored to the health sector as well as specific suggestions for individual action. As of 2023, the BreatheLife network includes 79 cities, regions and countries, reaching 492 million people. Cities and regions that join the BreatheLife network identify short-lived climate pollutants and reduction measures to prioritize; measure progress in reducing air pollution; and share strategies with other cities in the network. BreatheLife works with municipalities to provide guidance on air pollution monitoring, implement solutions and build grassroots support. Health care
professionals can use BreatheLife’s resources for up-to-date data and information, policy suggestions and individual actions (6);

- **International Day of Clean Air for Blue Skies**: an official day observed by the United Nations (UN), occurring annually on 7 September. It aims to build a global community of action and encourage countries to work together to protect air quality. The theme in 2023 was “The Air We Share,” focussing on the transboundary nature of air pollution (7);

- **World Asthma Day**: organized annually in May by the Global Initiative for Asthma to raise awareness and education on asthma. In 2023, the theme of the day was “Asthma care for All (8).”

**Note**: search your city on the BreatheLife platform to see whether your local government is “breathing life” into your region.

**References**:
The World Health Organization (WHO) conducts work on ambient air pollution across four broad categories. All the publications, tools and resources discussed on this slide are open for anyone to access and use.

- **Technical support, guidance and tools:** The following resources are available for use via WHO’s website:
  - Air quality standards
  - AirQ+, Carbon-H
  - Health Impact Assessment tools and Health Economic Assessment Tool for walking and cycling
  - Clean Household Energy Solutions Toolkit
  - WHO Global Air Quality Guidelines

- **Promoting interventions and initiatives:** That encourage healthy sectoral policies, address key risks from air pollution and contribute to co-beneficial climate change mitigation policies. For example:
  - The Urban Health Initiative is a framework that aims to reduce the mortality and morbidity caused by air pollution and lack of clean energy access in cities. It aims to equip health and other sectors with the data, tools and capacity to demonstrate to the public and decision-makers the full range of benefits that can be achieved by creating healthy urban environments. Pilot projects in Ghana and Nepal are being run under the initiative (10);
  - Integrated health in urban and territorial planning: the directory is an online repository of more than 100 open access resources and tools that provide information on planning and designing urban spaces from a health perspective and guidance on how to do it (11).

- **Monitoring and reporting on global trends:** in health outcomes associated with actions taken to address air pollution.
  - WHO Ambient Air quality database and data portal
  - SDG monitoring for air pollution related indicators

- **Raising awareness and solutions to mitigate health risks:** Such as:
  - Air pollution and health training toolkit for health workers (APHT)
  - Global conferences and joint initiatives
pollution:

• WHO Ambient Air quality database compiles data on ground measurements of annual mean concentrations of nitrogen dioxide and particulate matter (both PM\(_{10}\) and PM\(_{2.5}\)) (12);
• Air Pollution Data Portal monitors exposure, concentrations and health impacts of air pollution at national, regional and global levels from both ambient and household air pollution (13);
• Sustainable Development Goal (SDG) monitoring for air pollution-related indicators (see Slide 60 for more details) (13,14);

• Raising awareness and developing solutions to mitigate health risks through outreach, training, research and collaborations:
  • Air pollution and health training toolkit for health workers (APHT) is a set of materials designed to enable health workers to understand the health risks of air pollution and identify risk reduction measures (15);
  • Global conferences and joint initiatives, including the WHO First Global Conference on Air Pollution, the first ever global event focused on both air pollution and health. It underlined the links between air pollution and the global epidemic of noncommunicable diseases (NCDs) and positioned the health sector to catalyze actions for health-wise policies in sectors such as clean household energy, transport, and waste. More than 70 commitments to tackle air pollution were made to move the global community on a path towards cleaner air (16). A second Global Conference is planned for 2024 (17).

Note: this is only a selection of the resources available through WHO. Please visit https://www.who.int/health-topics/air-pollution to view the full range of WHO publications, tools and resources available that target air pollution and health.

