

SPI-B/EMG: MHCLG Housing Impacts Paper

Handling: This paper was written in response to an MHCLG commission for advice from SAGE to better understand the role of housing in transmission and how it might be mitigated. It summarises and integrates the key conclusions from the SPI-B and EMG Evidence Reviews that accompany this paper, which provide in-depth analysis and detailed supporting evidence.

Summary

Evidence relating to transmission within the home

The relationship between housing and health is well established but multifactorial and complex. Rates of transmission in housing are high, but existing datasets may not be sufficient to determine causal relationships and transmission pathways. COVID-19 mortality rates have been linked to houses of multiple occupation, temporary accommodation, multi-generation households, shortages of social housing and areas where overcrowding is more prevalent. However, the role of specific environmental, demographic and social factors is not yet known.

Probable risk factors for transmission within the home

Likely housing related risk factors for COVID-19 include: large household size; high density occupancy; poor quality housing; poor ventilation. Engineering mitigations applicable in other buildings will be difficult to achieve for household members due to proximity and time of exposure.

Likely household related risk factors include:

- a) high level of risk due to numbers of occupants, shared spaces and facilities, poor ventilation and length of exposure;
- b) high risk of exposure of household members outside the home due to a high level of occupational, family and social connectivity;
- c) high level of risk within the home due to vulnerable household members, caring and domestic responsibilities, intimate social relationships (families) or barriers to communication and shared action (in houses of multiple occupation);
- d) contribution of social deprivation to risk of occupational exposure, poor health and inadequate housing, and barriers to implementing mitigations, including overcrowding and lack of resources and control over housing conditions.

Mitigations likely to reduce transmission within the home

Mitigations with the potential to reduce risk include:

- a) guidance for housing providers and regulation to improve housing quality and reduce occupied density
- b) guidance for housing providers and occupants on improving ventilation provision and use
- c) co-designed strategies and communications to support all mitigation behaviours in the home, tailored for all types of households and household visitors
- d) provision of support for socially deprived households at high risk to implement all feasible mitigations, potentially including an offer of safe and appropriate accommodation outside the home if it is impossible to sufficiently isolate vulnerable household member(s)

Research required

Integration and analysis of existing data plus primary mixed methods research is required to understand patterns of infection transmission in the home and acceptable, feasible and effective methods of mitigation.

QUESTION 1: How are the environmental conditions in housing likely to influence transmission? How do housing conditions vary by tenure type?

There are known associations between housing quality and health, particularly with regard to respiratory illness, however due to the number of variables, causal links are harder to identify. Other important potential environmental risk factors are as follows:

Larger households. These are more at risk simply due to the increased opportunities for transmission, and higher numbers of potential infections (including when household members are quarantining or self-isolating at home). Larger households may also have larger social networks (e.g. more people linked to different workplaces and social networks, children in different school year groups).

Higher density occupation. This may be due to larger household sizes or limited space within the home, and may be linked to poor ventilation, shared spaces and limited facilities for washing, cleaning and cooking. Poor ventilation may also compound issues around high density. Homes with greater density (amount of space vs number of occupants) and fewer rooms (e.g. shared bedrooms) will be less able to physically isolate a sick household member. Key shared areas in the home (bathrooms and kitchens) are used by all occupants, and there will be multiple high touch sites (surfaces, handles, etc). These shared spaces may undermine engineering mitigation measures for fomite, droplet and aerosol transmission, and compliance with NHS advice for self-isolation at home.

Poor ventilation. Occupants spend long periods of time in the home, so risks of aerosol transmission may be greater. There is evidence that ventilation rates in many homes can be poor, due to inadequate and defective provision, and also environmental barriers (external noise, pollution, security, heat loss) and behavioural barriers (lack of knowledge, thermal comfort) to the effective use of ventilation. Ventilation rates are difficult to measure in use, and poor indoor air quality is not generally perceived by occupants. Occupants' ventilation use is driven predominantly by thermal comfort and energy use and is likely to be lower in winter. Ventilation provision is not necessarily related to the age of the home.

