HOW UKHSA SUPPORTS POLICY ON INDOOR AIR QUALITY AND HEALTH

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Over the last 10 years, there has been an attempt to better understand indoor air quality and its impacts on our health and wellbeing. UKHSA has established a Cleaner Air Programme, as part of its core activities, which aims to reduce people's exposure to air pollution, including poor indoor air quality, and achieve better outcomes for all. The work that UKHSA carries out on indoor air quality and health, for each of the core ambitions of its Cleaner Air Programme, is discussed below.

WHY DOES INDOOR AIR QUALITY MATTER?

The COVID-19 pandemic has led to people spending more time at home due to increased home working. This has raised the importance of indoor air quality (IAQ) and ventilation. People in developed countries spend about 90% of their time indoors, much of which is at home. This is especially the case for vulnerable populations, such as young children and the elderly. Over the last 10 years there has been an attempt to better understand IAQ, the factors affecting it, the health effects associated with exposure to air pollutants indoors and what should be done to improve IAQ and its impacts on our health and wellbeing.

The ingress of outdoor air indoors, housing conditions in terms of building characteristics (such as building form, building fabric, airtightness, infiltration and ventilation systems), indoor sources (from building and construction materials, furnishing and consumer products), as well as occupant activities (e.g., cooking, smoking, wood burning, cleaning, drying clothes indoors) are important modifiers of indoor air quality (Dimitroulopoulou, 2021).

Indoor air pollutants include particulate matter (e.g., $PM_{2.5}$, PM_{10}), volatile organic compounds (VOCs), combustion products (nitrogen dioxide -

NO_2, carbon monoxide - CO), radon and biological contamination. Exposure to indoor air pollutants cause significant adverse health effects; they can trigger or exacerbate asthma, other respiratory or cardiovascular conditions, irritate the upper airway system and may even have carcinogenic effects (NICE, 2020; RCPCH, 2020). Markers of dampness/moisture in buildings such as visible mould, mould odour, or moisture in the walls have been associated with respiratory health outcomes, such as exacerbation of asthma, respiratory infections and allergies. However, we know much less about the health impacts from indoor air pollution compared to outdoor air pollution.

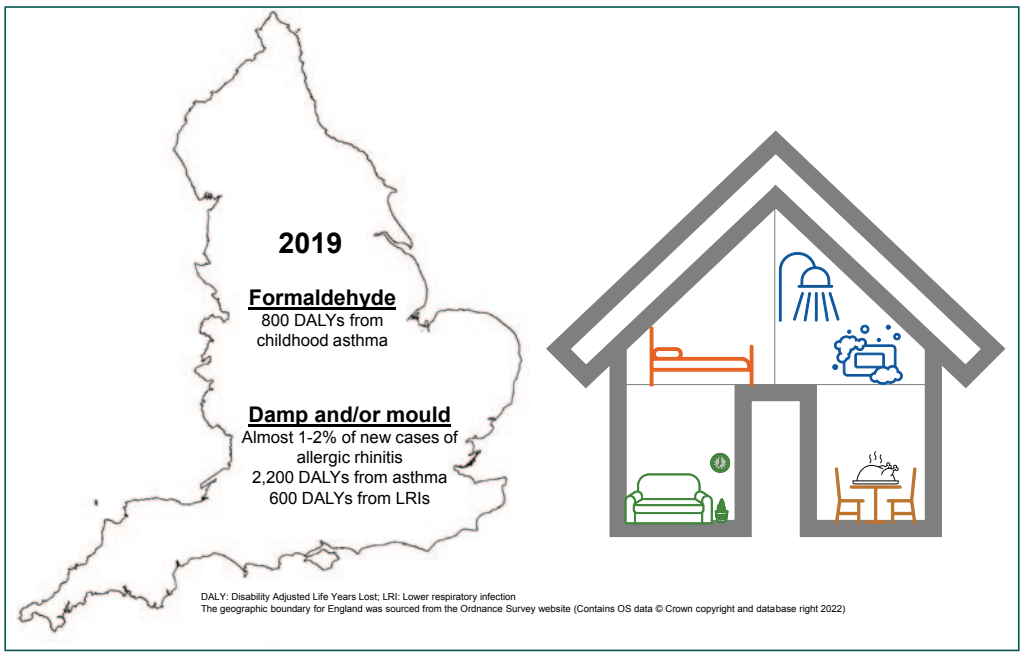
WHAT UKHSA IS DOING TODAY ON IAQ

UKHSA has established a Cleaner Air Programme, as part of its core activities, which aims to reduce people's exposure to air pollution, including poor IAQ, and achieve better outcomes for all – particularly for the most vulnerable groups such as those with pre-existing respiratory and cardiovascular conditions, older people, pregnant women and children, and deliver physical and mental health as well as climate change co-benefits (UKHSA, 2022). The core ambitions of the Programme are reported below together with the work related to IAQ, for each of them.