References:


In 2021, the World Health Organization (WHO) released the update of its global air quality guidelines for particulate matter (both PM$_{10}$ and PM$_{2.5}$), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide. Since the Global update 2005, there has been a significant increase in the quality and quantity of evidence illustrating the adverse human health effects linked to air pollution (1,2).

The aim of the air quality guidelines is to provide quantitative health-based recommendations for air quality, expressed as short- or long-term concentrations of the major air pollutants. The air quality guidelines outline optimal achievable air quality levels to protect human health worldwide and are applicable to both indoor and ambient air. The emphasis in the guidelines is placed on exposure, as this is the element that can be controlled to reduce dose and, consequently, related health effects. Values for major ambient air pollutants are given in the table on the slide, listed by average exposure over the listed time period (1).

The WHO global air quality guidelines also detail interim targets to guide reduction efforts of the major air pollutants towards the ultimate achievement of the guidelines in countries that far exceed the guideline limits (1,3).

The WHO air quality guidelines do not provide thresholds below which no health effects occur; they suggest the lowest levels possible given local constraints (1).

The air quality guidelines are aimed at three main audiences (1):

- policy-makers, lawmakers and technical experts who develop regulations on air quality at local, national and international levels;
- local and civil society groups, nongovernmental organizations and others who engage in advocacy work;
- academics and researchers who work on the impacts of air pollution.

Additionally, health professionals can use these guidelines in conjunction with local regulatory levels, which have been established in almost all major cities, to gauge risk to patients of real-time air pollution exposures. Air quality standards in different countries may vary due to local circumstances, such as technology available and economic feasibility (1,3).

References:


Figure:
- © WHO.
This slide illustrates two open access online databases mentioned in the *WHO global air quality guidelines* that can be used to find global air quality data and estimates.

1. **World Health Organization (WHO) Ambient Air Quality Database**: provides information on ground measurements of *annual average concentrations* of nitrogen dioxide and particulate matter (PM), including PM$_{10}$ and PM$_{2.5}$, for specific cities, towns, urban and rural areas based on available measurements. One strength of the WHO database is that all data included has been validated. However, as this database gives an annual concentration representative of a city or town as a whole, rather than individual monitoring stations, it cannot be used to share real-time air quality information with the general public or provide advice on air pollution-related health risks in the short-term. The database has been updated regularly since 2011 and is used as an input to derive the Sustainable Development Goal (SDG) indicator 11.6.2, Air quality in cities (1,2).

2. **OpenAQ**: is a non-profit-making effort to maintain an open access source to air quality data estimates. It uses an aggregated set of current and archived air quality data gathered in real-time from government agencies, aiming to give everyone access to the means to analyze, communicate and advocate for clean air. One strength of OpenAQ is that it provides real-time data from a large number of air quality monitoring stations around the world. However, the data on OpenAQ has **not** been validated. OpenAQ aims to empower policy-makers around the world to ensure everyone breathes clean air (3).

**Note**: use available data from these two sources to highlight any air quality information relevant to your context.

**References**:

The Sustainable Development Goals (SDGs) are 17 standards that provide a broad framework for economic, social and environmental development. Agreed upon in 2015 by the United Nations (UN) General Assembly, each goal is divided into several targets with accompanying indicators. These targets are due to be achieved by 2030. The SDGs emphasize that health is inextricably linked to environmental factors, including ambient air pollution (1,2).

Improving air quality is a cross-cutting issue and is essential to achieving many of the SDGs, including **SDG 9** (build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation), **SDG 12** (ensure sustainable consumption and production patterns and **SDG 13** (take urgent action to combat climate change and its impacts) (1).

