A breath of fresh air

Responding to the health challenges of modern air pollution

Summary for policymakers

Royal College of Physicians

The Royal College of Physicians

The Royal College of Physicians (RCP) plays a leading role in the delivery of high-quality patient care by setting standards of medical practice and promoting clinical excellence. The RCP provides physicians in over 30 medical specialties with education, training and support throughout their careers. As an independent charity representing around 40,000 fellows and members worldwide, the RCP advises and works with government, patients, allied healthcare professionals and the public to improve health and healthcare.

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Summary for policymakers

The links between air pollution and health are undeniable – air quality must be recognised as a public health issue, rather than a solely environmental one. The equivalent of around 30,000 deaths are estimated to be attributed to air pollution in 2025. The health impacts of air pollution are estimated to have an economic cost of £27 billion annually in the UK in 2019, and may be as much as £50 billion when wider impacts, such as dementia, are accounted for.

There is no safe level of air pollution. Increasingly ambitious action must be taken to improve air quality across the country to reduce avoidable deaths and improve the health of our population.

Why we have produced this update

In 2016, the Royal College of Physicians (RCP), alongside the Royal College of Paediatrics and Child Health (RCPCH), published *Every breath we take: the lifelong impact of air pollution*, highlighting the dangerous short- and long-term impact of air pollution on our nation's health.[1]

Over the past decade, new evidence has emerged about the harmful health impacts of air pollution even at low concentrations. The preventable deaths of both Ella Adoo-Kissi-Debrah and Awaab Ishak have shone a light on the reality of outdoor and indoor air pollution as a driver of serious and potentially fatal disease in children as well as in adults.

Air pollution negatively impacts health at all stages of life and early exposure can lead to ill health later in life.

The health harms of air pollution may take decades before they fully manifest. We now know that exposure to air pollution in one part of our lives may go on to impede our health as we grow[2] and age, with a much greater adverse health and economic impact than previously thought.

Air pollution emissions have reduced significantly over the past 100, 50 and even 10 years – but advances in exposure assessment, modelling and population health studies show that even lower levels of air pollution adversely affect our health, and the gains that have been made have not been the same everywhere, or for everyone.

Estimates of the mortality burden of air pollution in the UK in 2019 for the principal air pollutants, $PM_{2.5}$ and NO_2 combined, range between 29,000 and 43,000 deaths per year,[3] giving a central estimate of 36,000 deaths (or around 413,000 life years lost). It is possible that by 2025, this figure may have reduced further to around 30,000 deaths per year. While this is a welcome reduction from the 40,000 estimated deaths from the 2016 *Every breath we take* report, air pollution clearly still has a significant impact on public health – 30,000 deaths attributable to air pollution is 30,000 too many. In addition, many more people also experience more years living in poor health due to poor air quality.

The equivalent of around **30,000 deaths a year** in the UK are estimated to be attributed to air pollution.

This update provides new insights into why urgent action is now needed, directed at those fields where there have been the greatest changes and where a renewed focus will provide a platform for further improvements. It also includes cross-cutting issues such as inequalities, climate change, urban planning, education and economics, because many of these intersectoral factors are influencing the pollutant content of the air that we breathe and its adverse consequences on society, both in the short and, especially, in the long term.

Air quality policy is largely devolved – and there are different air quality challenges across the UK. A summary of the actions being taken in the devolved UK nations is covered at the end of this executive summary.

Both outdoor and indoor air pollution must be recognised as a public health issue. Governments and health bodies at a national and local level have the power to make the greatest impact. They need to take steps to tackle it so that everyone can have the best chance of good health.

The health harms of air pollution

Historically, air pollution has been framed as an environmental issue in the UK, with air quality policy predominantly led by the Department of Environment, Food and Rural Affairs (and equivalent bodies in local government with responsibility to deliver local air quality management).

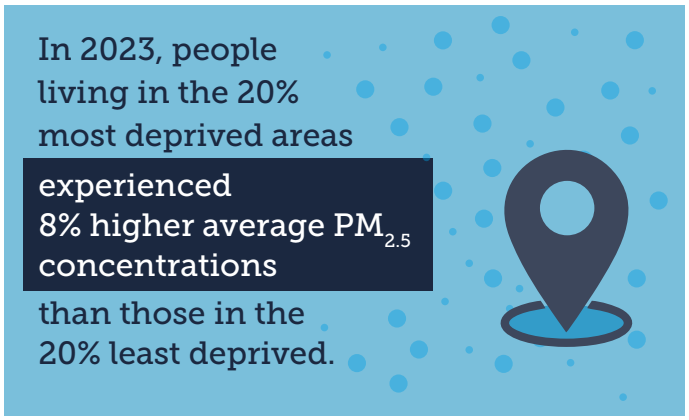
But there is now overwhelming health evidence connecting both acute and chronic exposure to air pollution to many different diseases and health outcomes across the lifecourse, as well as other determinants of health. Health and health impacts are at the centre of the consequences of air pollution.

Globally, air pollution is the largest environmental health risk causing loss of healthy years of life and premature death. In 2021, there were an estimated 8.1 million preventable deaths linked to outdoor and indoor pollution worldwide, 90% being attributable to non-communicable diseases.[4] At an individual level, exposure to air pollution shortens the average person's lifespan by 1.8 years, an impact that ranks just behind some of the leading causes of death and disease worldwide – cancer 2.5, tobacco smoking 2.1, malaria 0.3 and inadequate water/sanitation/hygiene 0.6 years, respectively.[4] In addition to the mortality impacts, air pollution also worsens people's health.

Estimates on the morbidity impacts of air pollution have found that in the UK in 2019, there were 3,010 new cases of lung cancer in adults and 9,750 new cases of asthma in children attributable to air pollution.

Air pollution is present everywhere in our lives, both outdoor and indoor. The air pollutants with the greatest effect on the health of the UK population are particulate matter, nitrogen dioxide (NO_2) and ozone (O_3). The greatest effects are attributable to particulate matter (PM), measured in the UK's atmosphere as PM_{10} and the even smaller $PM_{2.5}$.

People can be exposed to air pollution where they live, play, study or work. This exposure is distributed unevenly in the UK – urban areas tend to have higher concentrations of traffic-related air pollution and higher population density, while rural locations often experience air pollution linked to specific activities, such as solid fuel or wood burning, agriculture, road transport, and forest and heathland fires. Some people are also more susceptible to harm from air pollution because they are more likely to be living in poor health. Minoritised ethnic groups experience higher local NO_2 and $PM_{2.5}$ emissions regardless of deprivation and these disparities exist across a range of settings, including suburban areas, small towns and rural areas.