Poor housing quality. Poor quality of homes and poor thermal performance may exacerbate risk. Cold, damp and mould can exacerbate underlying health conditions and can be a barrier to some behavioural mitigations. There is emerging evidence of the effect of environmental conditions on the SARS-CoV-2 virus, with lower temperatures increasing virus survival. These conditions will be more prevalent in older homes which have lower requirements for regulatory compliance. Both overcrowding and poor environmental conditions, including cold and damp, have higher prevalence in the rented sector, particularly the privately rented sector. Occupants in private rented accommodation also have less control over the physical environment to improve conditions.

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QUESTION 2: How could we use EPC and EHCS data sets to better assess environmental risk factors? What other data sources exist that could be used to refine this model (e.g. sources of data on housing provided by employers, landlords and organisations)?

- Datasets such as Energy Performance Certificates (EPCs) and English House Condition Survey (EHCS) can give indications of the physical properties of the home, including location, size, built form, designed construction, heating and ventilation provision. However, performance gaps (differences between intended and actual performance) in construction are common and so EPCs will not necessarily present an accurate record of actual construction or conditions within homes. Using the EPC rating as a proxy/indicator for environmental performance is not recommended and extracting construction details from these datasets offers a more robust approach.

- EPC data does not contain information about occupancy, but other data (EHS, ONS) provide more detail on occupants and behaviour. It is possible to link datasets through the Unique Property Reference Number (UPRN), however there could be problems with data mismatch as outlined in the accompanying paper. The paper outlines an integrated model combining multiple datasets that could be used for analysing environmental risk factors and recorded COVID-19 clusters (EPC, EHS, ONS, AURN, PHE)?
- There are other potential datasets (landlords, smart meter data, building survey data, insurance data) but these exist in proprietary formats and may be protected through GDPR.
- There is very little measured data on actual indoor conditions in housing that evidences ventilation rates, indoor air quality and occupancy patterns and behaviours, and studies tend to be small scale and use varying methodologies. There may be data existing through environmental monitoring and smart home devices, but this is not readily accessible.

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QUESTION 3: What do we know about how transmission is happening in households, and does it vary geographically, with housing type, with demographics, with cultural practices?

- There is a lack of data on the characteristics of housing environments for people with COVID-19 and the routes of transmission and role of specific environmental, demographic and social factors are not known. Household data is not routinely collected at the point of testing and is required to understand how transmission is happening in households. Since data on household transmission is currently limited any interpretations should be made with caution.
- COVID-19 mortality rates are linked to houses of multiple occupation, temporary accommodation, shortages of social housing and areas where overcrowding is more prevalent. Evidence on household transmission of other viruses, such as influenza or common colds, indicates mixed results of household characteristics such as crowding on transmission.
- There is some evidence of initial high case fatality rates in multi-generational households in several countries. Mortality rates are likely to be higher in households containing both people who are vulnerable to severe consequences of infection (due to age or co-morbidity) and people who are 'highly networked' and so likely to be exposed to infection outside the home. Highly networked households are those with large numbers of members residing under one roof, with large social, support and/or kinship networks.
- A review of existing evidence on ethnicity, household characteristics and transmission indicates there is no evidence of a relationship between household secondary attack rates and ethnicity. Given the current absence of evidence on household transmission, it should not be a first assumption that community types are a risk factor. Instead it may be helpful to use the category of 'highly networked households' and to examine these across community types.
- Environmental and social risks and mitigation challenges associated with different types of housing and households are further described in the responses to questions 1, 4 and 6.

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QUESTION 4: Are there specific risks for particular types of households (e.g. multigenerational, HMOs) or specific communities (e.g. BAME, low income)?

As webs of social relationships, households face external and internal risks of infection transmission.

- **External risk.** External risk of infection is likely to be greatest in highly networked households, characterised by a web of indispensable occupational, family and social relationships. Risk is

especially high in households with workers in frontline, keyworker or low paid work with high social connectivity and low potential for mitigating infection risk (for example, by home working, avoiding public transport).

