NIHR Health Protection Research Unit on Environmental Change and Health

Housing, Indoor Air Quality and Climate Change

Healthy housing: indoor environmental quality report update

April 2023

Key messages

- The UK Government's "Net zero" commitment is to reduce the UK's greenhouse gas emissions by 100% from 1990 levels by 2050. To achieve this, improvements must be made to the energy efficiency of homes, which currently account for 21% of all carbon emissions.
- Home energy efficiency measures, aiming to reduce winter space heating needs, will affect the indoor temperatures and air quality of dwellings but there are uncertainties about the nature of those changes.
- The majority of effects from home energy efficiency are beneficial (such as improved warmth in winter), but some may also measures be detrimental for health (for example reduced ventilation).
- People in the UK spend about 90% of their time indoors and the proportion of this time spent in their own homes has increased, since COVID-19 due to more home working.
- Particular concerns arise in relation to pollutants derived from sources inside the home; e.g. cooking, combustion, cleaning, furnishings, the ground and biological agents (including mould)
- Levels of air exchange (from both intended and unintended ventilation) are a principal determinant of the concentrations of indoor air pollutants, yet there is very limited data on the real-world changes to the ventilation characteristics of homes from energy efficiency measures.
- There is also uncertainty about what ventilation characteristics would optimise benefits for health and avoid principal adverse effects.
- There are also important questions about the 'performance gap' between planned and actual ventilation levels in dwellings and how it can be reduced.
- Public awareness of indoor air quality issues appears limited.

- More information is needed to better understand the effects of improved energy efficiency measures on health, in particular collection of real-world data from a variety of housing types and settings.

The UK Government's "Net zero" commitment is to reduce the UK's greenhouse gas emissions by 100% from 1990 levels by 2050 (1). To achieve this, improvements must be made to the energy efficiency of homes, which currently account for around a fifth (2) of all carbon emissions. Home energy efficiency measures will affect the indoor temperatures and air quality of dwellings but there are uncertainties about the nature of those changes. The majority of effects from home energy efficiency are beneficial (such as improved warmth in winter), but some may also measures be detrimental for health (for example reduced ventilation).

An online workshop was held on 29 March 2021 with the aim of helping to shape research undertaken by the Health Protection Research Unit (HPRU) in Environmental Change and Health on 'healthy housing'. This included a range of professional stakeholders and public representation through Public Led Knowledge and engagement Team (PLANET). Its principal objectives were to:

1. **Review:**
    a. The state of the current housing stock and drivers for change
    b. Current understanding of the implications for health of housing interventions for climate mitigation/adaptation.
    c. Proposed work methods and datasets.

2. **Share initial HPRU plans for research in this subject**

3. **Discuss**
    a. Key knowledge gaps of relevance to healthy housing
    b. How the HPRU can engage effectively with stakeholders
    c. Research priorities for the HPRU

This report summarises the main points of the workshop and is structured around the three points listed under objective (3) above. Since the workshop was held, new research and modelling has been undertaken, which will aid decisions about next steps and future priorities.

Knowledge gaps

Multiple factors interact to influence the indoor environment, and the importance of these varies in space and time. Some of the factors discussed were:

1. The local microclimate and the impact it might have on indoor temperatures.

2. The temporal profiles and types of outdoor sources of air pollution that vary spatially and will likely be influenced by climate change mitigation actions.
3. The temporal profiles and types of indoor sources of air pollution that vary widely between and within homes.
4. The current levels of ventilation in dwellings that can greatly influence the indoor concentration of air pollutants and temperature. These vary between dwellings, with season and will also be influenced by heating system type, energy-efficiency retrofit and occupant behaviour. There is also a question of discrepancy between planned and actual ventilation levels. This might be another case where the intended performance differs from the actual performance, contributing to the "Performance Gap".
5. The development of new homes over floodplains, methane sources or otherwise polluted land. Taking the example of reclaiming floodplains, excess humidity that may be released could contribute to mould growth.
6. The potential impacts of climate and environmental change on sources of air pollution. It is not well understood how the changes in temperature and greenhouse gas concentrations may influence the concentration of indoor air pollutants.

Some of these factors have been studied independently in the past, often at low temporal resolution or in just one geographical region. This was mostly done through modelling studies, especially in the case of air quality where there is limited data of indoor air pollutant concentrations within homes.

Whilst existing studies have been informative, several knowledge gaps remain. For example, Volatile Organic Compounds (VOCs) can arise from indoor sources such as cleaning products or furniture and likely vary significantly over space and time. Currently, there is limited data on the concentration of VOCs in homes in England and the health effects of exposure. In addition, with limited data on the current levels of ventilation in homes and how these may change following energy-efficiency retrofit, there is also a knowledge gap on how important VOCs will be in the future in the context of healthy homes.