In 2021, the World Health Organization (WHO) revised its health-related air quality limit values, decreasing them to 5 µg/m^3 for $PM_{2.5}$ and 10 µg/m^3 for NO_2.[5] According to analysis of data from 2021–23 on background air pollution, 96% of neighbourhoods in England and Wales are above the WHO guidelines for $PM_{2.5}$ and 53% are above the guidelines for NO_2.[5a] For Scotland, data from 2022 show that 15% of the population are living in areas that exceed the WHO guidelines for $PM_{2.5}$ and NO_2.[5b] Globally this now means that around 99% of the population is breathing unhealthy and potentially toxic air. Studies have also established that adverse health effects of pollutants occur at concentrations even below current air quality limit values. Put simply, there are no safe levels of air pollutants, so the more we do to try and improve our air, the better.

The RCP believes the time has now come to recognise air pollution, both outdoors and indoors, as a public health issue. It needs to be taken much more seriously as an avoidable health risk, with an urgent need for much more ambitious action by the UK to improve the air that we all depend upon for life.

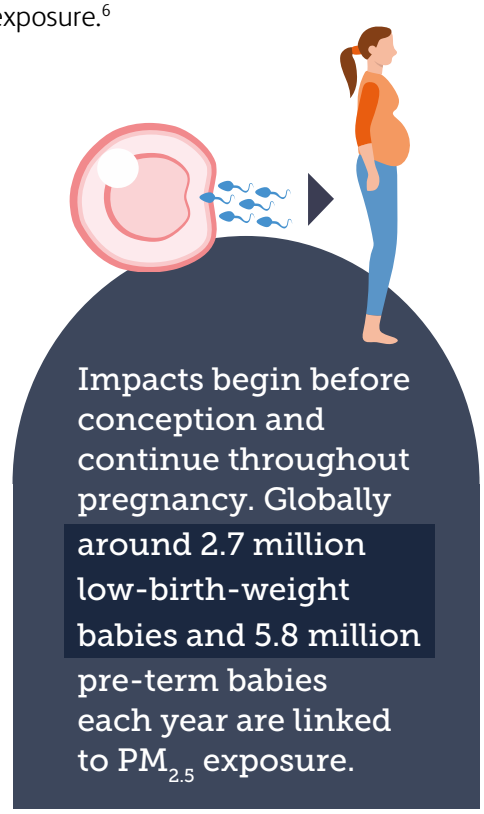
Impacts across the lifecourse

For a long time, it was thought that the health effects of air pollution in adults primarily impacted respiratory health. However, in recent years scientists have found links between air pollution and almost every organ system in the body and the major diseases that affect them. This includes the brain, lungs, cardiovascular system, metabolism, kidneys, liver, gastrointestinal tract, bones and skin.

Air pollution affects almost every organ in the body, including the brain, lungs, heart, liver and kidneys and the diseases linked to them.

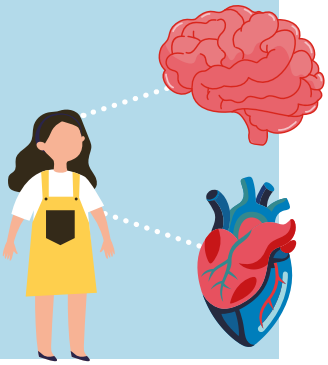
The volume of evidence regarding the impact of air pollution on health is rapidly growing. Since the RCP's report in 2016, new cohort studies with follow-up periods of over 25 years show how pollution exposures from decades ago influence morbidity and mortality risk cumulatively throughout life. Most significant has been the new knowledge of the impacts of air pollution in the earliest period of life (including before birth) and on our brain, including child and adult mental health, and dementia.

Air pollution negatively affects health at all stages of life, beginning before conception and continuing throughout pregnancy. Exposure during pregnancy can affect birth outcomes; globally around 2.7 million low-birth-weight babies and around 5.8 million pre-term babies each year have been linked to ambient and household $PM_{2.5}$ exposure.[6]



Children and adolescents face significant vulnerability due to the development of key protective systems, with impacts on lifecourse health trajectories. Evidence that long-term exposure to outdoor air pollution suppresses lung function potential during childhood has continued to strengthen since 2016, while early sustained exposure to PM, and especially to ultrafine particulate matter (UFP), in childhood has been found to be a significant risk factor for developing both Alzheimer's and Parkinson's diseases later in life. One study of lung function in London school children found a loss of around 5 per cent of forced vital capacity (FVC) of over a 5-year period[7] – though reassuringly, recent evidence has also shown that interventions to remove or reverse these impacts on reduced lung growth are also possible.[8] Reducing the exposure of today's children to air pollution would improve the health of our future adult population and reduce inequalities.

Children are vulnerable as they are developing their key protective systems. Effects include reduced lung growth, weakened immune systems, and reduced brain development.



In adults, the volume of mechanistic evidence suggests that associations between air pollution and cardiovascular disease are causal. A recent study using UK data found that air pollution increased the risks of multiple health conditions, particularly those affecting cardiovascular, renal and metabolic systems.[9] Given the prevalence of conditions such as cardiovascular disease and its severe impact on life and wellbeing, it is likely that if there are reductions in air pollution, significant health improvements will follow.

Air pollution affects brain health. Recent analysis using UK data has found that exposure to multiple air pollutants substantially increases the risk of dementia, especially among people with high genetic susceptibility.[10] As studies now link air pollution exposure and the development of neurodegenerative disorders like dementia and Parkinson's disease, specific policies need to address these new aspects – particularly given the UK's ageing population.

Exposure throughout life can substantially increase the risk of dementia.

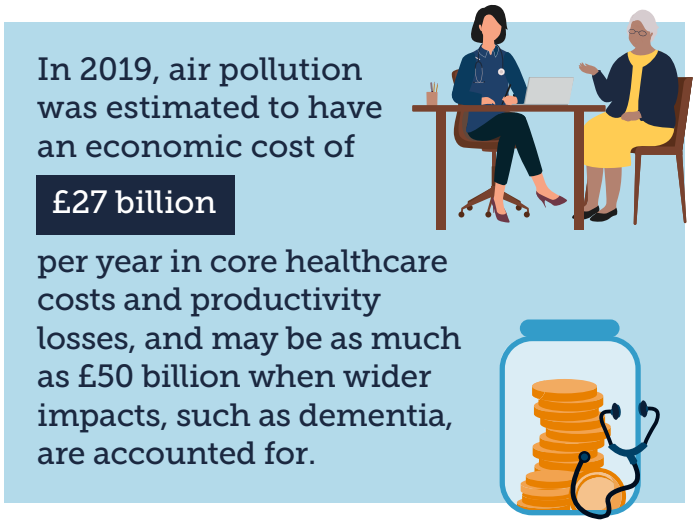
The impact of air pollution on mental health and cognition is under-researched and poorly recognised – yet sufficient emerging data and many plausible mechanisms suggest we must take the risks of poor air quality for brain and mental health at all ages seriously. Evidence links outdoor air pollutants to a variety of mental health problems, including depression, anxiety, personality disorder and schizophrenia.