- **Within household risk.** Transmission risks within the household depend on the physical vulnerabilities of members of the household; the organisation of domestic work such as cleaning and laundry; and the intimacy of interactions between various members of the household. Within households, people (usually women or paid domestic workers) who carry out the majority of exposing work are most at risk of transmission.
- **Socioeconomically deprived households.** Socioeconomically deprived households are most likely to be exposed to the environmental housing risks described above, particularly those living in local authority areas with high levels of barriers of access to housing services in the ONS multiple disadvantages index. They are also more likely to be employed in occupations with greater exposure risk, more likely to include a vulnerable household member (due to health inequalities) and less likely to be able to implement mitigation strategies outside and inside the home.
- **Houses of multiple occupation.** HMOs may be at high risk due to a combination of large household size, household members with different social networks, poor environmental conditions (including overcrowding), socio-economic disadvantage, and additionally the absence of a clear social script about how to carry out domestic work and manage interactions. There are sub-types that should be considered differently in terms of risks, mitigations and communications. For example, student housing, rented housing among migrant precarious workers and employee provided accommodation have different forms of: social relations, domestic labour and responsibility.
- In the absence of concrete evidence on household transmission of COVID-19 it is very important to proceed in ways that do not reinforce stigma and stereotypes of various types of 'risky' community or low-income households.

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QUESTION 5: What environmental and behavioural measures are known to be, or likely to be, effective to mitigate household transmission?

Improving housing quality and reducing density. Measures to reduce overcrowding in HMOs will reduce risk, and can be achieved through changes in tenancies, improved regulation and inspection of rented properties, and provision of alternative accommodation. Longer term, improved space and quality standards will reduce risk, both of COVID-19 but also for other health determinants and in future pandemics. Ensuring that sanitary provision (bathrooms, toilets and washing facilities) meets minimum standards and is well maintained will reduce risk. There needs to be more effective compliance with building regulations, in particular as-built performance standards. Regulatory standards need to account for occupancy demands and apply to existing buildings.

Improving ventilation. Improving ventilation rates can be achieved by ensuring that homes have satisfactory provision for extract and background ventilation, and that this is used effectively. For dwellings with mechanical ventilation systems, flow rates may be increased. Enhanced ventilation is required in homes with high levels of occupancy. There should be better advice and guidance to owners, landlords and occupants on the requirements and use of ventilation provision. This should be specific to the types of housing, occupancy profiles, ventilation provision and risk.

Use of sensors for indoor air quality and ventilation (for example CO₂ or IAQ sensors) may help to give occupants indications of poor ventilation and encourage use of ventilation systems. There is some limited evidence that use of appropriate air cleaning devices may be beneficial in some instances, particularly in high risk homes where other measures are not quickly achievable but does not replace other measures.

Whilst some short term measures may be implemented through better guidance, improving ventilation performance is a longer-term challenge. Current proposed regulatory change to Part F should develop improved ventilation standards and mechanisms to ensure compliance with these in use, whilst meeting other demands such as energy reduction, for example demand controlled ventilation and heat recovery ventilation. Improved standards for ventilation and enforcement of these, are required for existing buildings

Implementing environmental and behavioural mitigations (see Appendix for further details):

