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The World Health Organization (WHO) and other international agencies recognize air pollution as a major threat to human health. Numerous scientific studies have linked air pollution to a variety of health problems (Table \(\PageIndex{1}\)) including: aggravation of respiratory and cardiovascular diseases; decreased lung function; increased frequency and severity of respiratory symptoms such as difficulty breathing and coughing; increased susceptibility to respiratory infections; effects on the nervous system, including the brain, such as IQ loss and impacts on learning, memory, and behavior; cancer; and premature death. Immediate effects of air pollution may show up after a single exposure or repeated exposures. Other health effects may show up either years after exposure has occurred or only after long or repeated periods of exposure. Immediate effects of air pollution include irritation of the eyes, nose, and throat, headaches, dizziness, and fatigue. Such immediate effects are usually short-term and treatable. Sometimes the treatment is simply eliminating the person's exposure to the source of the pollution, if it can be identified. Symptoms of some diseases, including asthma, hypersensitivity pneumonitis, and humidifier fever , may also show up soon after exposure to some indoor air pollutants. Table \(\PageIndex{1}\): Sources and health effects of criteria pollutants Pollutant Sources Health Effects Ground-level Ozone (O3) Secondary pollutant typically formed by chemical reaction of volatile organic compounds (VOCs) and NOx in the presence of sunlight. Decreases lung function and causes respiratory symptoms, such as coughing and shortness of breath; aggravates asthma and other lung diseases leading to increased medication use, hospital admissions, emergency department (ED) visits, and premature mortality. Particulate Matter (PM) Emitted or formed through chemical reactions; fuel combustion (e.g., burning coal, wood, diesel); industrial processes; agriculture (plowing, field burning); and unpaved roads. Short-term exposures can aggravate heart or lung diseases leading to respiratory symptoms, increased medication use, hospital admissions, ED visits, and premature mortality; long-term exposures can lead to the development of heart or lung disease and premature mortality. Lead Smelters (metal refineries) and other metal industries; combustion of leaded gasoline in piston engine aircraft; waste incinerators; and battery manufacturing. Damages the developing nervous system, resulting in IQ loss and impacts on learning, memory, and behavior in children. Cardiovascular and renal effects in adults and early effects related to anemia. Oxides of Nitrogen (NOx) Fuel combustion (e.g., electric utilities, industrial boilers, and vehicles) and wood burning. Aggravate lung diseases leading to respiratory symptoms, hospital admissions, and ED visits; increased susceptibility to respiratory infection. Carbon Monoxide (CO) Fuel combustion (especially vehicles), industrial processes, fires, waste combustion, and residential wood burning. Reduces the amount of oxygen reaching the body's organs and tissues; aggravates heart disease, resulting in chest pain and other symptoms leading to hospital admissions and ED visits. Sulfur Dioxide (SO2) Fuel combustion (especially high-sulfur coal); electric utilities and industrial processes; and natural sources such as volcanoes. Aggravates asthma and increased respiratory symptoms. Contributes to particle formation with associated health effects. Source: www.epa.gov The likelihood of immediate reactions to air pollutants depends on several factors. Age and preexisting medical conditions are two important influences. Some sensitive individuals appear to be at greater risk for air pollution-related health effects, for example, those with pre-existing heart and lung diseases (e.g., heart failure/ischemic heart disease, asthma, emphysema, and chronic bronchitis), diabetics, older adults, and children. In other cases, whether a person reacts to a pollutant depends on individual sensitivity, which varies tremendously from person to person. Some people can become sensitized to biological pollutants after repeated exposures, and it appears that some people can become sensitized to chemical pollutants as well. Poor air quality is the largest environmental risk to public health in the UK, as long-term exposure to air pollution can cause chronic conditions such as cardiovascular and respiratory diseases as well as lung cancer, leading to reduced life expectancy. This edition of Health matters focuses on the health impacts that air pollution can have across a person's lifetime, the associated health inequalities, and the current and future outlook both in terms of new cases of disease and NHS and social care costs attributable to air pollution. It includes calls to action on reducing air pollution and exposure for the health service and healthcare professionals, local government, and the public. Scale of the problem Air pollution has a significant effect on public health, and poor air quality is the largest environmental risk to public health in the UK. In 2010, the Environment Audit Committee considered that the cost of health impacts of air pollution was likely to exceed estimates of £8 to 20 billion. Epidemiological studies have shown that long-term exposure to air pollution (over years or lifetimes) reduces life expectancy, mainly due to cardiovascular and respiratory diseases and lung cancer. Short-term exposure (over hours or days) to elevated levels of air pollution can also cause a range of health impacts, including effects on lung function, exacerbation of asthma, increases in respiratory and cardiovascular hospital admissions and mortality. Air pollutants are emitted from a range of both man-made and natural sources. Many everyday activities such as transport, industrial processes, farming, energy generation and domestic heating can have a detrimental effect on air quality. The UK Health Forum and Imperial College London, in collaboration with and funded by Public Health England (PHE), developed a modelling framework and estimated that a 1 µg/m3 reduction in fine particulate air pollution in England could prevent around 50,900 cases of coronary heart disease, 16,500 strokes, 9,300 cases of asthma and 4,200 lung cancers over an 18 year period. There are legal requirements and aspirational targets for levels of different air pollutants. The government recognises that protective health - and tackling air pollution - requires action, and is committed to improving the UK's air quality and reducing harmful emissions. The draft Clean Air Strategy, published in May 2018, sets out the case for action and demonstrates the government's determination to improve our air quality. The key air pollutants Air pollution is a complex mix of particles and gases of both natural and human origin. Particulate matter (PM) and nitrogen dioxide (NO2) are both major components of urban air pollution. Currently, there is no clear evidence of a safe level of exposure below which there is no risk of adverse health effects. Therefore, further reduction of PM or NO2 concentrations below air quality standards is likely to bring additional health benefits. 