Health inequalities

Explaining the effects of air pollution on inequality focusing solely on population exposure differences provides only a partial impression of health inequalities linked to air pollution.

Air pollution is harmful to everyone, but it disproportionately affects the most vulnerable groups in society. Vulnerabilities are typically most evident among those living in the most deprived communities in the UK, who are already at risk of health inequality. In 2023, individuals living in the 20% most deprived areas in England experienced 8% higher average $PM_{2.5}$ concentrations than those in the 20% least deprived. In addition, research has shown that in the UK, people from ethnic minority backgrounds typically experience a greater burden of air pollution compared with White populations – NO_2 and $PM_{2.5}$ concentrations are, on average, 83% and 27% higher, respectively.[11]

Vulnerable groups or those living in more deprived areas are more likely to experience the effects of other health inequalities. They are more likely to be more susceptible to the harms of air pollution because they are more likely to have poorer levels of health generally. They may also be less likely to benefit from air pollution reduction interventions and are less likely to be the major contributors of air pollution. We must recognise the importance of air pollution as a driver for poor health among deprived and vulnerable communities.
Health inequalities often start in childhood and tend to persist throughout a person's life. Reducing air pollution, especially during the prenatal period and childhood, can significantly impact on this trend, leading to fewer long-term health disparities.



Policy action should account for health, risk and economic impact to deliver the greatest and most equitable health gains. Our traditional methods to quantify the health impacts of air pollution give a broadly accurate overall estimate of the health burden in the population but do not always quantify differences in benefits of interventions for different population groups and local communities. Recent advances in health and economic impact assessment methods, which integrate local or regional demographic and disease incidence data with high resolution air quality modelling, may help to address this challenge by enabling policymakers to assess the distribution of health benefits for air quality control measures across a particular geographical area.[12]

The economic burden of air pollution

Air pollution has negative influences on the population's health and the environment, impacting the economy. The economic impact of air pollution is linked to healthcare costs, productivity losses and lost utility (the advantages that come from being well and not experiencing ill health). Looking at the core effects of air pollution, we estimate the economic cost for the UK in 2019 to be £27 billion, largely due to the loss of utility associated with the reduction in life expectancy (contributing 87% of the total). Healthcare costs contribute around 10% and productivity losses 3% (Table 1).*

Taking into consideration current policies targeted at reducing air pollution, this 2019 figure declines to £19 billion in 2040. But when we include the secondary and sensitivity effects of air pollution, our estimate of the economic costs of air pollution rises to £50 billion in 2019 and £30 billion in 2040. Dementia is the largest sensitivity effect by some margin, causing utility losses to fall as a percentage of the total damage to around 74%, healthcare costs to rise to 22% and productivity losses to rise to 4% in 2040. These figures are substantial, yet largely avoidable – addressing air pollution now will lead to long-term economic benefits.

Table 1. Aggregate annual costs of air pollution health impacts in 2019 and 2040 (£billion/year).

	2019	2040
Core effects		
Healthcare	2.6	1.6
Productivity	0.8	0.4
Utility	23.6	17.1
Core total	**27.0**	**19.1**
Sensitivity effects		
Healthcare	10.0	4.9
Productivity	1.5	0.7
Utility	11.4	5.4
Sensitivity total	**22.9**	**11.0**
Core + sensitivity total	**49.9**	**30.1**

*Calculations based on data from studies by Walton *et al* (2025)[13] and Beevers *et al* (2024)[14]

Indoor air pollution

In the UK, people spend around 80–90 % of their time indoors.[15] This means air quality is an important factor in homes, schools, workplaces, travel hubs and other public buildings. Indoor air quality is influenced by multiple factors – location and activities can impact levels of indoor pollution, with poor quality and over-crowded housing, the use of fuels for cooking and heating, the increasing number of chemicals from products and inadequate ventilation all causes of poor indoor air quality.

The WHO linked 154,000 deaths in Europe to household air pollution in 2019, but this is likely to be an underestimate.[16] Those from more deprived or vulnerable backgrounds are more likely to experience the effects of indoor air pollution; an estimated 904,000 homes in England have damp problems[17] and associated mould and are more likely to be occupied by older people, lone parents, children, families on low-incomes and people from minority ethnic groups, thereby contributing to health inequalities.

The COVID-19 pandemic shone a light on the importance of indoor environments as sources of air pollutants and the crucial role that ventilation plays in creating healthy indoor air. Unlike outdoor air, there are currently very limited regulatory standards for pollutant concentrations in indoor air. Despite the WHO setting out guidelines for a small number of selected indoor chemical pollutants, including recommended threshold values in 2010, actions to effectively regulate indoor air in general public, domestic and commercial settings are relatively modest. There is a lack of agreed metrics for many indoor air pollutants, and enabling reliable data collection to measure performance and ensuring compliance with building standards and guidelines has proven difficult.

Quantifying exposures and measuring the health impacts of indoor air pollution remain a substantial challenge. While the effects of some indoor pollutants such as radon, carbon monoxide, asbestos fibres and cigarette smoke are well recognised, the impacts of many other pollutants have been poorly characterised. This is partly due to the lack of data on pollutant presence and exposure in many indoor settings, as well as the effects of multiple exposures happening within the same environment. A global systematic review[18] identified that the most studied pollutants in the home environment are $PM_{2.5}$ and PM_{10}, NO_2, VOCs such as formaldehyde and polycyclic aromatic hydrocarbons (PAHs). Exposures are highly dependent on occupant activities. Data on the range of indoor pollutants that we are all exposed to and the levels of these exposures in most built environments remain limited – a gap in knowledge within the UK that is being addressed by the WellHome and INGENIOUS projects under the UKRI/Met Office Clean Air Programme.[19]

Ensuring good indoor air quality and identifying and implementing effective indoor air quality and ventilation solutions needs a multidisciplinary approach. The chief medical officer (CMO) for England's annual report for 2022[20] details a range of mitigation measures for tackling the many sources of indoor air pollution. The most appropriate measure depends on the particular environment, the sources and the people – there is no 'one size fits all' solution.

Air pollution and climate change

Air pollution and climate change, both matters of social justice and health inequality, are strongly linked. Burning fossil fuels pollutes the air we breathe and warms the planet.

The UK has legally binding net zero targets,[21] consistent with the Paris agreement[22] and supported through independent advice from the Climate Change Committee (CCC). There are opportunities for 'win-wins' for climate and clean air within the range of available net zero policies – the wider health benefits of net zero policies include reductions in mortality and morbidity linked to $PM_{2.5}$, and active travel. Net zero policy actions also influence indoor air quality with implications for health and wellbeing but it is important to understand how benefits will be distributed throughout the population and which actions will effectively reduce existing (and growing) health inequalities.