- Acceptability, feasibility and effectiveness of measures to mitigate transmission in other settings (e.g. isolation, 2m distancing, increased ventilation, handwashing and hygiene) will be affected by the nature of the home and household. In general, these will be harder to achieve for household members due to constraints of space and length of exposure, but may be useful for household visitors.
- There is some evidence that behaviours such as handwashing, surface cleaning and mask wearing in the home (when risk of infection very high) can reduce transmission of infection, including COVID-19. Well-designed interventions employing appropriate behaviour change techniques and developed with extensive user input to optimise accessibility and engagement can increase intentions to implement mitigation behaviours for COVID-19, and can increase infection control.
- In households with a high risk of transmission and substantial barriers to mitigations (especially self-isolation or quarantining) effective protection from transmission may only be achieved by providing accommodation outside the home. Modelling indicates that the impact of such policies on overall transmission rates in the UK is likely to be modest, given the risk of transmission before a household case is detected. Nevertheless, such a policy could decrease the number of deaths and hospital admissions if applied to high risk households containing clinically vulnerable people. Depending on the household circumstances and preferences this provision could be for highly exposed household member(s), contacts of positive cases or vulnerable household member(s).
- Across household structural types and groups at risk we recommend that the following are particularly targeted for communications, advice and support on mitigations and communications: socio-economically disadvantaged households, houses of multiple occupation, people vulnerable to severe consequences from COVID-19 (including older people, people with health conditions that put them at risk and people with disabilities), household members who provide care, child-care and cleaning, paid domestic workers.
- Communications should not stigmatise particular household or community types as 'risky' as this would be premature, divisive to the collective national effort of cooperating to combat COVID-19 and could contribute to social disorder.
- Communications will need to suggest that at times it is more important to be apart from the ones you love and care for in order to keep the whole family and broader community well. This will counteract the breaking of moral obligations to care among couples, kin and between generations that may make isolation and other measures seem 'unnatural.' These communications should also encourage those who do not usually do household work to take this up when the person who routinely does this is unwell.

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QUESTION 6: What barriers are there to delivery of the above mitigations (e.g. cost, feasibility, public acceptance, understanding of measures)? What are the potential solutions for addressing these barriers?

- Barriers to implementing mitigation behaviours in the home include limited awareness of the necessity and benefits, limited understanding of what needs to be done and how and concerns about restrictions on family life. These barriers can be partly overcome by co-design of behaviour change interventions and persuasive communications to increase motivation and skills for mitigation and acceptable and feasible strategies for reducing risk. Interventions should be developed for different household circumstances, including codes of conduct and 'social contracts' for occupants of HMOs.
- Communication-based interventions cannot address barriers such as the need to provide care for dependents, limitations of housing and lack of resources for or control over mitigation measures (including space, cost, time). These barriers are most common in low income households, which is likely to contribute to inequalities in transmission risk. The most effective way to protect these households is therefore to reduce their exposure to infection from activities outside the home, such as occupational and community exposure, and to ensure that vulnerable household members have good access to healthcare. Households with vulnerable member(s), high exposure and limited resources may benefit from practical support for self-isolating or quarantining within the home, such as support with shopping, pre-packed food to minimise shared time in the kitchen, provision of cleaning supplies, liaising with external organisations for wider support and anonymised helplines to respond to any concerns.
- Some mitigations may not be under the control of occupants, particularly tenants, such as the building fabric, ventilation systems, cleaning regimes, level of occupancy and availability of unoccupied space for social distancing or self-isolation. Where this is the case, guidance, regulation and enforcement will need to be directed at housing providers rather than occupants.
- Mitigation measures for ventilation will be harder to achieve and less acceptable during cold weather. These barriers are worse in thermally deficient housing and in fuel poor households and may have other unintended consequences such as damp and cold, so may require other support mechanisms.
- Offers of accommodation outside the home may be welcomed by some households with vulnerable member(s), high exposure and insufficient capacity to self-isolate but will only be taken up if essential needs are met, including ensuring that quarantining does not expose to higher infection risk and providing appropriate caring provision, necessities and facilities. It is essential that families are aware that quarantining outside the home is totally optional as many families will strongly prefer all members remaining in the home. Costs of provision may not be excessive since relatively few households will meet all the criteria for providing provision outside the home and also welcome such provision. However, such provision could potentially reduce health inequalities and be cost-effective if it prevents transmission to individuals from low income households at high risk of severe outcomes from COVID-19.

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QUESTION 7: What are the key research questions in relation to factors identified above?

What are the patterns of household transmission of COVID-19 in the UK, and what are the housing and household conditions of people who have COVID? What is the space provision, ventilation rates, IAQ and environmental conditions, are these sufficient, and how might they be improved? What are the patterns of occupancy, space usage and social networks? How are these affected by the physical provision and how do they vary across community types?