1. Particulate matter (PM) PM is a generic term used to describe a complex mixture of solid and liquid particles of varying size, shape, and composition. Some particles are emitted directly (primary PM); others are formed in the atmosphere through complex chemical reactions (secondary PM). The composition of PM varies greatly and depends on many factors, such as geographical location, emission sources and weather. The main sources of man-made PM are the combustion of fuels (by vehicles, industry and domestic properties) and other physical processes such as tyre and brake wear. Natural sources include wind-blown soil and dust, sea spray particles, and fires involving burning vegetation. PM is often classified according to by aerodynamic size and referred to as: coarse particles (PM10; particles that are less than 10 microns (µm) in diameter) fine particles (PM2.5; particles that are less than 2.5 µm in diameter) ultrafine particles (PM0.1; particles that are less than 0.1 µm in diameter) The size of particles and the duration of exposure are key determinants of potential adverse health effects. Particles larger than 10 µm are mainly deposited in the nose or throat, whereas particles smaller than 10 µm pose the greatest risk because they can be drawn deeper into the lung. The strongest evidence for effects on health is associated with fine particles (PM2.5). There is an extensive body of evidence that long-term exposure to PM increases mortality and morbidity from cardiovascular and respiratory diseases. Outdoor air pollution, particularly PM, has also been classified by the International Agency for Research on Cancer (IARC) as carcinogenic to humans (a Group 1 carcinogen) and causing lung cancer. There is some experimental evidence, however, that ultrafine particles may also pass through the lungs into the bloodstream. NO2 is a gas that is produced along with nitric oxide (NO) by combustion processes. Together they are often referred to as oxides of nitrogen (NOx). The Department for Environment, Food & Rural Affairs (Defra) estimates that 80% of NOx emissions in areas where the UK is exceeding NO2 limits are due to transport, with the largest source being emissions from diesel light duty vehicles (cars and vans). Other sources include power generation, industrial processes, and domestic heating. The Committee on the Medical Effects of Air Pollutants (COMEAP) has established that short-term exposure to NO2, particularly at high concentrations, is a respiratory irritant that can cause inflammation of the airways leading to - for example - cough, production of mucus and shortness of breath. Studies have shown associations of NO2 in outdoor air with reduced lung development, and respiratory infections in early childhood and effects on lung function in adulthood. Epidemiological studies have also shown associations of outdoor NO2 with adverse effects on health, including reduced life expectancy. It has been unclear whether these effects are caused by NO2 itself, or by other pollutants emitted at the same time by sources such as road traffic. 3. Other pollutants SO2 is produced when sulphur-containing fuels, such as coal, are burned. It is an invisible gas with a sharp smell and can dissolve in water. Chemical reactions of SO2 can also produce sulphates, which remain in the air as secondary particles, contributing to the PM mix. SO2 has an irritant effect on the lining of the nose, throat and airways, and the effects are often felt very quickly. Due to the increased use of gas and electricity, coal-burning is now relatively uncommon, and levels of SO2 have steadily declined over the last 50 years. Most SO2 in the UK now comes from industrial sources, such as coal and oil-burning power stations, as well as domestic sources such as boilers and stoves. NH3 is a gas released into the atmosphere from natural and man-made sources. Once emitted into the atmosphere, the subsequent deposition of NH3 can be a major source of pollution, causing nitrogen (N) enrichment (eutrophication) and acidification of soil and water sources. Atmospheric NH3 also reacts with acid gases, such as sulphuric and nitric acid, to form secondary PM2.5. The main health impacts of NH3 arise through its role in secondary PM2.5 formation and health effects associated with exposure to PM, as described above. Thus, NH3 not only plays a role in acidification and eutrophication but also contributes to the overall PM burden. Agricultural emissions of NH3 have been reported to be key contributor to some short-term episodes of high PM pollution in recent years. O3 is a gas and occurs both in the earth's upper atmosphere and at ground level. Ground level, or tropospheric O3, is not emitted directly into the air but is created by photochemical reactions involving the precursor pollutants NOx and volatile organic compounds (VOCs). Several epidemiological studies have reported adverse associations between short-term exposure to O3 and human health. The effects of exposure to O3 are predominantly respiratory, but adverse effects on the cardiovascular system have also been reported. Less convincing evidence exists for an association between long-term exposure to O3 and impacts on human health. 3.4. Carbon monoxide (CO) CO is a colourless, odourless and tasteless gas, produced when fuels such as gas, oil, coal and wood burn without enough oxygen. These are sources of fuel used in many household appliances, including boilers, central heating systems, gas fires, water heaters, cookers and open fires. Burning charcoal, running cars and the smoke from cigarettes also produce CO gas. Exposure to high indoor levels can be fatal, while exposure to lower levels can result in symptoms that resemble flu, viral infections or food poisoning. More information about CO in this collection and on the NHS website. 3.5. Non-Methane Volatile Organic Compounds (NMVOCs) NMVOCs consist of a large variety of chemically different compounds and in the environment come from both natural and anthropogenic sources. The total anthropogenic NMVOC emissions in the UK have decreased by 68% between 1970 and 2016. The rate of decline was most pronounced in the 1990s, largely reflecting the decline in coal mining, and has slowed in recent years. NMVOCs are emitted from a wide variety of products and processes including industrial processes and agriculture, and they also form a significant component of indoor air pollution emitted from household products. In the outside atmosphere, NMVOCs react with NOx in the presence of sunlight to form tropospheric O3, known to be harmful to health and the environment. Indoors, VOCs emitted from consumer products are not thought be to a significant public health issue when homes are well ventilated and when the products are used according to the manufacturers' instructions. But some sensitive people may suffer irritation of the eyes, nose and throat, headaches and dizziness if they are exposed. Indoor air pollution Air pollution isn't just about the outdoor world. There are a number of sources of indoor air pollutants that can harm health including: CO, NO2 and particulates from domestic appliances (boilers, heaters, fires, stoves and ovens), which burn carbon containing fuels (coal, coke, gas, kerosene and wood) VOCs from cleaning and personal care products, building materials and household consumer products (paints, carpets, laminate furniture, cleaning products, air fresheners, polishing) environmental tobacco smoke (ETS) and second hand smoke (SHS) radon is a naturally occurring radioactive gas that comes from the ground as the earth decays. There is an increased risk of lung cancer if exposed to high levels of radon for a long time, as it is the second highest cause of lung cancer after smoking. It's generally not a problem in outside air but can accumulate in