Net zero policies are an opportunity to deliver co-benefits that improve air quality and address climate change.

A recent study used the CCC's Sixth Carbon Budget data[23] to test the benefits of the net zero transition for road transport, active travel and building emissions on air pollution.[24] The findings emphasised the importance of a broad range of net zero policy actions – spanning housing, transport and active travel – to achieve a more equitable distribution of air quality co-benefits at a population level. Shipping, aircraft and industrial processes remain important air pollution sources to tackle in a net zero future.

Air quality modelling

Air quality modelling plays a central role in the development and evaluation of air quality policy. We need to be aware of what ambient concentrations there are and how they vary spatially and temporally to understand the impact on health and the environment. Having this understanding means informed and targeted policy can then be implemented. Some models can be used to answer speculative questions, while others can provide a retrospective indication of how effective a particular policy decision has been. They can also be used to answer a wide range of 'what if' scenario questions making them useful for both policy development and policy evaluation. Modelling, along with AI, could also help identify high-risk areas, especially those with high deprivation and poor air quality, for prioritised and targeted action. However, the right type of model has to be used for the right type of question.

Air quality modelling also holds significant potential as a tool for informing the public, particularly as advances in modelling techniques enable more granular, location-specific data. This level of detail would be especially valuable for protecting vulnerable populations from the adverse health effects of air pollution by supporting more informed decision-making and exposure management. To fully realise these benefits, a comparable approach to modelling indoor air pollution – analogous to existing frameworks for outdoor air quality – will be important.

Policies fit for the future

Air pollution is a complex issue or a 'wicked problem'. It is impossible to solve in a way that is simple or final due to its ever-changing complexity. As our understanding of its harms continues to develop, we must be prepared to take increasingly ambitious action.

We now have compelling new evidence on the detrimental impact of toxic air on brain health across the lifecourse, including its effects on early-life cognitive development, later-life neurodegenerative disorders, mental and brain health. Future policies need to respond to new and emerging evidence like this so that they address composite health impacts across the lifecourse, especially for vulnerable populations.

The CMO for England's annual report for 2022 highlighted the range of sectors that need to be involved in tackling air pollution.[20] We need joint action across a range of sectors, at national, local, regional and hyperlocal level to create new policies that will further clean up the air.

Actions to improve air quality need to take account of political, environmental, social, technological, economic and ethical considerations. The complexity sciences and the literature on complexity in evaluation provide tools and approaches to take account of systems where many components interact at multiple scales resulting in emergent behaviour, enabling decision-makers to make more informed choices. Co-production and participatory research are key, too – consideration of a range of interests can broaden discussions of priority areas for action, opening greater opportunities for progress as well as enabling areas of conflict or neglect to be identified.

As with tobacco smoking, health professionals must now take greater ownership of this public health challenge, to help prevent and manage the many diseases that air pollution is now known to cause, accelerate and exacerbate.

The public must have accurate and trusted information about the health impacts of short- and long-term air pollution exposure, the sources of indoor and outdoor air pollution, and practical advice to reduce personal exposure. The politicisation of clean air initiatives, including untruthful narratives, must be addressed with transparency and evidence. To achieve this, the government should fund and deliver a coordinated, UK-wide public health clean air campaign, drawing on the success of campaigns such as Better Health Smoke Free.[24]

Blame for the problem must not be transferred to those who disproportionately suffer the impacts. A public health campaign must be accompanied by action to tackle emissions at source. This is the most effective way to reduce pollution and its negative health impacts and should be prioritised over individual interventions to protect against pollution. Given changing sources of emissions, the UK government must regularly review the effectiveness of the air quality limit values and population exposure reduction targets, including assessing whether more stringent limit values, legally binding interim targets or other tools and approaches would be more effective at continuously driving down air pollution.

Brain health

Air quality policy development must evolve and respond to new and growing evidence about the widening extent of its health harms and impacts. Current air quality policy has largely been developed to mitigate the impacts of pollution on conditions like asthma, heart disease, COPD and lung cancer. The implications for brain and mental health are only just beginning to be explored, but there is now strong evidence that air pollution contributes to reduced cognition and dementia progression, including Alzheimer's disease[25–27] – the risk factors for these differ from conditions most commonly linked to air pollution like asthma.

The mental health burden of air pollution is not just an increase in diagnosed psychiatric disorders, but also a worsening of mental health in general. Dementia is the most significant sensitivity effect in the estimated cost of air pollution modelled in this report. When secondary and sensitivity effects, including dementia, are added to the estimated core effects of air pollution, the total estimated economic cost of air pollution in 2019 rises from £27 billion to £50 billion per year.[13]

Policy development must respond to new evidence on its health harms and impacts, including on brain health and dementia.

Future air quality policy should recognise and mitigate the impact of air pollution on brain and mental health. The effects of air quality on brain health should be recognised in existing environmental health strategies and be the subject of further research.

Development in air quality policies

Since the 2016 *Every breath we take* report, air quality policy has evolved differently across the UK nations with new legislation and a shifting policy focus having emerged in response to changing pollutant trends and sources.

Clean air zones (CAZs) have continued to be introduced by local authorities across England, and low emission zones (LEZs) in Scotland, to reduce NO_2 from road traffic to help national governments to achieve health-based air quality standards. Local initiatives such as clean air zones, low traffic neighbourhoods and London's Ultra Low Emission Zone have achieved some success in lowering vehicle emissions, with some early evidence of health gains.[28] However, they have also faced concerns and opposition, and local efforts to reduce NO_2 from road traffic have also been weakened by inconsistent national policies and political factors. Further work is required to ensure public support for policies aimed at benefiting public health and protecting the most vulnerable. Any new CAZs based on the existing emission standard restrictions are likely to deliver less benefit than those already in place, due to ongoing evolution of the vehicle fleet. This means the original emission restrictions may no longer be as effective in driving drive improvement.

The politicisation of road transport policies has undermined the public health rationale for their implementation. It has also highlighted the lack of awareness about the significance of air pollution, as well as the challenges faced by authorities when sectors of society do not feel adequately consulted about measures that are perceived to have the potential to inhibit their freedoms.[29] Stronger health framing of air pollution has the potential to mitigate these issues.

To provide consistency in air quality policy that gives the public, local authorities and businesses confidence to invest in cleaner technologies and behaviours, national government should integrate air quality policy with other policy areas, such as decarbonisation and net zero strategies, to avoid trade-offs at the expense of public health. Further work focused on public engagement and understanding as recommended by the Defra/UKHSA Air Quality Information System (AQIS) review is required to ensure that people are brought onboard with policies that are ultimately for broad public health benefit and to protect those most vulnerable.[30]

Domestic solid fuel burning is also an increasing area of contention. Domestic burning is now responsible for 20% of UK emissions of $PM_{2.5}$.[31] The growth in homes with wood burners is especially concerning.[32] These alone produced 11% of UK $PM_{2.5}$ in 2023.[31] Further regulations to reduce combustion emissions from wood burning were introduced in 2020, however, responsibility to implement these regulations has fallen to local authorities, which have limited capacity and resources to enact. Only one prosecution and three fines have been issued in nearly 2 years for illegal wood burning in smoke control areas since January 2022, despite councils receiving over 10,600 complaints.[33] Public awareness of the problem is low – the very limited active public messaging at a national level around the health impacts of solid fuel burning makes it challenging for local authorities to even broach the issue in their areas.

