

Summary

- There is an increasing volume of evidence that highlights the damage air pollution can play in exacerbating and potentially causing a range of acute and chronic health conditions.
- Most of the damaging effects of air pollution on health occur across the life course, and are of particular concern at early stages of development, as well as old age due to the prevalence of conditions that can be exacerbated by exposure to air pollution.
- Each year air pollution is associated with around 40,000 premature deaths in the UK, with associated costs estimated at over £20 billion.
- The problems surrounding poor air quality are increasingly becoming UK-wide. These therefore require national leadership to be addressed, and this should be taken in partnership with action at a local level.
- There is an important need for investment in research in this area to better understand the role of particular pollutants and to help inform policy responses. The UK is well placed to be a world leader on this, capitalising on the opportunities provided through the Industrial Strategy.

Introduction

1. The Academy of Medical Sciences promotes advances in medical science, and campaigns to ensure that these are translated into healthcare benefits for society. Our elected Fellowship includes the UK's foremost experts drawn from a broad and diverse range of research areas.
2. We welcome the opportunity to respond to the call for evidence by the Environment Food and Rural Affairs, Environmental Audit Committee, Health, and Transport Committees on the UK Government's plans for tackling the health and environmental impacts of outdoor air pollution.¹ Our response has been informed by engagement with a number of our Fellows with expertise in this area.
3. The inquiry raises questions on the strength of the UK Government's plan, which as highlighted by the four Committees working having launched this jointly, covers a wide range of policy areas. Our response focuses on aspects where the expertise provided through our Fellowship resides, which for matters of air quality relates to areas of medical research that seek to increase our understanding of how poor air quality impacts on health.

Air pollution and the health of the public

4. The environments in which we live are already determining our future health, which is shaped by a confluence of myriad factors that includes the air we breathe. The Academy is actively engaged in exploring what must be done now to improve future health as evidenced in our recent report on 'Improving the health of the public by 2040'.²

¹ Department for Environment, Food and Rural Affairs, Department for Transport (2017). *UK plan for tackling roadside nitrogen dioxide concentrations*.

www.gov.uk/government/uploads/system/uploads/attachment_data/file/633269/air-quality-plan-overview.pdf

² Academy of Medical Sciences (2016). *Improving the health of the public by 2040*.

<https://acmedsci.ac.uk/policy/policy-projects/health-of-the-public-in-2040>

5. Ambient air pollution consists of small and ultra-fine particles (particulate matter), and gases including nitrogen dioxide and ozone. It is largely invisible, and it caused an estimated 3 million premature deaths worldwide in 2012 – around 5.4 per cent of all deaths.³ The Royal College of Physicians and the Royal College of Paediatrics and Child Health 2016 report considered the impact across a lifetime of air pollution within the UK, concluding that around 40,000 premature deaths each year can be attributed to exposure to outdoor air pollution, with associated costs adding up to more than £20 billion.⁴
6. Deprived communities live in environments that experience higher levels of air pollution, and are therefore at greater risk of suffering the harmful effects on their health.^{5,6} These inequalities are important to consider in the development of policy responses.

Air pollution and early stages of development

7. Most of the damaging effects on health linked to air pollution occur across the life course, but some can begin as the foetus develops in the womb. Exposure to fine particulate matter of $\leq 2.5 \mu\text{M}$ (PM_{2.5}) is associated with adverse birth outcomes, such as low birth weight, preterm births and small for gestational age births.⁷
8. Infants have a relatively high metabolic rate, so they breathe a greater volume of air per minute than an adult relative to their size. This presents a double jeopardy: they are exposed to relatively higher doses of toxic pollutants, as well as being more vulnerable to their harmful effects. In addition, they are dependent on their parents for determining where they move, and therefore have little control over their exposure to air pollution.
9. As the central nervous system is still developing rapidly after birth, children remain susceptible to harmful effects of air pollution on their neurodevelopment and long-term cognitive health. Several types of air pollution, including PM_{2.5} and nitrogen oxides, have been associated with harmful effects on neurocognitive development.⁸ As with prenatal effects, exposure of young children to heavy metals impairs cognitive development and lowers IQ, even when exposed at very low levels.⁹
10. Within urban planning, little consideration has been given to the air pollution exposure in housing and schools from their proximity to roads and intersections. Within London, 802 schools in 2013 were found to be in locations with concentrations that exceeded the EU legal limit of $40\mu\text{g}/\text{m}^3$ for nitrogen dioxide.¹⁰ Similar issues have also been found in cities other than London. Greenpeace conducted an analysis of data collected by DEFRA's Pollution Climate Mapping Model, and found that in 2015, more than 2,000 schools, nurseries, further education centres and after school clubs in England were located within

³ World Health Organization (2012). *Public Health and Environment (PHE): ambient air pollution DALYs attributable to ambient air pollution, 2012*. www.who.int/gho/phe/outdoor_air_pollution/burden/en/