Improving air quality is central to the achievement of (1):

- **SDG 3**: Ensure healthy lives and promote well-being for all at all ages, which includes **Indicator 3.9.1** on reduction of the global mortality rate attributed to household and ambient air pollution. The World Health Organization (WHO) is the custodial agency for this indicator and details can be found on the Air Pollution Data portal (3);
- **SDG 7**: Ensure access to affordable, reliable, sustainable and modern energy for all, including **Indicator 7.1.2** on the proportion of the global population with primary reliance on clean fuels and technologies for cooking. WHO is the custodial agency for this indicator and details can be found on the Household Energy Database (4);
- **SDG 11**: Make cities and human settlements inclusive, safe, resilient and sustainable, which includes **Indicator 11.6.2** on annual mean levels of fine particulate matter (PM$_{2.5}$ and PM$_{10}$) in cities. WHO is the custodial agency for Indicator 11.6.2 and the data from the WHO Ambient Air Quality database is used as an input for this indicator (5).

Improving air quality and achieving the SDGs is essential to improving the health and futures of children across the world.

**References:**


**Figures:**
- **Left:** © WHO.
- **Right:** © UN.
The final section of this module explores an example of national actions related to child health outcomes and a traffic intervention implemented to reduce vehicle emissions.

**Note:** if you have examples that detail local, regional or national ambient air pollution interventions targeting the improvement of child health, they can be used here.

**Photo:**
Traffic pollution is a significant contributor to global ambient air pollution. In 1992, The Law Concerning Special Measures for Total Emission Reduction of Nitrogen Oxides (Automobile NOx Law) was enacted in Japan with the aim of reducing nitrogen oxides emissions from traffic in large cities. In June 2001, this law was amended to include particulate matter (PM) and became The Automobile NOx/PM Law that continues today (1).

The Automobile NOx/PM Law aims to reduce ambient air pollution concentrations of suspended PM and nitrogen oxides by banning the re-registration of diesel vehicles that do not meet set emission standards in 276 designated local government areas across Japan (1). These areas include both urban and rural communities. Designated areas were chosen based on local levels of air pollution due to vehicles emissions. In 2000, in the designated areas, diesel vehicles were estimated to account for 87% of suspended PM emissions (2).

Under this law, diesel vehicles that do not meet set emission standards are banned from re-registration. Emission standards apply to all types of diesel vehicles, including light and heavy commercial vehicles, buses and passenger vehicles. Emission standards set by the Law differ depending on vehicle type and the age of the vehicle. Registration restrictions were introduced in a staggered manner 2004–2015 based on the first registration year of the vehicle (1–3).

The Law offers vehicle owners two main options to ensure compliancy (2):
1. Retrofit old vehicles with approved devices that can control emissions of nitrogen oxides and PM;
2. Scrap and replace old, noncompliant vehicles with new, cleaner versions.

Data from Japan suggests that by 2008, about 70% of non-compliant vehicles had been scrapped (3).

References:

Photo:
• © WHO/ Conor Ashleigh. Traffic comes off an underpass in downtown Bangkok, Thailand.
Studies of the Automobile NOx/PM Law in Japan have largely been limited to assessing whether the law has been effective in reducing levels of ambient air pollution. One study, however, has assessed the impacts that the Law has had on concentrations of nitrogen dioxide and suspended particulate matter (PM) pollution and associated respiratory health effects in 3-year-old children in Japan (1).

Hasunua et al. (2014) studied 28 regions across Japan, including 16 regions designated as enforcement areas (intervention sites) and 12 regions where the Law was not enforced (control sites). The study evaluated lung function and measures of respiratory health in 3-year-old children in relation to standards required by the Law and associated decreases in nitrogen dioxide and PM (2).

Annual rates of decrease in measurements of ambient air pollution were assessed and found that (1):
- suspended PM decreased at a rate 2.5 times faster in areas where the Law was enforced in comparison to areas where the law was not enforced;
- nitrogen dioxide decreased at a rate 2 times faster in areas where the Law was enforced in comparison to areas where the law was not enforced.