Limit values and innovation

Many jurisdictions worldwide set legal maximum concentrations for outdoor air pollutants that should not be exceeded. The apex standards used in the governance of public air quality are those associated with maximum daily or annual mean ambient concentrations known as 'limit values'.

In 2023, following the Environment Act 2021, the UK government set an annual mean concentration target of reducing concentrations for $PM_{2.5}$ in England to 10 $\mu g/m^3$ by 2040, in line with the recommendations in the prevailing WHO 2005 global air quality guidelines.[34] Although the WHO subsequently issued new guidelines in 2021[35] recommending a lower maximum annual average for $PM_{2.5}$, these are not currently reflected in targets that apply to the UK.

Limit values encourage action, but continuous improvement needs to be embedded into air quality policy.

Limit values of air pollutants are important as legally binding targets. They have a number of strengths and limitations. They function in law on the basis of a simple pass or fail test, but air pollution harms do not stop below the limit value cut-off. The WHO 2021 air quality guidelines define 'the lowest exposure level of an air pollutant above which the guideline development group is confident that there is an increase in adverse health effects'. An air quality limit value alone does not directly improve air quality – it sets a desired destination, enshrined in law, but says nothing about how it can be achieved. The WHO provides a synthesis of health evidence to motivate actions, but the 2021 guidelines are not intended as a regulatory blueprint.

There is a clear need for increasingly ambitious action to tackle air pollution in the UK. Compared to other countries across the world, the UK is beginning to fall behind in terms of taking decisive action. EU member states are now on a path towards meeting the WHO air quality guidelines, while in 2024, the USA strengthened its $PM_{2.5}$ standard to 9 $\mu g/m^3$.

Continuous improvement must be embedded into air quality policy. Regulating around a maximum limit for acceptable air quality tends to focus disproportionately on those locations with the highest concentrations. Improving air quality requires actions that aim overwhelmingly to reduce emissions, sector by sector, process by process. While retaining what is beneficial in current policy setting is important, with sources of emissions continually changing, new approaches need to be explored in setting air quality standards in the UK. This should include co-development with people affected and application of complexity methods to take better account of political, environmental, social, technological, economic and ethical considerations. For example, one potential solution to address various concerns raised in relation to limit values – particularly the issue of ambition being constrained by feasibility in the most polluted areas of the country – is to establish regional concentration standards or targets as they have done in Canada.

There is also a substantial role for industry innovation and technology to improve air quality. The need for businesses to adapt to reduced greenhouse gas emissions is both a risk and an opportunity for air quality. The demanding requirements to deliver low or net zero environmental performance may prompt many industries to switch away from fossil fuel use, resulting in benefits for both climate and air quality. The extent to which low carbon innovation and transformation may deliver lower air pollution may depend on the extent to which air quality is viewed as a commercial priority.

Urban planning

The majority of people now live in cities, which are hotspots of air pollution, largely due to higher residential and traffic density. However, these features can also pose advantages and opportunities for how spaces are designed. Living in more compact places can reduce the amount of travel and shorten commute time; decrease car dependency; lower *per capita* rates of energy use; limit the consumption of building and infrastructure materials; maintain the diversity of choice among workplaces, service facilities, and social contacts; and limit the loss of green and natural areas.

Effective urban planning and space design can reduce air pollution.

The compact city is recognised as a leading model for sustainable urban living. However, its success is largely down to its design, which needs to actively reduce air pollution. Innovative urban models can be adopted, that prioritise people and active transport over cars. A key part in implementing new policies should be to consider their impacts on health, with the government taking a health in all policies (HiAP)[36] approach to place-based planning. Central to HiAP is the concept of addressing the social determinants of health as key drivers of health and health inequalities.

The role of healthcare professionals

There is broad agreement within the clinical community that clean air is important for health, but some clinicians feel inadequately trained on this topic.

Internationally, only 11 % of medical schools included air pollution in their syllabus as of 2020.[37] At postgraduate level in the UK, the General Medical Council sets the standards for and approves medical curricula and assessments for specialties and subspecialties, which are designed by royal colleges and faculties. The Joint Royal College of Physicians Training Board has asked the specialist advisory committees for internal medicine training, general internal medicine, acute internal medicine and respiratory medicine to consider air pollution in some form in their next curricula review.

Healthcare professionals must be equipped with the knowledge and confidence to discuss this issue with their patients and recognise their role as advocates for air quality being tackled as a public health issue. The CMO for England's 2022 report recommended that all healthcare staff should be trained on air pollution and how to communicate its risks to patients. A WHO toolkit for health professionals provides a 'Ten top tips of climate-health communication' for clinicians to use with their patients, which we have adapted to focus on clean air (Fig 1).[38]

Health professionals must take greater ownership of this public health challenge, speak about it with their patients and advocate for cleaner air.

As with tobacco smoking, it is vital for health professionals to make the case that air pollution is a health issue. Clinicians and their professional bodies must continue to stress the benefits of clean air and the local and central policy changes needed to achieve it. They should also trust in the ability of their patients to make rational behavioural choices when presented with honest information from trusted clinicians.