⁴ Royal College of Physicians (2016). *Every breath we take: the lifelong impact of air pollution*. www.rcplondon.ac.uk/projects/outputs/every-breath-we-take-lifelong-impact-air-pollution

⁵ Marmot M (2010). *Fair society, healthy lives: strategic review of health inequalities in England post-2010*. www.instituteofhealthequity.org/projects/fair-society-healthy-lives-the-marmot-review/

⁶ Brunt H, Barnes J, Jones SJ, Longhurst JW, Scally G, Hayes E. Air pollution, deprivation and health: understanding relationships to add value to local air quality management policy and practice in Wales, UK. *J Public Health (Oxf)*. 2017; 39: 485-497.

⁷ Shah PS, Balkhair T, Knowledge Synthesis Group on Determinants of Preterm/LBW births. Air pollution and birth outcomes: a systematic review *Environ. Int.*, 37 (2011), pp. 498-516 doi: 10.1016/j.envint.2010.10.009 www.sciencedirect.com/science/article/pii/S0160412010002254

⁸ Suades-González E, Gascon M, Guxens M, Sunyer J. Air Pollution and Neuropsychological Development: A Review of the Latest Evidence. *Endocrinology*. 2015;156(10):3473-3482. doi:10.1210/en.2015-1403. www.ncbi.nlm.nih.gov/pubmed/26241071

⁹ Liu J, Lewis G. Environmental Toxicity and Poor Cognitive Outcomes in Children and Adults. *Journal of environmental health*. 2014;76(6):130-138. www.ncbi.nlm.nih.gov/pmc/articles/PMC4247328/

¹⁰ Aether (2017). *Updated Analysis of Air Pollution Exposure in London – Final Report*. www.london.gov.uk/WHAT-WE-DO/environment/environment-publications/updated-analysis-air-pollution-exposure-london-final

150m of roads that exceed the EU legal limit.¹¹

Air pollution and adulthood

11. The damage caused by chronic exposure as well as repeated high pollution episodes is sometimes gradual, and may not be apparent for many years. For example, lung function naturally develops throughout childhood, and there are strong associations between long-term exposure to air pollution and impaired lung function growth in children, resulting in deficits of lung function at the end of adolescence.¹² In addition, a multicentre cohort study and meta-analysis found that, even at very low levels, air pollution has adverse effects on lung function in adults.¹³ The World Health Organization's International Agency for Research on Cancer also classified diesel engine exhaust as carcinogenic to humans in 2013, based on sufficient evidence that exposure is associated with an increased risk for lung cancer.¹⁴
12. Conditions that have been examined most frequently in relation to air pollution include respiratory and cardiovascular disease, and more recently, Type II diabetes.

Air pollution and respiratory disease

13. For people who already have asthma, there is strong evidence that air pollution can result in worsening symptoms and exacerbate the condition.¹⁵ A 3-year US longitudinal study found that increased risk of developing early school-age asthma was associated both with markers of traffic-associated outdoor air pollution near the home and with exposure to background nitrogen dioxide.¹⁶ The same study found that when this exposure was more highly concentrated there was an association with new-onset asthma. A study of women in the USA also reported an association between exposure to PM_{2.5} and new-onset asthma.¹⁷
14. Patients with Chronic Obstructive Pulmonary Disease (COPD) have a diminished capacity to clear inhaled material from their lungs and as a result may incur a higher-than-normal 'dose' at any level of air pollution. There is a comprehensive association between short-term air pollution exposure and COPD acute risk, indicating that improving air quality could reduce the risk of sudden onset of COPD and the burden of the disease.¹⁸

¹¹ <https://unearthed.greenpeace.org/2017/04/04/air-pollution-nurseries/>

¹² Götschi T, Heinrich J, Sunyer J, Künzli N. Long-term effects of ambient air pollution on lung function: a review. *Epidemiology*. 2008 Sep; 19(5): 690-701. doi: 10.1097/EDE.0b013e318181650f. www.ncbi.nlm.nih.gov/pubmed/18703932

¹³ Adam M, Schikowski T, Carsin AE, et al. Adult lung function and long-term air pollution exposure. ESCAPE: a multicentre cohort study and meta-analysis. *The European Respiratory Journal*. 2015; 45(1): 38-50. doi: 10.1183/09031936.00130014. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4318659/>

¹⁴ www.iarc.fr/en/media-centre/iarcnews/pdf/pr221_E.pdf

¹⁵ McConnell R, Islam T, Shankardass K et al. Childhood incident asthma and traffic-related air pollution at home and school. *Environ Health Perspect* 2010; 118: 1021-6.