buildings. PHE works with government and others to develop and review the evidence on indoor air quality. This includes the Royal College of Physicians and Royal College of Paediatrics and Child Health's systematic review on the effects of Indoor Air Quality on Children and Young People's Health. Why invest? PHE's cost of air pollution project quantified the potential costs to the NHS and social care system due to the health impacts of PM2.5 and NO2 in England. It estimated that between 2017 and 2025, the total cost of air pollutants for which there was more robust evidence for an association, was £1.69 billion for PM2.5 and NO2 combined (£1.54 billion for PM2.5 and £60.81 million for NO2). A tool to estimate the cost of air pollution for each local authority was made available, as part of this project. Air pollution can impact people of working age, which can also have economic effects, for instance, if they have to take days off work. Defra estimated that in 2012, poor air quality cost the economy £2.7 billion through its impact on productivity. Dealing with poor air quality in all its forms is a priority for the government, with the UK having signed up to tougher legally binding national emission ceilings for 5 major pollutants (PM, NO2, SO2, NMVOCs and NH3). In the draft Clean Air Strategy, the government has committed to reducing the harm to human health from air pollution by halving the population living in areas with concentrations of fine PM above World Health Organization (WHO) guideline levels (10µg/m3) by 2025. Air pollution is not an issue that occurs in isolation. Pollution can be associated with other environmental hazards that affect health, and it can contribute to health inequalities. However, measures that improve air quality can also offer wider public health and wellbeing co-benefits, including an improvement in overall environmental quality, increased physical activity, noise reduction, greater road safety and climate change mitigation. Multiple interventions, each producing a small benefit, can act cumulatively to produce significant overall benefits. How air pollution harms health 1. Where pollutants go in the body and what they do When air pollutants enter the body, they can have effects on various different organs and systems, not just the respiratory system. This includes: the eyes, nose and throat the lungs and respiratory system the heart – heart and blood vessel diseases, including strokes and hardening of the arteries, are one of the main effects of air pollution Emerging evidence suggests that air pollution may also affect the brain and is possibly linked to dementia and cognitive decline. There is also emerging evidence associating air pollution with early life effects such as low birth weight. 2. Impact of air pollution across a person's lifetime Air pollution can affect everyone, and air in all areas of the UK contains some proportion of man-made air pollutants. Exposure to air pollution has various different health effects, which come about at every stage of life, from a foetus' first weeks in the womb all the way through to old age. The health effects of air pollution are complex, and range in severity of impact. In some cases, damage can be gradual and may not become apparent for many years. The 3 main conditions associated with air pollution are respiratory conditions (such as asthma), cardiovascular disease (CVD), and lung cancer, and there is emerging evidence for associations with dementia, low birth weight and Type 2 diabetes. COMEAP has highlighted that exposure to air pollution contributes to many thousands of deaths in the UK, through increasing the risk of CVD, respiratory disease and cancers. There is therefore a strong case for action to tackle air pollution, and action to improve air quality and health is a priority area for PHE. The following sections outline the various health effects and conditions that come about at different stages of life. The Royal College of Physicians' report, 'Every breath we take: The lifelong impact of air pollution', presents the findings of multiple international studies regarding each of these health effects. 2.1. Early childhood development: pregnancy, the developing foetus and infancy Pregnancy and early childhood are critical times for the formation and maturation of body systems, and the time during which the most rapid changes take place. Factors that adversely affect human development, including air pollution, can have both immediate and long-lasting effects on a person's health, and some health impacts may only emerge later in life. As well as potential effects on foetal growth, air pollution exposure is associated with low birth weight and premature birth. 2.2. Lung function development and decline Exposure to air pollution in early life can have a long-lasting effect on lung function. There is evidence that the process of normal lung function growth in children is suppressed by long-term exposure to air pollution. Throughout childhood, there is a natural development of lung function and maximising this is important, as low lung function leads to less reserve if lung disease develops. Lung function in adulthood slowly declines with age, and there is emerging evidence that air pollution and living near a busy road accelerate this decline, for both adults and older people. Minimising this is important to maximise reserve, especially if lung disease develops in later life. 2.3. Asthma Asthma, a long-term inflammatory condition of the conducting airways of the lungs, leads to cough, wheezing, chest tightness, and shortness of breath. Asthma symptoms in those who have the condition can be exacerbated by various stressors, including respiratory viral infection, allergen exposure, and episodes of elevated air pollution. There is increasing evidence of air pollution having a potential role in causing asthma, especially in people who live near busy roads, as well as being a trigger that can make an asthmatic's symptoms worse. 2.4. Cardiovascular disease There is strong evidence for the effects of both short and long-term exposures to air pollution on CVD in adults. Air pollution can both contribute to the development of CVD and exacerbate heart conditions that already exist, with the strongest associations having been observed for PM. The COMEAP report: The Effects of Long-Term Exposure to Ambient Air Pollution on Cardiovascular Morbidity: Mechanistic Evidence, details the mechanisms of effect of air pollutants as they impact on cardiovascular morbidity. The risk of heart failure, myocardial infarction (heart attacks), arrhythmias (abnormal rhythms of the heart) and stroke is increased by both short and long-term exposure to air pollution in susceptible individuals. This includes older people and individuals with pre-existing cardiovascular and respiratory conditions. The strongest associations have been observed for fine PM, which is associated with both cardiovascular morbidity and a reduction in life expectancy as a result of increased death from CVD (and respiratory disease and lung cancer). Despite the robust evidence for adults, it remains unclear whether exposure to air pollution during childhood influences CVD development in later life. However, it has been found that in children, there are changes in biomarkers of cardiovascular function, such as blood pressure and pulmonary arterial pressure, after exposure to air pollution. 