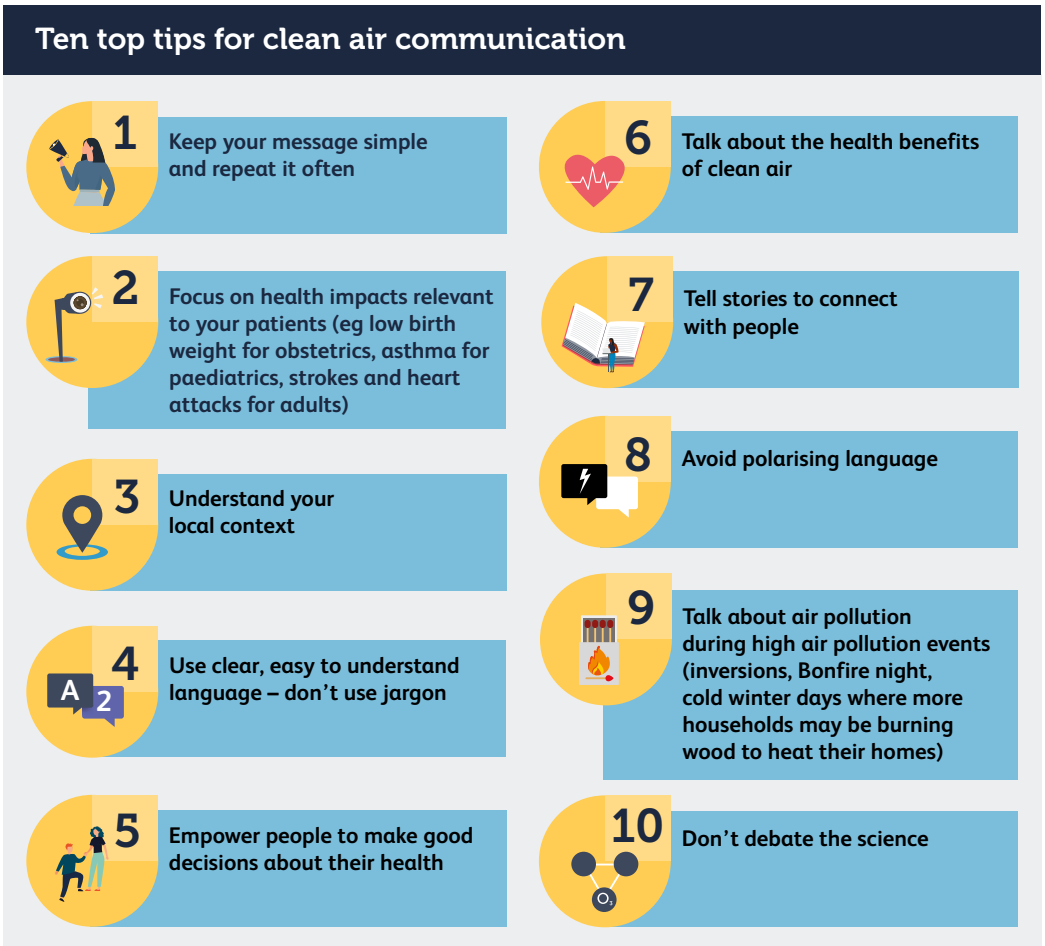


Fig 1. Ten top tips for clean air communication. Adapted from WHO (2024).[38]

A summary of work in the devolved nations

As air quality policy is largely devolved, each administration is working towards different targets and taking slightly different approaches to improving air quality.

Scotland has a $PM_{2.5}$ air quality target of 10 µg/m³ annual mean, which was set for achievement by 2020. The Scottish government launched its second air quality strategy, Cleaner Air for Scotland 2 (CAFS2),[39] in 2021 and commissioned a global health review in 2023, which linked even low-level pollution to both physical and mental health issues.[40] While traffic-related emissions are being addressed through expanded low emission zones (LEZs) in major cities, efforts to curb domestic heating emissions have stalled due to public and industry pushback, further highlighting the need for strong public engagement in policy implementation.

In Wales, the Environment (Air Quality and Soundscapes) (Wales) Act 2024 has introduced new duties and responsibilities for ministers and local authorities, including a commitment to develop targets in line with the most recent WHO guidelines. The Clean Air Plan was published in 2020, which included a delivery plan to promote awareness of air pollution and plans to develop a fair road user charging package.[41] Measures to amend speed limits have been a source of contention with the public and policies to address $PM_{2.5}$ from domestic solid fuel burning are under consideration.

Northern Ireland's air quality issues in many ways mirror those in Wales, but with a delay in policy implementation. In 2020, a public discussion on the draft Clean Air Strategy was launched, and the final strategy is due to be published in 2025. There are challenges with high levels of solid fuel burning, and cross-border smuggling and transboundary emissions from the Republic of Ireland, which restricted certain fuels in 2022.[42] Significant $PM_{2.5}$ contributions also come from agricultural ammonia, with Northern Ireland accounting for 12% of UK emissions.[43] A draft ammonia strategy and net zero energy policy aim to reduce these emissions.[43,44] Coordinating these efforts with the Clean Air Strategy is essential to avoid trade-offs and enhance public health outcomes.

Recommendations

Action can and should be taken to tackle air pollution across all parts of society and by all groups of people, including national, regional and local governments, industry, regulators, the NHS, clinicians, and individuals in society. Cross-governmental action is needed for the widespread improvement of air quality.

The recommendations in this report are for all nations of the UK, with nation-specific recommendations as they apply.

Air quality as a public health issue

1 National, regional and local governments across the UK must recognise air pollution as a key public health issue and take increasingly ambitious action to reduce people's short- and long-term exposure to outdoor and indoor air pollution.

- Outdoor and indoor air pollution is recognised by the UK, EU and WHO as the greatest environmental risk to health.[45] Around 30,000 deaths are estimated to be attributable to long-term exposure to air pollution in the UK each year, with the health impacts of air pollution including dementia estimated to cost the UK £50 billion in 2019. With new and growing evidence of health harms,[46] including at low concentrations, air pollution must be recognised as a public health issue. Protecting human health needs to sit at the heart of air quality policy making so that interventions maximise public health gains for the population as a whole, and protect vulnerable groups in particular.

Limit values

2 Governments across the UK should work with stakeholders and citizens, including marginalised and vulnerable groups, children and young people, older people, minoritised ethnic groups and disabled people, to identify robust pathways towards the delivery of the World Health Organization's 2021 global air quality guideline levels.

- National governments across the UK must ensure that there are defined policy pathways towards achieving the WHO global air quality guidelines. In England, the annual mean $PM_{2.5}$ target to be reached by 2040 is now recognised by WHO as 'Interim target 4' – with most of the country on track to meet it by 2030. There is clear opportunity for increased ambition to achieve greater public health gains with a pathway(s) towards the 2021 WHO global air quality guidelines for all air pollutants. The Environment (Air Quality and Soundscapes) (Wales) Act 2024 must be implemented to meet the WHO guidelines on air quality. Air Quality Standards (Scotland) Regulations 2010 should align new limit values with the 2021 WHO guidelines and a new Act should be created in Northern Ireland to enshrine WHO limit values in law.

3 Governments across the UK must take increasingly ambitious action on air pollution as our knowledge about its role in causing and accelerating disease and impairing fetal and child developmental processes continues to develop. The UK must become an international leader in creating cleaner air through increased ambition and technical innovation.

- While the UK has historically led the world in tackling toxic air, in recent years other economically developed regions such as Europe, Canada, New Zealand and the USA have either already achieved, or are moving rapidly towards achieving, the 2021 WHO global air quality guideline levels for both particulate and gaseous pollutants. Continuous action to tackle air pollution is required. Maximising the public health gains from improved air pollution will require strong ambition and leadership, as well as cross-government support and action. The UK must create bold and bespoke air pollution policies to ensure that it leads again and does not trail behind other comparable high-income nations.