These findings are in line with other studies on the Law that have associated a decrease in ambient air pollution measurements with enforcement of restrictions on diesel vehicles (3,4).

Additionally, Hasunua et al. (2014) evaluated reductions in nitrogen dioxide and suspended PM related to the Law and contributions to decreases in asthma, wheezing, bronchitis, allergic rhinitis and atopic dermatitis in 3-year-old children living in enforcement areas. The study controlled for a range factors including maternal smoking, income, pets, bottle feeding, parental allergic disease and nursery school attendance. The study found significant correlations between improvements in air quality and reductions in asthma and atopic dermatitis prevalence (1):
- reduction in nitrogen dioxide of 1 part per billion (ppb) was significantly associated with a decrease in prevalence of asthma, at a rate of 0.118% (95% confidence interval (CI):0.012–0.225);
- reduction of suspended (PM) of 1 microgram per cubic metre (µg/m³) was significantly associated with a decrease in prevalence of asthma, at a rate of 0.05% (95% CI:0.020–0.080);
- atopic dermatitis prevalence was significantly positively correlated with increases in nitrogen dioxide (0.390% (95% CI: 0.107–0.673) per 1 ppb) and suspended PM (0.141% (95% CI: 0.058–0.224) per 1 µg/m³). Allergic rhinitis, however, increased significantly in both intervention and study areas.

This study contributes to the evidence base highlighting the importance of national policy interventions to improve ambient air quality and protect children’s health.
References:
For more information and recommended reading

For more information on children and air pollution see the additional training modules:
• Children and respiratory diseases linked to the environment
• Global climate change and child health
• Household air pollution
• Indoor air pollution
• Lead
• Second-hand smoke

Recommended reading and additional learning on ambient air pollution:
• Air pollution and health training toolkit for health workers (APHT)
• Ambient air pollution: health hazards to children
• WHO global air quality guidelines

For more information on ambient air pollution and child health please see the World Health Organization (WHO) training package on children’s environmental health for the health care sector (1). The following modules may be of particular interest:

• Childhood respiratory diseases linked to the environment
• Global climate change and child health
• Household air pollution
• Indoor air pollution
• Lead
• Second-hand smoke.

To read and learn more on ambient air pollution see the below recommended references:

• Air pollution and health training toolkit for health workers (APHT) (2)
• Ambient air pollution: health hazards to children (3)
• WHO global air quality guidelines: particulate matter (PM2.5 and PM10), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide (4).

References:
To end this presentation, a reminder that achieving a clean and healthy environment can be fought on many fronts. Health professionals are uniquely placed to take action on air pollution and ensure that children have clean air to breathe.

Figure:
• © WHO.
Acknowledgements for current version

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Approach to development

The World Health Organization’s (WHO) Training package for the health sector is a collection of modules with internationally harmonized information and peer-reviewed materials. A team of experienced professionals from over 15 countries and nongovernmental organizations (NGOs) participated in the original conception and development of the package over several in-person workshops between 2004 and 2016. These workshops identified key areas of concern related to child health and the environment, including emerging issues, on which the global health sector require additional training.

Subsequent updates of individual modules have been completed, including Ambient air pollution: training for the health care providers, 3rd edition. This update has been completed using a thorough literature search and review of the medical research database PubMed for relevant research published in the past 10 years. This literature search focused on published systematic reviews and meta-analyses, as well as some cohort, case-control and cross-sectional studies. WHO’s online repository was searched for any relevant publications. Literature searches were also conducted across other United Nations (UN) agencies repositories for relevant reports, data, figures and other source material. Other major repositories were searched as relevant.

All recommendations discussed in this module come from official, publicly available WHO guidelines and guidance. Other suggestions for action are not official WHO guidelines or guidance and are examples of local or national actions taken and are accordingly indicated and referenced.

The example of national actions featured in this module was identified through the literature search and review and through searching reference lists.

This module has been through an extensive review process with experts and has been reviewed by relevant technical teams and departments within WHO.