1. Increasing the evidence base

Damp and mould

To inform the governments' guidance on damp and mould (DHSC/UKHSA/DLUHC, 2023), UKHSA led on the quantification of the respiratory burden of disease in England from exposure to damp and mould in housing. In 2019, the presence of damp and/or mould in English residences (3-4%) was estimated to be associated with approximately 5,000 cases of asthma and 8,500 cases of lower respiratory infections among children and adults and contributed to 1%-2% of new cases of allergic rhinitis. Using alternative data sources, primarily from self-reporting, that suggests that the percentage of dwellings affected by damp and/or mould may be even higher, the total number of cases could be 3-8 times greater (Clark et al., 2023).



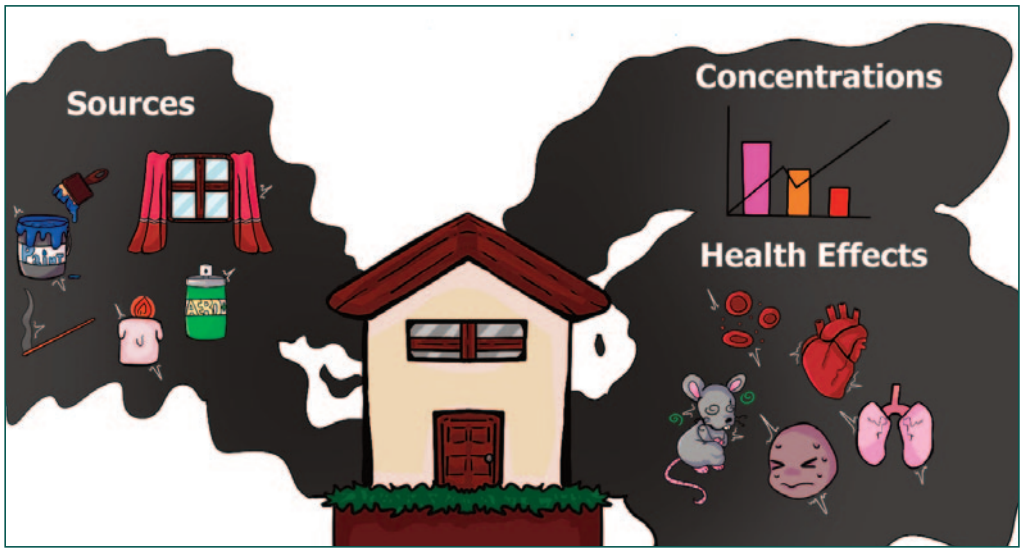
Respiratory burden of disease from exposure to damp and mould and formaldehyde in UK homes (from Clark et al., 2023)

Indoor sources

A systematic literature review has been carried out on concentrations, emissions from indoor sources, and health effects of volatile organic compounds (VOCs) measured in European and UK homes (Halios et al., 2022). 65 individual VOCs were identified, and 17 of them, most frequently occurring in homes, have a relevance to health. Widely used building and construction materials (e.g. composite boards, paints and coatings) are sources for 11 VOCs: benzene, ethylbenzene, xylenes, styrene, toluene, acetone, acetaldehyde, formaldehyde, trimethylbenzene, naphthalene, α- pinene and limonene. UKHSA is leading on the development of a modelling tool to assess exposure to chemicals in homes. Health effects from exposure to these chemicals and emission rates from construction materials and consumer products found in the literature review will provide a valuable input for modelling tools.

Indoor air quality guidelines – Ventilation standards

Until recently, in the UK, there were no IAQ guidelines for



Chemicals in homes (from Halios et al., 2022)

individual VOCs. UKHSA carried out a comprehensive literature review of existing assessment values proposed by health organisations around the world, we selected the most appropriate existing health-based guidance values for inhalation and proposed them as health-based IAQ guidelines for 11 individual VOCs in the UK (Shrubsole et al., 2019; PHE, 2019). These are recommended as performance criteria for ventilation in the revised building regulations (Approved Doc. F for ventilation).

UKHSA carried out a literature review (Lowther et al., 2021) to identify if carbon dioxide (CO_2) is a pollutant with known health effects at low levels (below 5000 ppm) measured in indoor environments. Looking at the individual designs of human studies, we concluded that any health impacts can be indicative of reduced ventilation, emissions of human bio-effluents and presence of indoor air pollutants, so CO_2 is only an indicator for ventilation at these levels. Reviewing international ventilation standards concluded that the current consensus that CO_2 concentrations below 1000 ppm represent good IAQ, in the range of 1000–1500 ppm represent moderate IAQ and above 1500 ppm represent poor AQ, seems to be appropriate.