¹⁶ Chen Z, Salam MT, Eckel SP, Breton CV, Gilliland FD. Chronic effects of air pollution on respiratory health in Southern California children: findings from the Southern California Children's Health Study. *J Thorac Dis* 2015; 7: 46-58.

¹⁷ Young MT, Sandler DP, DeRoo LA et al. Ambient air pollution exposure and incident adult asthma in a nationwide cohort of U.S. women. *Am J Respir Crit Care Med* 2014; 190: 914-21.

¹⁸ Li J, Sun S, Tang R, et al. Major air pollutants and risk of COPD exacerbations: a systematic review and meta-analysis. *International Journal of Chronic Obstructive Pulmonary Disease*. 2016; 11: 3079-3091. doi: 10.2147/COPD.S122282. www.ncbi.nlm.nih.gov/pmc/articles/PMC5161337/

Air pollution and cardiovascular disease

15. Epidemiological studies have shown significant associations between air pollution and a range of cardiovascular effects in adults.^{19,20,21} Short-term and long-term exposure to air pollution can increase the risk of a number of cardiovascular events, heart attack, heart failure, abnormal heart rhythms, and stroke in susceptible individuals, such as older people or those with pre-existing medical conditions such as diabetes.^{22,23,24}
16. It is not currently possible to measure environmental nanoparticles in the blood to help determine the underlying effects on the cardiovascular system. However, one recent study sought to use gold nanoparticles as a trackable nanoparticle comparable to those that are present in air pollution. The team, which included Academy Fellow Professor David Newby FMedSci, showed in both animal and human studies that these nanoparticles pass from the lungs into the circulatory system, and accumulate at sites of vascular inflammation.²⁵

Air pollution and the economic costs

17. A number of estimates of economic cost have been made that take into account the high morbidity as well as mortality due to air pollution. The Department for Food, the Environment and Rural Affairs has previously estimated that the annual social cost of the health impacts associated with ambient concentrations of particulate matter and NO₂ between £25.3 billion – £29.7 billion.²⁶ The Committee on the Medical Effects of Air Pollutants has suggested that the level of overlap in estimates between pollutants may be greater than originally thought, which would impact on this estimated cost.²⁷
18. There is an evidence gap in relation to the cost of the different co-morbidities arising from pollution. Treating these morbidities is expensive, for both the NHS and the social care system, but no accurate estimates of the magnitude of the costs exist. In light of this, Public Health England (PHE) has sought to develop a modelling framework to quantify the present and future morbidity (in terms of medication prescription, hospitalisation, GP consultation) caused by ambient air pollution.²⁸

¹⁹ Brook RD, Rajagopalan S, Pope CA 3rd et al. Particulate matter air pollution and cardiovascular disease: an update to the scientific statement from the American Heart Association. *Circulation* 2010; 121: 2331-78.

²⁰ World Health Organization (2013). *Review of evidence on health aspects of air pollution – REVIHAAP Project*. www.euro.who.int/_data/assets/pdf_file/0004/193108/REVIHAAP-Final-technical-report-final-version.pdf

²¹ Newby DE, Mannucci PM, Tell GS et al. Expert position paper on air pollution and cardiovascular disease. *Eur Heart J* 2015; 36: 83-93b.

²² Sanidas E, Papadopoulos DP, Grassos H et al. Air pollution and arterial hypertension. A new risk factor is in the air. *J Am Soc Hypertens*. 2017 Sep 27.. pii: S1933-1711(17)30334-0.

²³ Wei Y, Zhang JJ, et al. Chronic exposure to air pollution particles increases the risk of obesity and metabolic syndrome: findings from a natural experiment in Beijing. *FASEB J*. 2016; 30: 2115-22.

²⁴ Mazidi M, Speakman JR. Ambient particulate air pollution (PM_{2.5}) is associated with the ratio of type 2 diabetes to obesity. *Sci Rep*. 2017; 7: 9144.

²⁵ Miller MR, Raftis JB, Langrish JP, et al. Inhaled Nanoparticles Accumulate at Sites of Vascular Disease. *ACS Nano*. 2017; 11(5):4542-4552. doi:10.1021/acsnano.6b08551. www.ncbi.nlm.nih.gov/pmc/articles/PMC5444047/

²⁶ Department for Environment, Food & Rural Affairs (2015). *Valuing impacts on air quality: Updates in valuing changes in emissions of Oxides of Nitrogen (NO_x) and concentrations of Nitrogen Dioxide (NO₂)*. www.gov.uk/guidance/air-quality-economic-analysis

²⁷ Committee on the Medical Effects of Air Pollutants (2015). *Nitrogen dioxide: interim view on long-term average concentrations and mortality*. www.gov.uk/government/publications/nitrogen-dioxideinterim-view-on-long-term-average-concentrations-and-mortality

²⁸ Estimation of costs to the NHS and social care due to the health impacts of air pollution. www.parliament.uk/business/publications/written-questions-answers-statements/written-question/Commons/2017-02-01/62660

