

Indoor air quality

When we talk about air pollution, we tend to think about time spent outside and emissions from industrial chimneys and traffic. But air pollution also exists in indoor environments.

Some estimates suggest we spend more than 80-90% of our time inside – in schools, workplaces, transport systems or at home^{1,2}. Air in these environments, therefore, contributes to our overall exposure to air pollution.

Indoor air pollution has received much less attention than outdoor pollution. While we have an understanding of the type of pollutants that are produced from indoor sources, there are still large evidence gaps about the amount of emissions that are produced in real-life settings and our exposure to pollution indoors.

Indoor environments are complex and varied with a range of emission sources, removal mechanisms, activities and actions that can impact the amount of pollution we experience.



Our health is affected by outdoor and indoor air pollution

Air pollution is a major health threat:

569,000

premature deaths in the WHO European region³ in 2019 were due to outdoor and indoor air pollution, which is also associated with a number of chronic conditions.

Many of the pollutants found indoors are the same as those we face outdoors, and there is a constant exchange between indoor and outdoor air. This means that many of the pollutants found indoors have come from the outside, while some outdoor pollutants may have originated from indoor sources.

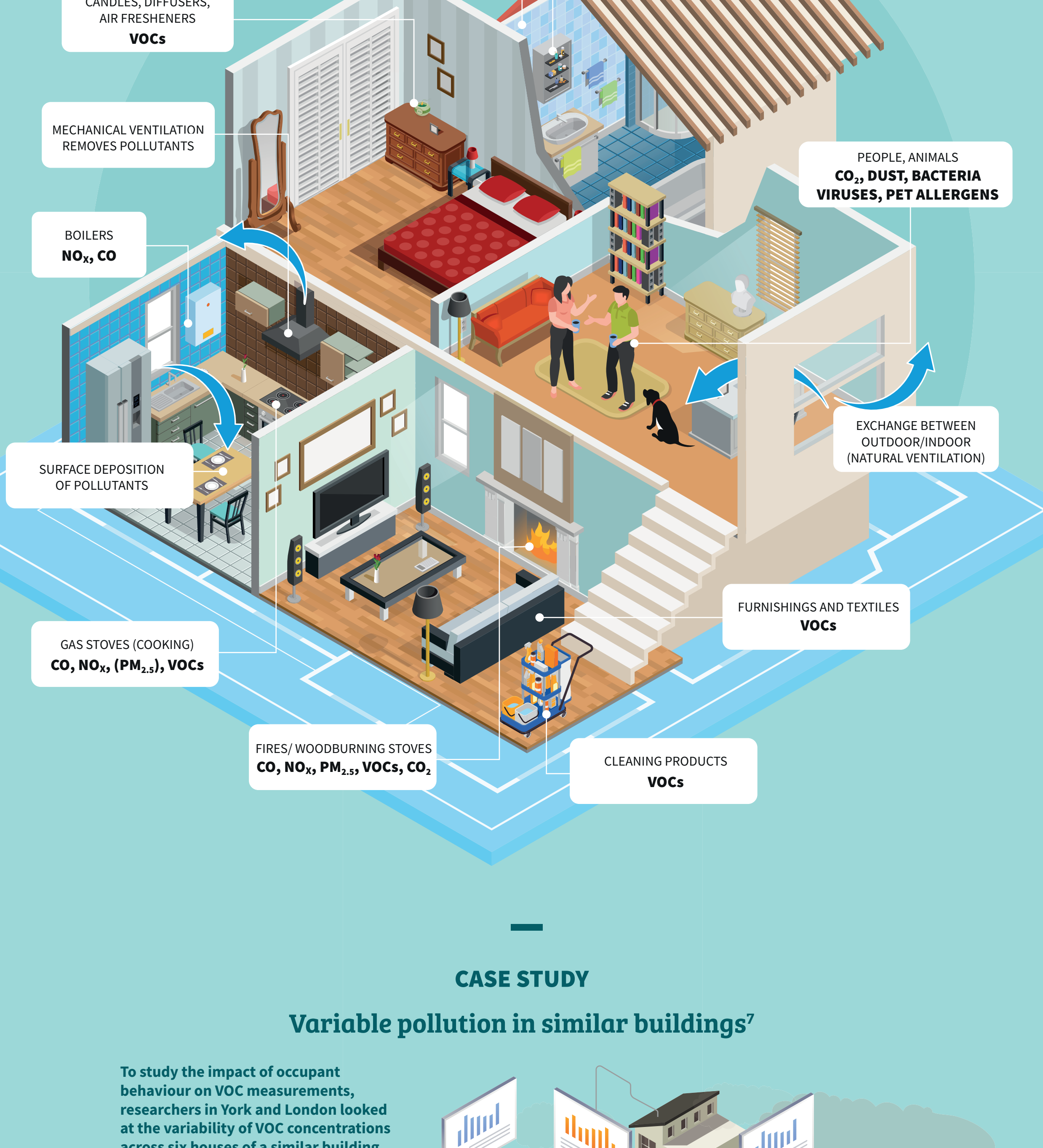
There is less dispersion of air indoors compared to outdoors, so some pollutants, notably volatile organic compounds (VOCs) and carbon monoxide, can build up to higher concentrations indoors.