UKHSA is working with ISIAQ (International Society on Indoor Air Quality and Climate) on the development of an open database on international indoor environmental quality (IEQ) guidelines (Toyinbo et al., 2022; Dimitroulopoulou et al., 2023a). The database aims to be actively used by researchers, practitioners, and policymakers across the world.

Climate Change

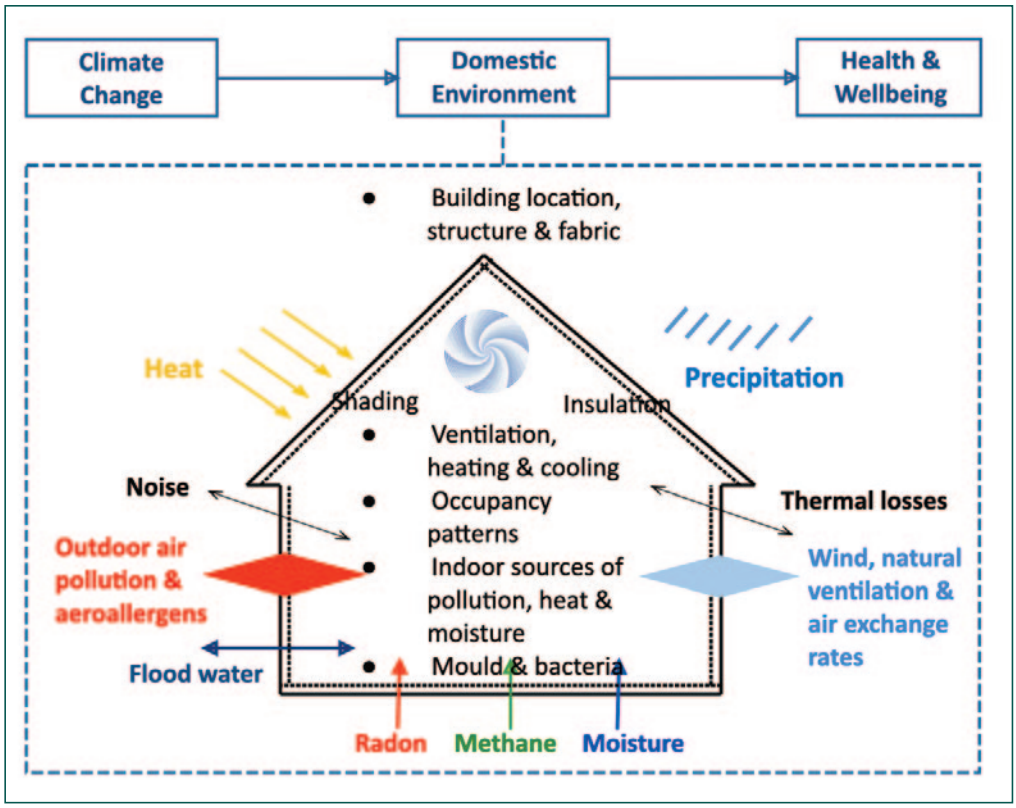
There is growing evidence that climate change has the potential to significantly affect public health, due to mitigation and adaptation policies in the building sector (Vardoulakis et al., 2015). Chapter 5 of the UKHSA's Health Effects of Climate Change report provides the latest evidence on the impact of climate change mitigation and adaptation policies on IEQ and health, which also takes into consideration indoor exposures to air pollution and damp and mould (Dimitroulopoulou et al., 2023b). The net-zero challenge requires significant changes in the performance of both new and retrofitted buildings. Increasing airtightness of dwellings in pursuit of energy efficiency could build up the concentrations of pollutants generated from indoor or ground sources, and biological contamination. This may be due to inadequate ventilation caused by shortcomings of ventilation systems in fabric retrofitted homes. A better understanding is needed in the UK of how IEQ parameters (IAQ, ventilation, indoor temperature and noise) interact and how current and emerging building infrastructure, design, construction, and materials used, may affect these parameters and hence our health and wellbeing.

Inequalities

UKHSA is providing funding and supervision support to PhD projects to develop evidence on the factors that affect personal exposure, especially of vulnerable populations, considering both indoor and outdoor air, and addressing inequalities. Ferguson et al. (2023) concluded in her review that low socio-economic homes experienced higher levels of indoor PM, NO_2, VOCs and ETS, whereas higher radon concentrations were found in homes with a greater material wealth. Inequalities in exposures may arise from poor quality housing, location near congested roads, lack of occupant education regarding the harm of indoor second-hand smoke, and/or higher occupant density resulting in greater re-suspension of particles (Ferguson et al., 2021). Personal exposure modelling estimated $PM_{2.5}$ exposure for around 1.3 million children 4–16 years old in the Greater London area. Children from low-income homes generally have higher personal exposure to $PM_{2.5}$, but the relationship is nonlinear. 57 % of London's school-aged population have a daily exposure that exceeds the previous World Health Organization (WHO) 24-h guideline of 15 μg/m^3. Residential indoor sources of $PM_{2.5}$ are a large contributor to personal exposure for school children in London.