What is the relative impact on household viral levels and infection rates of adherence to the range of recommended behaviours (e.g. self-isolation, social distancing, handwashing, frequency of cleaning shared surfaces, ventilation, mask-wearing). Do CO₂ or other IAQ monitors provide a useful indicator of ventilation;

and how do these devices influence behaviour? What is the effectiveness of air cleaners in domestic environments?

What mitigation advice and communication strategies are acceptable and feasible for the wide variety of higher risk housing and households identified in this paper?

How are households connected with wider societal interactions? A household, like other institutional settings sits within its wider community. We need to understand how household members interact with the community, and how the clustering of contacts may affect transmission (do adults in a household work in similar or the same settings; say, healthcare workers, factory workers, students?)

Appendix: Overview of environmental and social risks, mitigations, barriers and facilitators

What is the risk?	What are potential mitigations?	What are barriers or facilitators of implementing these mitigations?
Crowded conditions (e.g. HMO, small accommodations, large numbers of occupants)	<p>a) self-isolation not possible b) unavoidable extensive sharing of spaces and facilities</p>	<p>Priority of reallocation of rented accommodation</p> <p>Identification/provision of accommodation outside the home for vulnerable or test positive member</p> <p>Education and support about increased ventilation, cleaning, mask-wearing when high risk</p> <p>Improved policy and regulation on space standards in new and existing rented housing, and support</p> <p>Other health support, such as flu vaccination</p>
Existing housing stock underperforms in ventilation, and may be unsafe in other ways (e.g. damp and mould, warmth) meaning that isolation and increased time in home may have both direct effects on SARS-CoV-2 transmission and iatrogenic effects in the development and exacerbation. Housing design that encourages open plan areas may also complicate self-isolation.	<p>Evolution and development in housing stock to ensure that new housing stock is of sufficient quality to avoid direct and indirect effects, and with sufficient space for self-isolation in the context of multiple occupancy households.</p> <p>This evolution should be informed by a multisectoral and multidisciplinary approach, from architects and building professionals to occupiers and health professionals.</p>	<p>This will require longer-term planning and is likely to be expensive for existing housing stock.</p> <p>Guidance and regulations will require differentiation between work and public environments and home environments.</p> <p>Regulation needs measurable and enforces performance-based standards.</p>
Deprivation and socio-economic position are strongly linked to substandard and suboptimal housing quality, generating inequalities in the direct effects of SARS-CoV-2 transmission and in the iatrogenic effects of quarantine and isolation.	<p>Targeted mitigations to improve specific housing conditions could include installation of features to improve air quality, warmth and heating efficiency, and ventilation.</p>	<p>Occupants of rented homes may have less control over their physical environment, particularly the ability to make changes or improvements. Housing tenure in particular is linked to socio-economic position, meaning that poorer households are more likely to experience lack of control over quality of housing and of ability and resources to undertake necessary improvements.</p>
Aerosols are increasingly recognised as a route for transmission of SARS-CoV-2, with increased risk in domestic environments.	<p>Increasing ventilation will dilute the virus and speed its removal from the environment. Domestic ventilation can be primarily natural (e.g. trickle vents and windows), primarily mechanical (e.g. continuous extract), or fully mechanical.</p>	<p>Current regulations relating to ventilation performance do not account for occupant density, form and orientation of the building, or internal air flows.</p> <p>In addition, there is evidence that current housing provision may</p>