As with outdoor air pollution, the impacts of indoor air pollution are unevenly spread in society. Air pollution often affects the health of vulnerable groups, like the very young, the elderly, and those with existing health conditions⁴. In the UK, people with lower socioeconomic status are more likely to live in an area with poor outdoor air quality which can affect their indoor air quality^{4,5}. There may be limits to what individuals can do to improve the air quality around them, for example in rented accommodation or public spaces.

Major indoor air pollutants and their health impacts:

Pollutant	Description	POTENTIAL HEALTH EFFECTS
Fine particulate matter (PM _{2.5})	Small particles of less than 2.5 microns diameter	Asthma, chronic obstructive pulmonary disorder, lung cancer, dementia, metabolic effects, impact on the reproductive system, ischaemic heart disease, stroke, heart failure
Volatile organic compounds (VOCs) and semi-volatile organic compounds (SVOCs)	Umbrella term for a group of many organic compounds that are emitted as gases. Includes formaldehyde and benzene, (VOCs) and phthalates (SVOCs)	Irritation, respiratory problems, cancer, nervous system damage
Biological aerosols	Includes viruses, moulds	Asthma and breathing problems, infectious diseases, allergies
Nitrogen oxides (NO _x)	Nitrogen oxide (NO) and nitrogen dioxide (NO ₂)	Asthma
Carbon monoxide	Unreactive gas	Fatal at high concentrations
Radon	Radioactive gas found in parts of the UK	Lung cancer

MAIN POLLUTANTS AND THEIR SOURCES IN THE HOME^{2,6}



CASE STUDY

Variable pollution in similar buildings⁷

To study the impact of occupant behaviour on VOC measurements, researchers in York and London looked at the variability of VOC concentrations across six houses of a similar building age and size.

The study showed variability in the amounts of several VOCs, particularly compounds called monoterpenes which include some fragrances.

Although monoterpenes themselves are not considered hazardous, they can react in the air to form formaldehyde and particulates. As part of the study, occupants kept an activity log. The highest levels of monoterpenes seemed to be linked to the use of fragranced cleaning products and scented candles. Although small, this study showed some of the challenges in understanding indoor air quality, the variability in measurements across different buildings, and the impact that our behaviour can have on the indoor environment.



How can we address indoor air quality?

With our knowledge of the harm air pollution can have on health and the proportion of our exposure to air pollution that occurs indoors set to increase, we need to give indoor air more attention. Improving indoor air in the UK presents several challenges and needs collaboration across disciplines and sectors.

Our understanding of indoor air pollution in the UK is very limited

We need a more complete picture of indoor air quality in the UK to understand where we should target interventions, support their development and assess their impact. This will require multidisciplinary research that links indoor air emissions, air chemistry in different indoor environments and exposure to pollution in real-life settings and should include the introduction of a widespread, long-term, systematic surveillance of indoor air quality and health in a variety of different environments to establish a national baseline for indoor air quality. Information gained from such a programme would help inform interventions and enable us to measure changes over time to assess their impact, for example from product reformulations or changes to building materials.



France's indoor air observatory⁸ has now been running for over 20 years. It was created to support policymaking, setting a baseline for indoor air quality in houses across France. A national survey took indoor air quality measurements in around 500 houses, which were representative of the overall housing stock. This baseline has helped inform guidelines for indoor air pollutants, including for formaldehyde. The observatory has also undertaken additional studies to answer specific questions, for example about the impact of energy efficiency measures on indoor air quality or the air quality in schools. **There is currently no equivalent indoor air surveillance programme in the UK.**

Climate change mitigation and air quality are linked

There are important links between climate change and air quality, and efforts to address climate change can improve air quality, sometimes called co-benefits⁹. We need to consider the impact on air quality when designing policies towards net-zero to make sure we can simultaneously benefit health through improved air quality.

For indoor air, this could be ensuring sufficient ventilation strategies are in place when designing energy efficient buildings to prevent a build-up of indoor air pollutants.

Policy levers to address indoor air quality are spread across Government

Collaboration and coordination across Government is needed to develop and implement policy options that reduce indoor air pollution. Some legislative powers are devolved and responsibility for regulations, their enforcement and other policy levers affecting indoor air pollution are spread between government departments.