Protecting public health from air pollution

19. As the Academy highlights within our 'Improving the health of the public by 2040' report, over the coming decades the UK population will face a wide range of complex health challenges and opportunities, many of which can only be fully addressed through strategies to secure and improve the health of the public as a whole.²⁹ Legislative interventions, such as action to ensure clean air, can have profound impacts on health, as demonstrated by the improvements in air pollution following the Clean Air Act of 1956.³⁰
20. The problems surrounding poor air quality are increasingly becoming UK-wide. Figures released by the Department for Food, the Environment and Rural Affairs in September 2017 highlight that the lack of progress towards tackling air pollution is a national problem, with 278 of the 391 Local Authorities in the UK having Air Quality Management Areas established as of 2016, which are declared when a Local Authority fails to meet its air quality targets.³¹ This is an increase from 258 in 2010. Similarly, research published last month by the Royal College of Physicians and Lancet Countdown collaboration indicates that 44 UK cities are in breach of World Health Organization guidelines for air quality.³²
21. It is increasingly clear that air pollution is a national problem that requires action at both national and local level. The UK plan acknowledges that poor air quality persists in certain areas, and recognises that this represents an urgent health problem. However, we do not believe that this urgency is adequately reflected in the proposals within the plan, and some of our Fellows believe this falls short of the Supreme Court's verdict in 2015 that this should be addressed in "the shortest possible time."³³ It is important that this is driven at a national level.

Investing in research

22. There is a pressing need to ensure that the research base is aligned with (and helps to identify) future challenges from air pollution and opportunities to address them. Challenges and opportunities will increasingly occur across interdisciplinary boundaries, and the funding landscape must be dynamic in order to respond to these trends as they emerge. While the links between air quality and health highlighted above warrant urgent action to reduce the public's exposure to air pollution, there is also an important need for investment in research that will help inform policy responses. As highlighted by the Royal College of Physicians, we need to improve our understanding of the impact of air pollution on our health, economy and communities.³⁴ We need further research on air pollution's effects on specific respiratory and cardiovascular conditions to help identify how individual pollutants affect the body. In addition, research into the adverse health effects of pollution should include systemic effects such as obesity, diabetes, changes linked to dementia, and cancer, as well as effects on the developing foetus and in early childhood. Causal attribution will require judgement based on evidence from toxicology, clinical studies and epidemiology.

²⁹ Academy of Medical Sciences (2016). *Improving the health of the public by 2040*.

<https://acmedsci.ac.uk/policy/policy-projects/health-of-the-public-in-2040>

³⁰ Greater London Authority (2002). *50 years on: the struggle for air quality in London since the great smog of December 1952*. <http://cleanair.london/wp-content/uploads/CAL-217-Great-Smog-byGLA-20021.pdf>

³¹ Department for Environment, Food & Rural Affairs (2017). *Air Pollution in the UK 2016*. https://uk-air.defra.gov.uk/assets/documents/annualreport/air_pollution_uk_2016_issue_1.pdf

³² www.rcplondon.ac.uk/news/research-shows-44-uk-cities-breach-world-health-organization-guidelines-air-pollution

³³ www.supremecourt.uk/cases/docs/uksc-2012-0179-judgment.pdf

³⁴ Royal College of Physicians (2016). *Every breath we take: the lifelong impact of air pollution*. www.rcplondon.ac.uk/projects/outputs/every-breath-we-take-lifelong-impact-air-pollution

23. Public policy should be evidence-based. Research should therefore also focus on studies that will improve the efficiency and effectiveness of the public health actions. Population cohort studies need to be large and representative of the population. The UK has expertise in modelling of pollutants, which combined with routine systems for recording health outcomes such as mortality, hospital admissions and primary care activity makes it well placed to carry out world-leading research in this area.
24. In terms of funding for this important research, even with the Government's plans to invest £4.7 billion by the end of this Parliament in science, research and innovation, the UK spends below the OECD average for public investment in research, which stands at 0.66% GDP.³⁵ The Academy of Medical Sciences, together with the other national Academies, is calling for the UK to set a target of 3% of GDP for combined public and private R&D spending in order to remain internationally competitive.
25. The Industrial Strategy Challenge Fund, as highlighted in the UK plan on air quality, offers opportunities for investments in research aimed at tackling air pollution, and also for providing cleaner technology and zero emission transport in the future. We welcome the inclusion within the first wave of this Fund of batteries for clean and flexible energy storage that will help to achieve this.³⁶ These studies should be progressed with urgency.

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³⁵ OECD (2017). Main Science and Technology Indicators
http://stats.oecd.org/Index.aspx?DataSetCode=MSTI_PUB

³⁶ www.gov.uk/government/news/business-secretary-announces-industrial-strategy-challenge-fund-investments