To address these gaps, there is a need to collect detailed data, ideally through performing large-scale longitudinal studies. The collected data would inform and validate modelling processes, which in turn will allow the quantification of health risks under different climate and energy scenarios and help identify vulnerable sub-groups of the population.

The importance of indoor environmental quality largely depends on the presence of occupants and their behaviours. Another knowledge gap discussed concerns the change in occupant behaviour associated with the Covid-19 pandemic and continuation of working-from-home. Some issues are largely exacerbated with the near continuous presence of occupants in their homes as a result of public health measures, including 'lockdowns', and the increase in time spent working-from-home (hybrid working (3)). Understanding how behaviours changed since the onset of the pandemic and during lockdown restrictions is

important, since these practices are likely to continue for the foreseeable future. In addition, the pandemic has highlighted the importance of ventilation in minimising the risk of transmission of airborne diseases and this is something that should be considered when modelling the indoor environment.

Another topic where knowledge gaps remain relates to the uptake of air conditioning. It is unclear how this will unfold, who might have access to it and what its effects might be on the local microclimate, ventilation, and energy demands. This is especially important in regard to the potential to widen existing health inequalities.

Drawing from the contribution of members of the public in our workshop, public awareness on these issues needs addressing. A large proportion of the public are not well informed on the potential consequences of poor indoor environmental quality and the factors that influence it. An early introduction in the school curriculum to indoor air quality and ventilation and their role in the spread of airborne diseases should be considered.

How should the HPRU engage effectively with stakeholders?

In addition to the numerous stakeholders that contributed to the first workshop, more organisations were identified to contribute, including the Chartered Institute of Environmental Health and health professionals.

Emphasis was placed on the role of the public as a stakeholder. While we already have members of the public within our stakeholder group, part of the discussion focused on how this may be taken further.

Stakeholders from a broad sample of the population, living in different housing types and settings, should be sought to engage with this work, especially from a health equity perspective.

A stakeholder mapping process was suggested to optimise the engagement depending on the type of stakeholder and their needs. Overall, a regular and fluid engagement was thought to be best in most cases. With this approach, updates could be provided while the research is ongoing to allow regular involvement of the relevant stakeholders.

Since “information does not necessarily equal action”, another important point raised is the need to measure the effectiveness of our engagement. This may be achieved through stakeholder surveys that aim to capture how our research outputs are likely to influence their decision making, what the obstacles to action are and how these may be overcome and the rate of knowledge mobilisation to influence policy.

Priorities for HPRU research

1. Undertake a mapping process of the various factors that contribute to healthy housing and identify evidence that is currently available; both modelling and monitoring based. This should consider a broad range of housing types and

occupants behaviours. Where appropriate, liaise with other research groups to obtain access to useful datasets.

2. Determine what information would be insightful to have but is currently unavailable. Discuss, through a position paper, why collecting this information is critical if we are to ensure homes are fit for purpose. Present some of these insights in a webinar.
3. Plan the development of a computational model that better reflects time and space and will address some of the knowledge gaps identified through this workshop. Consider during the design stage how the outputs of this model can inform decision making in the most effective way. This may be done through a co-design process with the involvement of stakeholders.
4. Develop the framework of future engagement and knowledge mobilisation with decision makers and other end users of the research outcomes, and consider how the effectiveness of this engagement can be measured.
5. Identify potential methods to address the public awareness gap.
6. Monitoring pilot studies to aid more detailed modelling. Recent publications cite many potential health and planetary benefits through reducing greenhouse gases (4) and increasing energy efficiency measures (5) but note that large-scale monitoring is urgently required in a variety of housing types in different settings in order to understand and quantify these effects and avoid potential negative health impacts and remediation costs (2).

Progress made

- In line with the priorities identified at the workshop, a position paper was published in the prestigious journal The BMJ (2), where the case for monitoring the effects of home energy efficiency on indoor air at a large scale was made.
- In collaboration with HEICCAM, a Clean Air Network, a webinar was delivered on the topics of home energy efficiency, ventilation and indoor air.
- A modelling framework, that considers changes in exposure to several pollutants with time and space, has been developed. This will be used to quantify the impact of climate change mitigation actions on indoor environmental quality and health. A paper is currently in preparation where the modelling framework is applied on two contrasting case studies. Future work will apply this framework at the housing stock level and carry out a cost-benefit analysis to guide policy.

Workshop reflections

- A workshop at the start of a project offers the opportunity to inform key stakeholders of the planned research and receive feedback and advice at an early stage.
- In our experience, the input provided by the stakeholders did not significantly alter the project's deliverables but helped refine the format of the planned outputs to be in line with the needs of the wider stakeholder community.

- The workshop has also improved the visibility of our work at an early stage, potentially increasing the effectiveness of output dissemination and impact.
- Understandably, the workshop has led to some objectives being identified by the workshop participants as priorities which do not fit the project's remit. Although they could not be incorporated in the project, they can inform future research.

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