2.5. Cancer There is strong evidence that outdoor air pollution is linked to lung cancer, and the IARC has classified outdoor air pollution and PM from outdoor air pollution as carcinogenic to humans. Despite the strong evidence for adults, there is weaker evidence related to effects on children, with the World Health Organization (WHO) reporting in 2005 that there was 'insufficient evidence for ambient air pollution and childhood cancer'. This could be in part due to lung cancer being rare in children. However, as it is believed that lung cancer can take many years to develop following exposure, some research suggests that exposure in childhood could contribute to the development of cancers in later life. 3. Current and future impact Having a thorough understanding of how air pollution is likely to impact health and related healthcare costs over time is important for future policy and resource planning. The Environmental Audit Committee has estimated that health costs as a result of air pollution range between £8.5 billion and £20.2 billion a year. To estimate the NHS and social care costs for treating health effects, PHE developed a modelling framework to quantify present and future morbidity. PHE's report, Estimation of costs to the NHS and social care due to the health impacts of air pollution, provides the methods and results of the modelling exercise to quantify: the future incidence and cumulative incidence cases of air pollution related diseases the NHS and social care costs; specifically primary care, prescription, secondary care, and social care, associated with air pollution The following sections present the incidence of all conditions associated with long-term exposure to PM2.5 and NO2 in England, as quantified by the modelling framework. It makes a strong case for investing in prevention and early intervention at local and national levels, as well as allowing the necessary resources for the cases that cannot be prevented. As presented in the table below, PHE's modelling framework found that in 2017 there were 63,430 (±2,154) total incidence cases of disease attributable to PM2.5 in England. It is predicted that between 2017 and 2035, 1,327,424 (±9,927) new cases of disease would be attributable to PM2.5, equivalent to 2,248 new cases of disease per 100,000 people. The highest numbers of these cases are predicted to be from coronary heart disease (CHD), diabetes and COPD. PHE's modelling framework found that in 2017, there were 60,648 (±2,549) total incidence cases of disease attributable to NO2 in England. It is predicted that between 2017 and 2035, 1,140,018 (±11,800) new cases of disease would be attributable to NO2, equivalent to 1,933 new cases of disease per 100,000 people. The highest numbers of these cases are predicted to be from diabetes and asthma. 4. Air pollution and health inequalities Although air pollution can be harmful to everyone, some people are more affected because they live in a polluted area, are exposed to higher levels of air pollution in their day-to-day lives, or are more susceptible to health problems caused by air pollution. The most vulnerable face all of these disadvantages. Groups that are more affected by air pollution include: older people children individuals with existing CVD or respiratory disease pregnant women communities in areas of higher pollution, such as close to busy roads low-income communities 4.1. Low-income communities There is clear evidence that people with a low income are affected by air pollution in a number of different ways. This is because they are more likely to: have existing medical conditions live in areas with poorer outdoor and indoor environments, including the quality of air (for example, near to industry or busy roads) have less access to jobs, healthy food, decent housing and green spaces, which all contribute to poorer health The disadvantages that come about as a result of poor income add up, putting deprived populations who are more likely to be in poor health at greater risk from air pollution and its adverse health impacts. These inequalities can also affect people throughout their lives, from the prenatal stage through to old age, particularly as deprived communities often have limited opportunities to improve their environment. Call to action: reducing air pollution Improving air quality is crucial to reduce the health impacts discussed above and, in turn, help people live longer, healthier lives. A study in 2006 found that reducing PM by 10µg/m3 would extend lifespan in the UK by 5 times more than eliminating casualties on the roads, or 3 times more than eliminating passive smoking. Everyone needs to play their part. Local government Local authorities have a statutory role in assessing and improving local air quality, and the cumulative effects of this local action are significant. The effect of a range of interventions to improve air quality has greater potential to reduce the associated burden of disease than anyone intervention alone. As the greatest impact will be achieved by synergistic packages of interventions, a strategic approach involving a combination of legislative, policy, behavioural and technological interventions is required in order to realise the greatest benefits. When new plans and programmes are designed, and when new development or regulatory consents are issued, options appraisals can preferentially select approaches that have the greatest potential to benefit air quality and health. PHE recommends that evaluation is embedded in the design and costing of all future national and local interventions, from their outset, to systematically gather evidence of effectiveness and cost-effectiveness to inform future policy development. Councils can: invest in infrastructure and public transport, and promote active travel and cycle routes implement measures to reduce air pollution caused by road traffic and other sources design healthy environments, bringing in spatial planning, urban design, road and building layouts, and green spaces Case study: ECO Stars Fleet Recognition Scheme. Pedestrians, cyclists, and users of other modes of transport that involve physical activity need the highest priority when developing or maintaining streets and roads. This can mean: reallocation of road space to support walking and cycling restricting motor vehicle access introducing road-user charging and traffic-calming schemes creating safe routes to schools improving or adding green spaces and tree cover improves air quality, as well as making spaces feel more welcoming small-scale improvements, such as good street lighting or improved road crossings Taking effective local action to reduce air pollution and improve public health requires an inclusive, multi-disciplinary approach across local authority functions involving spatial and transport planners, environmental and public health teams, local political and community leaders and the public. Coordination between local areas is also vital to align approaches and avoid displacement of pollution from one populated area to another. Defra and PHE's Air Quality: A briefing for Directors of Public Health report provides simple steps to specifically improve public health as part of local authority work to review and address local air quality. These range from a basic assessment that all Directors of Public Health can conduct, to more detailed steps for identifying key locations of concern, sources of air pollution, and how to correctly rank air pollution in a local Joint Strategic Needs Assessment. Both this briefing and the NICE guideline on outdoor air pollution (NG70) provide guidance for local authority staff working in transport, planning, local air quality management, and