For example, public transport vehicles and hubs are in the Department for Transport's remit; the Department for Business and Trade is responsible for product and chemicals regulation; responsibility for planning and housing regulations lies with the Department for Housing, Levelling Up and Communities and the Department for the Environment, Food and Rural Affairs is responsible for managing outdoor air pollution and legislation. In 2022, a Cross Government Working Level Group on indoor air pollution was set up to support coordinated efforts to consider indoor air pollution in relevant policy areas.

Indoor air quality regulation and guidance is fragmented and confusing

Regulation is one route to act on indoor air pollution but needs to be more coherent in the UK. There are currently no specific targets for indoor air pollution comparable to those we have for outdoor air pollution. However, there are a range of regulations and guidance from different areas of Government which can all impact indoor air quality¹⁰.

There are few mechanisms to check whether regulations and guidance are being followed. In addition, who is responsible for compliance with regulations can depend on the building and its use. This can be complicated where a building has a mixed purpose – a care home, for example, is both a workplace and a dwelling. Regulation has often been developed based on an average 'worker' of good health and working age. As air pollution is often more harmful to vulnerable groups (for example children, the elderly and those with pre-existing health conditions), some of the current advice or regulations may not be sufficient. In particular, not all pollutants are covered by existing regulation for indoors and there is little enforcement against breaches of outdoor limits.



Outdoor air quality legislation

Air quality legislation in the UK is built around outdoor air quality. Efforts to meet legally binding limits for the concentrations of certain pollutants in outdoor air will indirectly contribute to improving indoor air quality.

The National Emissions Ceilings Regulations 2018 set emissions reduction commitments for overall national emissions for five key pollutants, including VOCs, PM_{2.5} and NO_x. A high proportion of overall VOC emissions come from indoor sources and so are included in the emissions calculations.

Building and workplace regulations

Building Regulations Part F sets out requirements for ventilation in buildings to ensure an adequate supply of fresh air and removal of pollutants and control of humidity. Ventilation guidance is also included in The Workplace (Health, Safety and Welfare) Regulations. The Control of Substances Hazardous to Health (COSHH) Regulations require employers to assess and control the risks posed by hazardous substances, including some indoor air pollutants, in the workplace. For certain substances, there are specific workplace exposure limits which an employer must ensure are not exceeded. Exposure limits to mixtures are assumed to be a sum of those for the individual components.

Product regulation

Several regulations applying to chemical substances, particularly VOCs, are relevant to indoor air quality when products containing these compounds are used in indoor environments. These include chemicals regulated under the Registration, Evaluation and Authorisation and Restriction of Chemicals (REACH), VOCs in Paints, Vernishes, Resins and Vehicle Refinishing Products Regulations 2012, and the Construction Products Regulations 2013.

Guidance

The Health and Safety Executive (HSE) has guidance aimed at building managers and employers on aspects of indoor air quality including ventilation, humidity, and exposure to specific pollutants. Health based guidelines for indoor air pollutants have been produced by the World Health Organization (WHO), and Public Health England (PHE¹¹). PHE guidance has informed a booklet 'Indoor Air for Care' from the National Institute for Care Excellence.

Guidance on heating and ventilation is available from the Chartered Institute of Building Services Engineers.

¹ https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1124738/Chief-medical-officer-annual-report-air-pollution-dec-2022.pdf

² https://uk-air.defra.gov.uk/library/reports/report_id=1101

³ <https://www.who.int/en/news-room/facts-sheets/item/air-quality>

⁴ https://uk-air.defra.gov.uk/assets/documents/reports/can0910701130944_AQnequalityENL_AEAT_0506.pdf

⁵ https://www.london.gov.uk/sites/default/files/air_pollution_and_inequality_in_london_2019_update_0.pdf

⁶ <https://journal.buildingdisciplines.org/articles/10.5334/bc.100>

⁷ <https://pubs.rsc.org/en/content/articlehtml/2017/en/c6em00569a>

⁸ <https://www.osa.fr/fr/>

⁹ <https://royalsocietypublishing.org/doi/10.1098/rsos.200101>

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- Indoor air is an important contributor to our overall exposure to air pollution. We need to consider indoor environments to achieve the health benefits possible from improved air quality.
- We need collaboration across disciplines and sectors to improve indoor air quality.
- Government should continue to enhance coordination across departments and regulatory bodies on indoor air quality to develop and implement policy options to improve indoor air quality.
- We need long-term, systematic monitoring of indoor air quality and health to establish a national baseline, inform policy development and prioritisation, and assess the impact of interventions.
- We should consider the links between air quality and net zero when developing policy and technology solutions for both.