4 **The UK government must regularly review the effectiveness of the air quality limit values and population exposure reduction targets as public health measures, including assessing whether more stringent limit values, legally binding interim targets or other tools and approaches would be more effective at continuously driving down air pollution and yielding the best possible public health outcomes, including a dedicated focus on populations with high levels of pollution and vulnerability to health harms.**

> There is no evidence of a safe threshold for many pollutants. Research shows that levels of air pollution that are considered to be below current regulatory standards still have significant negative health impacts. For the UK to deliver the greatest possible health gains from its clean air policies, government needs to regularly review the best tools and approaches to reduce air pollution, and how actions can focus on areas and populations with high levels of pollution and vulnerability to health harms. These include people who are pregnant, children, older people and those with medical conditions, as well as those living in deprived urban and rural communities. Responsibility to identify and implement the most effective approaches to tackle air pollution should be held jointly by between government departments responsible for health and the environment. They need to be supported by those with responsibility for transport, net zero and energy, and housing and local communities.

Action on air pollution at source

5 **National and local governments must take greater action to tackle all sources of air pollution, increasing action where progress is already being made and tackling areas that have been overlooked or lightly regulated, such as agriculture, indoor and domestic emissions.**

> Tackling air pollution at source is the best way to deliver improved air quality. Some sectors, such as industry and transport, have seen effective and welcome emission reductions, while other sectors, such as agriculture and air pollution from buildings and indoor environments, lag behind.

There is an urgent need to address air pollution from residential buildings, particularly focusing on the management of moisture, emissions from wood burning and other solid fuels used for heating, volatile organic compounds (VOCs) and other pollutants from household, cleaning and personal care products, and promoting use of low-emission alternatives across all these categories, through education, policy changes and product standards. Efforts must continue to be made in agriculture and transport, which remain significant emitters – for example, improving manure management by implementing proper storage and handling of livestock manures and slurries to reduce ammonia emissions.

Public health campaign

6 **Government should fund and deliver a coordinated, UK-wide public health clean air campaign to provide accurate and trusted information about the health impacts of short- and long-term air pollution exposure, the sources of indoor and outdoor air pollution, and practical advice to reduce personal exposure. The campaign should use accessible and tailored messaging across multiple platforms to ensure relevance and reach target audiences, including vulnerable population groups and individuals.**

> Drawing on the success of campaigns such as Better Health Smoke Free,[24] UK government and the devolved nations should deliver a mass media campaign with accessible information about the main sources of outdoor air pollution, such as vehicle use and solid fuel burning, and the sources and impacts of indoor air pollution. Action and advice on how to reduce individual exposure should also be included, with a focus on vulnerable groups whose health and wellbeing are disproportionately impacted by air pollution. This campaign should be provided across multiple platforms, including daily pollution information on weather reports by broadcast media (TV, radio and online), text message and smartphone applications, and easy access to information. At times of particularly high pollution levels, governments across the UK should issue alerts, including recommended actions to reduce harmful exposure. Blame for the problem must not be transferred to those who suffer the impacts – a public health campaign must be accompanied by coordinated and systemic actions to reduce air pollution.

7 National and local governments should ensure that the public are fully engaged in the development of air quality policies through actively listening to their concerns and creating a shared, evidence-based vision of better health through better air.

> Governments must actively engage with the public affected by poor air quality and by measures to tackle it, by designing and implementing policy interventions that improve air quality. This needs to be supported by access to evidence-based, trustworthy information that establishes a health-based rationale for action to counter misinformation and maximises support for interventions.

Planning and the built environment

8 National and local governments must take a health in all policies (HiAP) approach to the built environment and delivery of local services in urban and rural areas, including evidence-based policies covering transport, planning and development, active travel and the provision of green and blue spaces. To maximise health gain, government should introduce a statutory duty to require the integration of health in all environment and planning policies, including the proposed large increase in providing new homes across the UK.

> Air pollution, health and wellbeing must be placed at heart of place-based design and in local government services. Initiatives addressing inequalities and inequities such as Marmot Places[47] – with improved housing quality, public transport, access to green spaces and active travel – will improve health and air quality. The involvement of public health professionals and practitioners is vital to ensure that action to improve air quality is joined up across all levels of government and working towards the same goal of improving health. Specialist public health resources must be increased in local authorities, with directors of public health given more influence.

9 National and local governments need to deliver improvements in the provision of public transport to reduce emissions from personal vehicle travel and ensure that the infrastructure needed for increased active travel is in place, with the goal of achieving 50% of urban journeys being made on foot or by bike by 2030.

> A shift to low-carbon and healthier urban and transport planning is essential. Electric vehicles have often been proposed as the panacea, but these only go some way to reducing emissions and do not address important issues such as healthy use of public space, congestion, urban heat islands, and lack of physical activity in the population that is essential for good physical and mental health. Providing infrastructure and enabling adoption of walking and cycling ('active travel') and public transport use will reduce the need for private vehicle use, with added air quality and public health co-benefits. Road space reallocation away from private car use and to active travel and public transport will be required, and the government must provide strong messaging and leadership on the necessity of this.

Indoor air quality

10 National governments across the UK should work with the research community, industry, third sector and regulators to develop a cross-departmental indoor air quality strategy. This needs to address the health harms from exposures to air pollution, such as from wood-burning stoves or from damp and mould in homes, workplaces, transport, healthcare settings, and indoor public and retail spaces. It should include ongoing representative measurements and opportunities for action through net zero design and retrofit, enforcing current regulations and developing 'fit-for-purpose' revised product and building regulations, as well as improving indoor ventilation and setting standards for healthy indoor air quality.

- Despite society spending a significant proportion of time in buildings, indoor air quality has received much less attention and research than outdoor air. Yet, we know that in our homes and other buildings is where we are exposed to pollution from outdoor air, as well as from chemical and biological substances generated indoors. Net zero policies and climate adaptation will require many changes to old and new buildings that will, in turn, change our indoor environments. A dedicated strategy, held jointly across government departments responsible for health, the environment and net zero, would deliver a coordinated approach that recognises the interconnection across the health and sustainability agendas and delivers technical, regulatory and behaviour co-benefits.

Inequalities and inequities

11 All air quality policy developed by national and local governments across the UK must consider the disproportionate impacts of air pollution on certain groups, including recognised ethnicity- and deprivation-based disparities. It should focus action on areas and populations with high levels of air pollution and greatest vulnerability to health harms from pollution.

- The impacts of air pollution are disproportionately experienced by vulnerable populations and marginalised communities at risk of poorer health outcomes. Of the groups that are more exposed, many will also be more vulnerable to the exposure – including children, older people and those living with existing chronic health conditions. All policy developed at a national, regional and local level across the UK to tackle poor air quality must recognise and actively consider where interventions are most needed and the benefits of taking action to reduce inequalities, including how interventions can be targeted and tailored to benefit socially disadvantaged and marginalised groups. As has been learnt from the COVID-19 pandemic, local communities should be involved in decision making and co-development to promote uptake and sustainability of initiatives.