environmental and public health. The health service and healthcare professionals Health professionals and local government have an important part to play in helping the public to understand the health effects of air pollution and offering their patients advice on managing their conditions, as well as actions they can take to reduce their day-to-day and lifetime exposure to air pollution. Advice is best if it is tailored to a patient's level of vulnerability. For example, individuals with asthma or other respiratory conditions should be advised not to undertake vigorous exercise when outdoor air pollution levels are high. It is important to review how people can minimise their exposure to air pollution on a longer-term basis, whether this is through travel choices or other changes to their lives. Defra and PHE's Air Quality: A briefing for Directors of Public Health report identified 6 principles for communicating with the public about air pollution. When it comes to health effects, it is important to focus on what is known for certain about the health consequences of air pollution. Messages that health professionals can communicate to their patients include: air pollution affects everyone, and can particularly affect some individuals who are more vulnerable to harm - including those with heart and lung disease, children, and the elderly particulates are now known to contribute to heart disease and lung cancer many years of life are lost each year in the UK, as a result of air pollution people's behaviour can reduce their contribution to local air pollution people's behaviour can reduce their exposure to air pollution To avoid exposure to high levels of air pollution, it is important to be aware of air quality. People can do this by keeping an eye on online updates from relevant organisations, such as Defra's Pollution forecast and air quality updates on social media. Defra's Daily Air Quality Index (DAQI) provides recommended actions and health advice for both the general population and for at-risk individuals. The index is numbered 1 to 10 and divided into 4 bands, low (1) to very high (10), to explain air pollution levels in a simple way. In addition to communicating the right messages to patients, the health service must no longer be a major polluter itself. The NHS Sustainable Development Unit estimates the baseline NHS impact on air pollution is 9.5bn road miles, 7,285t NOx and 330t PM2.5 emitted. It estimated that a 3% increase in uptake of active travel by NHS staff in England would lead to healthier staff, saving over £265m in avoided health treatment costs and improving health by 114,000 Quality Adjusted Life Years (QALYs). As well as leading by example and setting the benchmark for cleaner air and safe workplaces, the NHS can influence and work with other decision-makers and professionals, whose choices and plans affect people's exposure to air pollution. They include councillors, traffic and spatial planners, and Environmental Health Officers (EHOs). The public Health professionals and local government have an important part to play in communicating health messages to the public, both during air pollution episodes and more generally regarding the long-term benefits to health of improving air quality. One of the many actions people can take, to reduce both their exposure and how much they contribute to air pollution, is to consider their travel options. Even using a petrol car rather than a diesel can make a big difference, especially in towns and cities where NO2 levels are likely to be highest. It is important that health professionals and local government help communicate local options to the public to help them make the healthiest choices. The Department for Transport reported that in 2016, 67% of the usual mode of travel to work was by car or van. If the journey is less than a mile, walking or cycling are preferable, especially as active travel has the additional benefits of improving physical and mental health and quality of life. Case study: Clean Air Day 2018, the UK's largest air pollution campaign Case study: Primary school celebrates Clean Air Day with street party Using public transport also makes a difference, as it reduces the number of cars on the road. Walking or cycling to work or to get to public transport whilst avoiding polluted routes, such as main roads, can help to improve health and reduce exposure. If driving is the only option, congestion can be reduced if people are able to avoid travelling during morning and evening rush hours. Driving economically, such as accelerating gently, adhering to speed limits, and ensuring tyre pressures are correct, saves money by using less fuel, reduces the number of road collisions and reduces air pollution. People can also reduce pollution by turning off their engines when waiting, especially when other people are nearby or when waiting for children during the school run. Improving our environment and health is not just about day-to-day travel choices. There are lots of day-to-day actions that can reduce emissions. Defra has provided practical guidance on the best use of open fires and wood-burning stoves, and turning down central heating and turning off appliances when they are in standby or not in use can all make a difference that adds up over time. In the longer-term, people can consider lower-emission alternatives when they are buying their next car, updating their home heating system, or carrying out other home improvements. In many cases, the government provides grants or other incentives and installing energy-saving measures and home electricity generation using solar panels or wind turbines can help to reduce our dependence on fossil fuels over time. Resources Download supporting references Download the Health matters infographics Read the Health matters blog Read case study: Reduced bus emissions and improved air quality in Brighton & Hove Read case study: ECO Stars Fleet Recognition Scheme Read case study: New data on pollution levels around hospitals and surgeries from BLF Read case study: Clean Air Day 2018, the UK's largest air pollution campaign Read case study: Primary school celebrates Clean Air Day with street party As a library, NLM provides access to scientific literature. Inclusion in an NLM database does not imply endorsement of, or agreement with, the contents by NLM or the National Institutes of Health. Learn more: PMC Disclaimer | PMC Copyright Notice . Author manuscript; available in PMC: 2017 Mar 1. Air pollution continues to be a major public health concern affecting nine out of ten individuals living in urban areas worldwide. Exposure to air pollution is the ninth leading risk factor for cardiopulmonary mortality. The aim of this review is to examine the current literature for the most recent updates on health effects of specific air pollutants and their impact on asthma, chronic obstructive pulmonary disease (COPD), lung cancer and respiratory infection. A total of 53 publications were reviewed to establish new insights as to how air pollution is associated with pulmonary morbidity and mortality. Considerable past evidence suggests that air pollution is an important factor that enhances pulmonary disease, while also causing greater harm in susceptible populations, such as children, the elderly and those of low socio-economic status worldwide. Asthma, COPD, lung cancer and respiratory infections all seem to be exacerbated due to exposure to a variety of environmental air pollutants with the greatest effects due to particulate matter (PM), ozone and nitrogen