Interventions

UKHSA (formerly Public Health England, PHE) previously worked with NICE (The National Institute for Health and Care Excellence) for the development of guidelines on indoor air quality at home, which are PHE co-badged (NICE, 2020). Both structural and behavioural interventions are proposed, to



The impact of climate change on indoor environmental quality and health (from Vardoulakis et al., 2015).

reduce the sources of indoor air pollution and improve ventilation and are addressed to different groups (local authorities, healthcare professionals, and building industry). For instance, they provide guidance for local authorities on how to reduce damp and condensation and increase ventilation.

UKHSA carried out a systematic literature review to examine the impact of portable air cleaners on indoor air quality (PM2.5) and health, focussing on adults and children in indoor environments (homes, schools and offices) (Cheek et al., 2020). Analysed studies all showed reductions in PM2.5 of between 22.6% and 92.0% with the use of air cleaners. Associations with health impacts were found to include those on blood pressure, respiratory parameters and pregnancy outcomes. Changes in clinical biochemical markers were also identified. However, evidence for such associations were limited and inconsistent. Despite that, there is not enough evidence to confirm health benefits but given that there is strong evidence that exposure to particulate pollutants is harmful to health, using portable air cleaners is likely to have positive health impacts.

Participation in research networks

UKHSA participate in the networks funded by the Government (UKRI) (HEICCAM, TAPAS, FUVN) that address future air quality challenges at the indoor-outdoor interface in residences and in schools. UKHSA is either a co-investigator or partner/advisor.

2. Support our stakeholders - Contribution to policy making

UKHSA has been working together with DLUHC, DfE, Defra, HSE and DHSC/OHID to ensure a joined-up approach on government actions affecting IAQ;

• DHSC / UKHSA / DLUHC (2023) developed a new consolidated guidance for the rented housing sector which sets out the health risks associated with damp and mould and the practical steps housing providers can take to minimise these risks. The guidance is aimed at private and social rented landlords.

• UKHSA contributed to the revision of Building Regulations (Part F: ventilation and Part L: airtightness) led by DLUHC. The PHE IAQ guidelines for selected VOCs (2019) were used as performance criteria for ventilation.

• UKHSA also contributed to the revision of HHSRS (Housing Health and Safety Rating System) organised by DLUHC. UKHSA sat on the Project Board, providing expert advice on hazards and minimum standards.

• UKHSA are working together with HSE (UK REACH work programme, 2022/23) on a Regulatory Management Options Analysis (RMOA) that examines exposure of the general public to formaldehyde from formaldehyde releasers in articles (such as building and construction materials).

• UKHSA worked with DfE for the revision of Guidance BB101 on ventilation, thermal comfort and IAQ in schools (DfE, 2018). Following our PHE recommendation, the WHO (2010) indoor air quality guidelines were incorporated for the first time in the UK into a UK Government guidance.

• UKHSA staff co-authored Defra's Air Quality Expert Group report on indoor air quality (AQEG, 2022).

• UKHSA staff were co-authors in the Chief Medical Officer's annual report 2022 on air pollution, with chapters on air quality and health effects (Exley et al., 2022) and inequalities in relation to air pollution exposure and health (Dimitroulopoulou et al., 2022).

• UKHSA sits on three Cross Government (X-Gov) Groups related to IAQ: i) indoor air quality, chaired by DHSC, ii) gas safety and carbon monoxide awareness, chaired by HSE; iii) Net Zero Co-Benefits, chaired by DESNZ. The members of these X- Gov groups share knowledge and activities in the relevant areas, with an aim to identify any barriers to action and identify ways to move beyond them as well as potential opportunities for cooperation.

• Alongside government departments, UKHSA also works with external stakeholders and organisations (i.e., WHO, NICE, CIBSE – Chartered Institute for Building Services Engineers, and the Royal Colleges RCP/RCPCH) to provide scientific input, using expert knowledge and experience on indoor air quality in relation to public health. For example, UKHSA members of staff are currently working on the revision of CIBSE TM57 design guidance for schools. This is informed from a previous WHO project on assessing combined exposure to multiple chemicals in indoor air in schools (WHO, 2020; 2022), in which UKHSA had participated.

3. Improving awareness of indoor air quality

UKHSA staff have presented and been panellists in various events, including panel discussion on IAQ and health, organised by All Party Parliamentary Groups, Clean Air Networks Conference, UK Indoor Environment Group (UKIEG) Conferences and webinars, UKHSA and Air Quality (AQPH) Conferences and other events organised by our Stakeholders. UKHSA also contributed to the recent POSTbrief on IAQ to inform Parliamentarians of IAQ issues (POST, 2023)

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