		not be achieving adequate ventilation performance.
Bathrooms are important shared spaces that may create increased risks even with individual self-isolation due to many high contact points and some evidence of risks from defects in sanitary plumbing leading to cross-transmission in high-rise housing blocks. Bathrooms are also subject to the same concerns relating to ventilation. Bathrooms may also pose a challenge when individuals are self-isolating in multiple occupant households.	Enhanced cleaning, improved hygiene, closed toilet lids while flushing and attention to plumbing systems (e.g. not ignoring unexplained odours).	Economic status will also contribute to reduced space provision, for example more people sharing accommodation to reduce costs. As noted above, those living in suboptimal housing may have less control over their physical environment, particularly the ability to make changes or improvements. This relates as well to the link between socio-economic position and housing tenure.
Domestic activities such as cleaning and cooking require use of shared spaces, which (especially for kitchens) carry high potential for fomite transmission. Storage for waste is challenging in small kitchens. Shared spaces for domestic activities may also pose a challenge when individuals are self-isolating in multiple occupant households.	Enhanced cleaning, improved access to waste disposal, use of kitchen rotas	Ability to undertake NHS-prescribed mitigations relating to self-isolation are also challenged by the presence or absence of characteristics in the physical environment. For example, suggesting that individuals stay in separate rooms and use separate bathrooms requires space provision and multiple bathrooms, which may not be the case in multiple occupant households.
Multigenerational households lead to higher numbers of intergenerational contacts. This means bringing those who by reason of age are more vulnerable in contact with a range of people who may bring SARS-CoV-2 infections 'into the home', whether through occupational or other exposures. In addition, larger households are associated with increased likelihood of positive tests within household. Household overcrowding, not population overcrowding, is a driver of infection.	Encouraging multigenerational social distancing is key to protect vulnerable older adults, especially in the context of caring arrangements for young children and older adults. Reducing reliance on informal caring networks supports lone parent families who may otherwise rely on informal caring arrangements, possibly by increased access to childcare.	This may be seen to be 'unnatural' in the context of dense kin networks and established caring arrangements. Multigenerational distancing may be impossible for some lone parent families without access to childcare. Multigenerational distancing also requires access to space provision, which may not be the case Potential reinforcement of gendered inequalities through increased domestic and caring work to women.
Different family types may experience patterned risks for SARS-CoV-2, and within these household types specific groups may be at particular risk. Overall, highly networked households containing vulnerable people with	Mitigations should be aimed at supporting and encouraging isolation where needed, with particular focus on supporting access to services and support.	Resources needed to support distancing will be disproportionately required by families of lower socioeconomic position.

<p>workers in frontline, keyworker or low paid work will be most at risk.</p> <p>Within single occupancy and shared adult households, low income middle aged or older men working in highly networked or key worker occupations</p> <p>Within two-person households and nuclear families, women with unequal burdens of domestic work</p> <p>Within lone parent households, older parents in small rented low cost domestic spaces working in highly networked or key occupations</p> <p>Within multigenerational and extended multifamily households, elder relatives and women with unequal burdens of domestic work</p>	<p>Within single occupancy and shared adult households, mitigations should focus on support in securing essential food and medical supplies.</p> <p>Within lone parent households, mitigations should focus on supporting access to COVID-safe childcare.</p> <p>Within multigenerational and extended multifamily households, mitigations should focus on the specific vulnerabilities of older family members.</p>	
<p>Risk factors relevant across homes include interactions between susceptible and infected occupants, whether in quantity, time or transmission via aerosols, droplets or fomites.</p>	<p>Avoid non-essential within-home contact; ensure all household members adhere to test, trace, and isolate procedures; reduce shared time and increase cleaning and ventilation between uses of shared spaces; avoid sharing surfaces; provision of personal protective equipment (gloves, face masks, face shields)</p> <p>Offering accommodation for highly exposed/quarantining household member(s) or vulnerable household members to self-isolate could overcome challenges of limited space.</p> <p>Improved ventilation provision, better advice on ventilation, with focussed advice for specific housetypes and ventilation systems.</p> <p>Use of CO₂ sensors as indicators of ventilation</p>	<p>Implementation of mitigations may be challenged by emotional barriers, for example where mitigations interfere with family interaction.</p> <p>Practical obstacles, e.g. the need to provide care for dependents or lack of space in the home, may preclude successful implementation of mitigations.</p> <p>Cultural barriers to accepting accommodation for vulnerable household members may prevent self-isolation.</p> <p>Cost and access for installation/maintenance.</p> <p>Cost of production/knowledge of systems and provision</p>
<p>Heating/ventilation/cleaning facilities or regime substandard</p>	<p>Occupants may lack resources or authority to implement infection control</p>	<p>Require relevant authority (e.g. landlord) to take responsibility for ensuring adequate heating/ventilation/cleaning</p>