oxides. New publications reviewed reaffirm these findings. Continued vigilence will be essential to lessen the effects of air pollution on human health and pulmonary disease. Cooperation at a multi-national level will be required on the part of governments, industry, energy-based enterprises and the public working together to solve our air quality issues at the local, national and global level.Keywords: particulate matter, ozone, criteria pollutants Ambient air pollution is a major global public health problem, affecting both developing and developed countries. Many developing countries derive energy from natural, inexpensive sources for industrial, commercial and living purposes, but do not have sufficient technologies to mitigate potential air pollution arising from these energy sources. According to the World Health Organization (WHO) Ambient Air Pollution database, derived from measurements taken in 1600 cities in 91 countries, almost nine out of ten individuals living in urban areas are affected by air pollution [1]. Exposure to outdoor air pollution is the ninth leading risk factor for mortality, and outdoor air pollution is responsible for 3.2 million deaths each year [2]. Recent studies show that exposure to air pollution is associated with acute and chronic cardiopulmonary mortality and all cause mortality [3-5]. The aim of this review is to examine the current literature for the most recent updates on health effects of specific air pollutants and their impact on asthma, chronic obstructive pulmonary disease (COPD), lung cancer and respiratory infection. A total of 53 publications were assessed and included in the review to relay the current state of knowledge as to how air pollution is associated with pulmonary morbidity and mortality. The included literatüre covers epidemiologic, controlled human, and animal toxicologic studies. Current air pollution frequently found in urban areas is a dynamic and complex mixture of both man-made (anthropogenic) pollutants and natural sources. Six common ambient air pollutants are particulate matter (PM), ozone (O3), sulphur dioxide (SO2), nitrogen oxides (NOx), carbon monoxide (CO), and lead. In the United States, these primary air contaminants are classified as "criteria" pollutants by the Environmental Protection Agency. National Ambient Air Quality Standards have been set for each of these pollutants, by law, which must undergo an extensive literature review update every five years to ensure adequate health protection of the public. These same pollutants are found worldwide to differing degrees, but all are associated with adverse human health, as discussed below. A recent review of global premature mortality due to outdoor air pollution by Lelieveld et al., found that fine PM (PM2.5) is estimated to cause 3.3 million deaths per year worldwide[6]. PM is mainly formed through industrial processes and traffic-related sources (gasoline and diesel), coal and oil fuel combustion, farming and road construction. PM is commonly subdivided into three size classifications: coarse particles with diameters 2.5 to 10 µm (PM10), fine particles with diameters less than 2.5 µm (PM2.5), ultrafine particles with diameters less than 0.1 mm (UF). Traffic-related sources of PM are thought to be responsible for approximately 20% of air pollution-related mortality in Germany, the United Kingdom and the United States [6]. Coarse particles are often caused by disturbances of crustal materials (dust) and are a problem in the Middle East and other desert areas due to dust storms. Throughout the world residential and commercial energy use is linked to premature mortality, but is especially prevalent in Asia, where biofuel used for heating and cooking produces high levels of fine PM[6]. The potency of PMs in causing an adverse health impact is dependent, in part, on their deposition in the airways and the composition of their surface components[7] As urban centers increase in size and the global climate continues to change, it is estimated that ground level ozone (ozone smog) will become an even greater of health hazard. Ozone smog forms when nitrogen oxides and volatile organic compounds from vehicle, power, and other sources mix with sunlight and heat. As such, as the temperature increases, ozone formation increases. Other criteria pollutants, such as SO2, NOX, and CO, which are produced by fossil fuel combustion will continue to contribute to air pollution in large urban areas as well, especially in dense cities, such as those in Asia. Indoor air pollution can also be a source of exposure of exposure to air contaminants, made up of multiple pollutants, including environmental or secondhand smoke, combustion of solid fuels for home heating and cooking, formaldehyde, volatile organic compounds, and intrusion of ambient air pollution. A primary source for global household air pollution is the incomplete combustion of biofuels resulting in high levels of chemical components such as carbon monoxide, sulfur oxides, nitrogen oxides, particulates, benzene, formaldehyde, polyaromatic compounds, arsenic, and lead. Its relative contribution to human exposure can be relatively high, based on the time spent indoors. A more recent concern has been the atmospheric findings of transport of PM, ozone and even infectious components over large distances, including dust from Mongolia to the Western United States as well as Saharan dust crossing the Atlantic to deposit in countries of the Carribean. Climate change and air quality are also closely related. Recent data suggest that climate change is associated with elevations of both ozone and PM in the atmosphere[8]. Children and adolesents are more susceptable to the effects of air pollution than adults. The human respiratory system develops in utero to adolescence. Although lung function development continues in girls until their late teens and in boys until their early 20s, from birth to approximatley 6 years of age represents the greatest period of postnatal development, with formation of more than 80% of new alveoli following birth. Susceptibility to the adverse health effects of environmental and chemical toxicants may vary in different lung development stages. Environmental exposures can alter the development of both immune function and lung mechanics, including lung injury and repair [9]. Due to smaller airways, immature detoxification and metabolic systems, as well as frequent exposure to outdoor air, children are often more susceptible to airway toxicants than adults [10]. The good news is that long-term improvements in air quality have recently been shown to result in statistically and clinically significant positive effects on lung-function growth in children and also adolescents from 11 to 15 years of age reported by Gauderman and collegues in 2015 [11]. The elderly population has also been shown to be more susceptable to inflammation and respiratory complications due to air pollution. In the elderly, particle clearance might be less efficient or impaired by other dysfunctions. A 2015 study by Carosino et al demonstrated using an animal model that exposure to PM exacerbates allergic inflammation in the lung [12]. Ozone has also been shown to cause oxidative stress, inflammatory responses and immunologic disease in laboratory animals [13]. Li et al. have demonstrated that SO2 affects the airway inflammatory and immune responses of asthmatic rats and enhances their susceptibility by aggravating inflammatory responses in the lung [14]. Exposure to air pollutants can lead not only to inflammation, but