12 A whole-systems approach is needed to join up public sector bodies and agencies with responsibilities for air quality, public health, education, social care and healthcare services, to pool resources and deliver coordinated action. These actions must be evidence-based and tackle air pollution as a wider determinant of health and contributor to inequalities, thereby reducing the gap in healthy life expectancy and health outcomes experienced across the UK.

- Improving air quality will reduce health inequalities as fewer people are affected by its health impacts, including those whose health is more susceptible to its impacts. This will, in turn, reduce NHS and social care costs and productivity losses. Joining up the many and varied public sector bodies with responsibility for air quality, public health and healthcare services will enable joint action. Currently, these can be fragmented and wide-ranging, involving multiple bodies across government, the NHS and the third sector. The need for strong national action, leadership and incentives – as well as measurement and enforcement at hyperlocal level – is critical here to success.

Net zero

13 The Department for Energy Security and Net Zero should ensure that air quality co-benefits are maximised and integrated within the UK's mitigation and adaptation actions for climate change and net zero. It should act on opportunities to close the persistent inequalities in air pollution impacts through targeting investments to reduce greenhouse gas emissions for families living in fuel poverty, social housing and the private rented sector, and in those living in areas with the greatest deprivation.

- From the transition to low-carbon, 'clean' energy to delivery of net zero housing and clean transport, many of the actions for transition to net zero will bring large air quality co-benefits. The WHO COP26 special report on climate change and health highlighted the health benefits of coordinated action on mitigation through benefits from improved air quality, finding that benefits outweighed costs by two to one.[48]

Developers in England and the devolved administrations must demonstrate how they will minimise local air quality impacts during the construction (and demolition) phase of new developments. The current state of damp and mould in UK housing shows that it is crucial that adequate attention is given to ventilation of homes and buildings as part of energy insulation.

14 Air quality needs to be included in organisations' corporate social responsibility (CSR) initiatives as part of their 'green' and sustainable action plans.

> Many businesses and organisations have CSR initiatives with a big focus on reducing their carbon footprint and improving the sustainability of their practices. Air quality should be included in CSR initiatives, with equal weight and importance to carbon footprint, with dedicated KPIs and reporting.

Health professions

15 The NHS in England, Wales and Scotland, and Health and Social Care (Northern Ireland), need to reduce air pollution from all sources. The NHS in each nation should facilitate air quality action by commit to sharing data and evidence for supporting actions to improve air quality, integrating and analysing both central and local data sources to enable tracking of progress towards measurable air quality targets.

> A dedicated national framework is needed to consistently assess and share data on air quality and its associated health benefits. This will help to ensure a standardised approach to evaluating and communicating these co-benefits across the NHS and integrated care service providers. In England, this will help maximise the positive impact on health from the NHS in England's net zero ambitions and Green Plan delivery.

16 Medical royal colleges, faculties, and professional and membership bodies need to incorporate education on air quality into undergraduate and postgraduate training programmes, continuing professional development, assessments and clinical guidelines, to enable health professionals to take account of air pollution in the prevention, diagnosis and management of diseases and conditions.

> New science has established that serious harm from air pollution extends beyond the lungs and cardiovascular system as a driver of many different diseases, such as brain disorders, cancer in non-smokers, and childhood disorders. While research continues to grow, the link between air pollution and mental health remains understudied and often overlooked, even though evidence indicates that air pollution significantly affects brain health and cognitive function. Clinicians must be aware of these developments so that they can take account of them in their practice.

17 Health professionals and practitioners have a responsibility to speak to and educate their patients about the health effects of air pollution and to advocate for cleaner air.

> Patients should be empowered to understand how air quality may be affecting their health and/or health conditions. It is key that doctors, and all healthcare professionals, understand that they have a responsibility to talk to patients about air pollution, its health risks, and how to avoid it or reduce its impacts. The advocacy of clinicians talking about the health impacts of air quality that they see in their work is vital to make the case that air pollution is a health issue, just as tobacco smoking is.

Research

18 Air pollution researchers and policy makers should routinely make use of co-produced tools and methodologies from complexity science and participatory research to inform policy development.

> Air pollution is a 'wicked problem' due to its ever-changing complexity, meaning that it is impossible to solve in a way that is simple or final. The impacts of air quality policy initiatives cannot be considered separately from their physical, geographical, social, cultural, political and economic contexts. Utilising tools from complexity science would achieve a multitude of benefits, including enabling representation of both the positive and negative potential impacts of policy options across priority areas such as health, economy, clean energy and climate change. Adopting these methods in the policy-making process can identify paths of causal interaction with broader outcomes, to enable beneficial outcomes to be optimised and unintended negative consequences to be mitigated. This approach leverages the insights of diverse stakeholders, including affected communities, to create more relevant and effective solutions as recently demonstrated in the Defra Air Quality Information System (AQIS) review.[30]

19 UK Research and Innovation (UKRI) and its research councils, the National Institute for Health and Care Research (NIHR) and charitable funders should support studies on the effects of air pollution through the lifecourse to address priority research questions identified by the UK Committee on the Medical Effects of Air Pollutants (COMEAP). Key areas for future research include identifying and understanding links between exposure and susceptibility throughout the lifecourse, the lag periods between exposure and short- and long-term health impacts, including multiple indoor and ambient environmental exposures and multimorbidity outcomes, and identifying opportunities for effective (and cost-effective) early intervention. The negative impact of air pollution on mental and behavioural disorders, reduced cognition, impaired childhood learning and dementia also mandates further research.

> Having sufficient research and evidence covering the span of air quality issues will lead to a more comprehensive understanding of the problem and better solutions to inform policy development and drive innovation. Principles of co-design should be embedded throughout the research process, from inception to delivery and impact. The research community should adopt best practice in public involvement to incorporate the perspectives, knowledge and lived experiences of patients, carers, advocates, service users and communities in the research process. They should also utilise public engagement activities, such as citizen science and community outreach, to share research findings with affected communities. This will deliver studies that address the concerns and needs of those most impacted by air pollution and will also support buy-in for potential mitigation strategies.

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Air pollution is the largest environmental health risk globally, causing loss of healthy years of life and premature death. This report provides new insights into why urgent action is needed to improve air quality across the country. It presents the latest evidence on the impacts of air pollution on health and health inequalities, the economic costs and policy solutions fit for the future. A set of 19 recommendations set out the much-needed action required from governments and other stakeholders to clean up the air that we are all so dependent upon for our health and wellbeing.

Led by the RCP's special adviser on air quality, Professor Sir Stephen Holgate CBE, the report was developed with the help of 30 clinical and academic experts and approved by RCP Council.

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