also changes in lung function. In 2013 Rice et al using The Framingham Heart Study found short-term exposure to PM2.5, ozone, and NO2 were associated with a lower FEV1 and FVC in nonsmoking adults [15]. In children Mölter et al. have reported that lifetime exposure to PM10 and NO2 may be associated with reduced growth in FEV1 [16]. A longitudinal cohort study reported in 2015 showed that long-term NO2 and PM10 exposure decreased lung function parameters (FEV1, FVC) [17]. Two studies of Chinese schoolchildren in 2013 and 2014, found long-term exposure to ambient air pollution was associated with a number of adverse effects, such as wheezing, cough or phlegm. Of interest was that PM10 may be the most relevant pollutant associated with adverse effects as well as with impaired lung function [18, 19]. A large body of evidence also demonstrates an association between short-term exposure to air pollutants and the incidence of asthma exacerbations and hospital admissions. Short-term exposure to ozone has been shown to be significantly associated with increased hospitalizations in children [20]. Ierodiakonou and colleagues also recently found exposure to ambient air pollutants was associated with reduced lung function and increased airway responsiveness in asthmatic children [21]. Poor air quality due to high levels of ozone has been shown to not only contribute to the exacerbation of asthma, but to also be a cause in the development of asthma [22]. It is less clear what are the effects of other sources of air pollutants in asthma development, such as traffic-related emissions. However, a systematic review published in 2015 suggests that exposure in early childhood to traffic-related air pollution (TRAP) containing PM2.5 is associated with an increased incidence of asthma up to the age of 12 years [23]. However, the European Study of Cohorts for Air Pollution Effects (ESCAPE) found conflicting findings of no association between PM2.5, PM10 or NO2 and the prevalence of childhood asthma [24]. This difference might be due to study design and/or multiple other causes of asthma in children. A Korean study published in 2015 demonstrated long-term exposure to TRAP may be associated with an increased risk of asthma, allergic sensitization and decreased lung function in schoolchildren depending on the proximity of their residence to a major road [25]. A study from Japan in 2014 of 10,069 children aged 6-9 years found TRAP associated with development of asthma [26]. Finally, in a recent review article of 2014, Trevor et al. shows a consistent relationship between biomass smoke and asthma symptoms [27]. Air pollution leading to adult-onset asthma still remains unclear. However, Young et al. in 2014 reported that PM2.5 exposure increases the risk of developing asthma in adult women [4]. In addition, a large 2015 European study of 23,704 adults followed ten years from eight countries to show an association between TRAP (PM2.5) exposure and increased asthma incidence in adults [28]. Chronic obstructive pulmonary disease (COPD) is most commonly associated with smoking, however, a new study of 2015 estimated the prevalence of COPD among nonsmokers varies from 1.1% to 40% in different countries [29]. The high incidence of COPD among non-smokers is in large measure associated with indoor air pollution from biomass combustion [30] and second-hand tobacco smoke. A recent 2014 study demonstrated that improving air quality in the home decreases the incidence of COPD [31]. Other risk factors for COPD include occupational exposures and outdoor air pollution. The fraction of COPD attributable to occupation in a study of 2015 was 31.1% among nonsmoking workers [29]. There are some epidemiologic studies showing an association between outdoor air pollution and COPD from both developing and developed countries [3, 32]. A 2014 meta-analysis study reported that outdoor air pollution was associated with an increase of COPD incidence and prevalence [33]. In the same review, the authors mentioned that a 10 µg/m3 increase of PM10 in outdoor air can induce significant acute exacerbations of and mortality from COPD. A recent European review suggests a role of ambient air pollution and COPD[34]. Tsai SS. in 2013 that there is a strong relationshio between air pollution and acute exacerbations of COPD-related hospital admission[35]. However, two cohort studies in 2014 and 2015 demonstrate limited evidence of associations between outdoor air pollution and COPD incidence[36, 37]. Cigarette smoking is considered the most important cause of lung cancer. However, cigarette smoking is not the sole cause for lung cancer; additional risk factors include environmental and occupational exposures. Yu et al. in a study published in 2015 found somatic genomic mutations attributed to household air pollution (associated with coal combustion) in tumor and adjacent normal lung tissues and peripheral blood samples from 164 patients with previously untreated non-small cell lung cancer (NSCLC) compared to patients also with NSCLC from other regions with low levels of household air pollution (coal combustion) [38]. In October 2013, the International Agency for Research on Cancer (IARC) accepted outdoor air pollution and related PM as a class I human carcinogen based on data from human, animal and mechanistic studies[39]. Concurrent epidemiological studies in 2013 and 2014 indicate a positive correlation between air pollutants and lung cancer after adjustment for cigarette smoking [40, 41]. A European study also reported an association between incidence of adenocarcinoma and air pollution [41]. A recent 2015 meta-analysis shows that ambient exposure to nitrogen oxides, SO2, and PM2.5 from vehicle emissions significantly increases the risk of lung cancer [42]. Other studies also report that NO2 exposures are positively associated with lung cancer risk [41, 43, 44] and have the strongest associations with all-cause mortality and lung cancer [45]. As with PM2.5, positive correlations are reported based on a wide variety studies [46, 47]. A meta-analysis found that for each 10 µg/m3 increase in PM2.5, a meta-relative risk for lung cancer of 1.09 occurred [48]. In a case–control study from Canada, a mixed exposure to PM2.5 and NO2 was related with a larger risk for adenocarcinomas compared with other cancer subtypes [49]. In a recent study and review in 2012 and 2015 found professional drivers exposed to diesel engine exhaust have an elevated risk of lung cancer [50, 51]. Only a limited number of studies have examined the relationship between air pollution and respiratory infections. Vulnerable populations appear to be children, the eldery and people with chronic illness. Two recent epidemiological studies published in 2012 and 2014 demonstrate associations between short-term air pollution (traffic-related PM, ozone and organic carbon-based PM2.5), enhanced respiratory infection symptoms and increased emergency department visits by children [52, 53]. Concern for air pollution and its health implications continue to be a world-wide problem today. Air pollution remains a complex mixture of anthropogenic pollutants and natural sources. Of the six pollutants, PM and ozone represent the most widespread health threats for cardiopulmonary disease. Air pollution once thought of as purely a local or regional problem, now is recognised as a global issue with potential long distance atmospheric transport. Air pollution is an important contributor to respiratory complications, especially for developing countries who use biomass fuels and coal for heating and cooking in the home. It is essential that local, national and global efforts are undertaken by government, industry and the private sector to lessen the burden of air pollution to provide better respiratory health protection for everyone. -Almost nine of ten individuals living in urban areas worldwide are affected by air pollution. -The lack of a fully developed pulmonary metabolic capacity in children make them more susceptible to air pollutants compared to adults. -Air pollution continues to be associated with reduced lung function and enhanced airway reactivity in children suffering from asthma. -Prolonged exposure to air pollution exposes children to an increased risk of developing asthma. -Air pollution and ambient exposure to nitrogen oxides, SO2, and PM2.5 from vehicle emissions significantly increase the risk of lung cancer. -Short-term episodes of air pollution in children can heighten respiratory infection symptoms and the frequency of emergency room visits.

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Air pollution and acute respiratory infections among children 0-4 years of age: an 18-year time-series study. Am J Epidemiol. 2014;180:968–977. doi: 10.1093/aje/kwu234. [DOI] [PMC free article] [PubMed] [Google Scholar] Skip to main content What is air pollution and how does it lead to disease in our bodies? Air pollution is the presence of one or more contaminants in the atmosphere, such as dust, fumes, gas, mist, odour, smoke or vapor, in quantities and duration that can be injurious to human health. The main pathway of exposure from air pollution is through the respiratory tract. Breathing in these pollutants leads to inflammation, oxidative stress, immunosuppression, and mutagenicity in cells throughout our body, impacting the lungs, heart, brain among other organs and ultimately leading to disease. What organs are impacted by air pollution? Almost every organ in the body can be impacted by air pollution. Due to their small size, some air pollutants are able to penetrate into the bloodstream via the lungs and circulate throughout the entire body leading to systemic inflammation and carcinogenicity. What diseases are associated with exposure to air pollution? Air pollution is a risk for all-cause mortality as well as specific diseases. The specific disease outcomes most strongly linked with exposure to air pollution include stroke, ischaemic heart disease, chronic obstructive pulmonary disease, lung cancer, pneumonia, and cataract (household air pollution only). There is suggestive evidence also linking air pollution exposure with increased risk for adverse pregnancy outcomes (i.e. low-birth weight, small for gestational age), other cancers, diabetes, cognitive impairment and neurological diseases. What are some of the most important air pollutants leading to disease? Although there are many toxins that have adverse impacts on health, pollutants with the strongest evidence for public health concern include particulate matter (PM), carbon monoxide (CO), ozone (O3), nitrogen dioxide (NO2) and sulphur dioxide (SO2). Fine particulate matter are an especially important source of health risks, as these very small particles can penetrate deep into the lungs, enter the bloodstream, and travel to organs causing systemic damages to tissues and cells. How long does someone need to be exposed to air pollution to harm their health? Health problems in children and adults can occur because of both short- and long-term exposure to air pollutants. The levels and duration of exposure that can be considered 'safe' vary by pollutant, as well as the related disease outcomes. For some pollutants, there are no thresholds below which adverse effects do not occur. Exposure to high levels of particulate matter, for example, can lead to reduced lung function, respiratory infections and aggravated asthma from short-term exposure. Whereas long-term or chronic exposure to fine particulate matter increases a person's risk for diseases with a longer onset, like some noncommunicable diseases including stroke, heart disease, chronic obstructive pulmonary disease and cancer. Are some populations more likely to be at higher risk for disease from air pollution? The children, elderly and pregnant women are more susceptible to air pollution-related diseases. Genetics, comorbidities, nutrition and sociodemographic factors also impact a person's susceptibility to air pollution. Does exposure to air pollution during pregnancy impact the health of the fetus? Maternal exposure to air pollution is associated with adverse birth outcomes, such as low birth weight, pre-term birth and small for gestational age births. A growing body of evidence also suggests that air pollution may affect diabetes and neurological development in children. Are the health risks the same between ambient air pollution and household air pollution? The health impacts from exposure to ambient air pollution or household air pollution are dependent on the types and concentrations of the pollutants in the air pollution mixture to which an individual is exposed. However, the health risks and disease pathways between ambient and household air pollution exposure are often similar, due to their similar composition. Fine particulate matter for example is a common and critical pollutant of both ambient and household air pollution leading to negative health impacts. Additional safety risks are associated with many of the fuels and technologies used in the home emitting air pollution. These include burns and poisonings (from kerosene ingestion), as well as physical injury related to fuel collection, including musculoskeletal damage, violence, and animal bites. It is important to note that the death and disability estimates attributed to air pollution do not account for all health outcomes associated with air pollution. WHO estimates are likely conservative as only health outcomes for which there is strong certainty in the epidemiological evidence are included (i.e. stroke, ischemic heart disease, chronic obstructive pulmonary disease, pneumonia, and lung cancer). What is the link of desert dust, air pollution and health?Desert dust episodes contribute directly to air pollution by increasing particulate matter concentrations and in some regions is an important – sometimes main – source. Desert dust episodes – or sand and dust storms – constitute a growing public health, mainly for respiratory diseases, and environmental concern for many areas of the world. It also has an important transboundary component, which is important to take into account when addressing it at regional and international level. The APHT toolkit for health workers is a comprehensive set of training materials exploring different air pollution and health topics and reflecting global... In 2019, air pollution – both ambient and household – was the largest environmental risk to health, carrying responsibility for about one... The WHO Household Multiple Emission Sources (HOMES) model can help policymakers and program planners determine how household air pollution levels and... This is the 2024 update of the Compendium of WHO and other UN guidance on health and environment. The Compendium is a comprehensive collection of available... A systematic review of the evidence has demonstrated the key role of clean household energy in improving global health, reaffirming the importance... This report summarizes evidence and information and formulates practical advice on personal- level actions to reduce exposure to ambient air pollution....