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Highlights

- Updates a 2013 review on housing interventions, with stronger focus on overcrowding
- Includes both peer-reviewed and grey literature with resident and staff involvement
- Gives a broader overview to alleviate negative impacts if rehousing is not feasible
- While rehousing often reduced overcrowding, it did not always improve wellbeing
- Identifies 3 types of interventions: rehousing, home improvements, multisectoral

Interventions that could mitigate the adverse effects of household overcrowding on wellbeing: A rapid realist review with stakeholder participation from urban contexts in England

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Declaration of Interest

The authors have no competing interests to declare.

Abstract

Background: Household overcrowding has increased in England. However, there is limited synthesis of evidence about what can be done to reduce the impact of overcrowding on health/wellbeing.

Methods: A rapid realist review of English language peer-reviewed and grey literature of interventions from comparable settings to urban contexts in England that addressed household overcrowding/health outcomes. A search was conducted (01.06.23 and updated on 07.03.25) in MEDLINE, EMBASE, Web of Science, SCOPUS and of relevant grey literature sources. Two expert panels informed the review. The first comprised individuals with lived experience of overcrowding in London; the second local and regional government representatives from London, Salford and Doncaster (England). Both panels contributed to guide the scope/literature identification and test/refine programme theories. Final full-text screening and quality appraisal were completed by two independent researchers.

Results: Thirty peer-reviewed papers and 27 documents from participating local authorities were included. The peer-reviewed literature, from multiple countries and of variable study designs and quality, contained 14 evaluated interventions across three categories: Rehousing (n=6); Home improvements (n=6); Multisectoral collaboration (n=2). A synthesis of the peer-reviewed literature with expert panel comments and grey literature, identified contexts and mechanisms that could facilitate or hinder achievement of positive wellbeing outcomes. There was reluctance to be rehoused elsewhere and home improvements may alleviate the worst impacts of overcrowding, while residents may benefit from better healthcare co-ordination.

Conclusions: Other interventions such as home improvements and improved healthcare co-ordination/access could address wellbeing when residents in overcrowded accommodation cannot or do not wish to move.

Keywords: Housing; Overcrowding; Health/Wellbeing; Public Health; Rapid Realist Review

1. Introduction

The challenge of accommodating rising population numbers in urban areas with limited space is a common one and not a new phenomenon internationally.(1) However, measured against comparable

countries, England has larger numbers of residents per household.(2) Moreover, statistics for 2019/20 from the English Housing Survey revealed the highest levels of overcrowding in the country since 1995/96, with 8.7 percent of households in the social rented sector and 6.7 percent in the private rented sector being overcrowded.(3, 4) Regional variations were also confirmed in figures from the English Housing Survey (2019/20), with as many as 9.2 percent of London households overcrowded in comparison to 2.5 percent for England as a whole.(3, 4) There are pockets of overcrowding throughout England, with differences by ethnicity affecting those from a Black, Pakistani or Bangladeshi ethnicity in particular.(5)

There are different definitions to characterise a household as 'overcrowded' or 'crowded'. Generally it occurs when the number of residents exceeds the capacity of the dwelling space available, which may be measured variously depending on the geographical context through e.g. number of rooms, floorspace per person.(1) In the UK the 'bedroom standard' is commonly applied (although here regional variations also exist(6)). This standard assumes that certain household members need to have their own bedroom, while others according to their age and gender, can share.(7) There is a recognition that whether a household is 'crowded' as such may not invariably relate to the number of people residing in the dwelling, but also demographic characteristics such as age/gender constellations and their relationships (i.e. an otherwise 'crowded' household by quantitative measures, may not be so if for example two adults are a couple).(1)

As amply demonstrated in a relatively recent World Health Organization (WHO) review,(8) overcrowding can affect wellbeing in multiple ways. It often increases the risk of other housing issues such as environmental hazards (e.g. damp and mould, disrepair or clutter) and the risk for respiratory and gastrointestinal infections. Consequently in numbers from England, 40 percent of overcrowded households had reported significant mould in contrast to only 16 percent of non-overcrowded households.(9) Combined with other adverse housing circumstances, overcrowding can contribute to

poor physical and mental health, but also have wider socioeconomic ramifications such as poorer educational outcomes due for example to a lack of sleep.(8)

There is a lack of current evidence on interventions or measures that may reduce overcrowding or the adverse health outcomes associated with overcrowding. The last systematic review that explicitly addressed the effects of housing interventions on health by Thomson and colleagues (10) was published over 10 years ago. Moreover, its broader scopes – housing interventions in general – did not provide more in-depth coverage or isolation of effects that specifically concerned overcrowding *per se* compared to other and potentially non-overcrowding housing issues (due e.g. to poverty). Although a more recent systematic review on buildings and health(11) includes some recommended interventions, it is primarily concerned with and draws from the evidence base on the associations between buildings and health (i.e. not interventions), and again is not restricted to overcrowding.

The present review aimed to fill this research gap. To achieve this aim, we conducted a rapid realist review (RRR)(12) with participation of key stakeholders from urban contexts in England to identify peer-reviewed literature (including international if providing transferable lessons) as well as grey literature of local mechanisms by which interventions to address or mitigate household overcrowding on health/wellbeing may be effective. A realist approach helped gain a better understanding of which interventions may show promise in which circumstances, than would have been possible if concentrating on effectiveness alone for a complex issue such as housing overcrowding.(12)

2. Methods

PROSPERO was initially searched to verify that the proposed review may indeed fill a research gap and that there were no ongoing and/or significantly overlapping reviews on this topic. A protocol was then pre-registered on PROSPERO [Registration number anonymised for peer-review, but we have

uploaded a censored version of the protocol]. We undertook a rapid realist review (RRR),(12) influenced by RAMESES (Realist And MEta-narrative Evidence Syntheses: Evolving Standards) (13), see Additional file S1. Similar to a full realist review, an RRR provides a framework to collect and synthesise relevant and sufficient evidence on contexts/mechanisms/outcomes (CMO) to theorise how or why a group of interventions or single interventions could achieve their effects. An RRR specifically seeks to respond to time-sensitive and emerging policy issues, such as overcrowding where time/resources are more limited than permitted by a full realist review. It diverges from full realist reviews in two respects. Firstly, there is a shorter window for iteration or the possibility of adding further documents as one would typically see in a *full* realist review. Secondly, an integral part is the involvement of stakeholders to streamline the process.(12) Expert panels of stakeholders allow for the review to be guided to and oriented around key available literature, for conclusions to be co-developed and made more applicable to policy making.(12)

2.1 Stakeholder involvement

We convened expert panels of a) individuals with lived experience of household overcrowding according to our definition above (hereafter: 'residents') in London (comprising two separate panels in Tower Hamlets and Islington); and b) local and regional government representatives (hereafter: 'staff') across London (Greater London Authority, Tower Hamlets, Newham, Camden and Islington) and non-London authorities (Salford and Doncaster). Residents consisted of Tower Hamlets contacts that had participated in a similar project by [acronyms anonymised for peer-review] and from an Islington charity for ethnic minority women [name anonymised for peer-review]. The inclusion criteria for residents were that they must:

- live in either of our two focused London boroughs (Tower Hamlets or Islington);

- have had lived experience themselves or have supported residents who had experience of overcrowding (so can be self-defined given the importance of subjective experience for wellbeing, see e.g. (14));
- be parents or caregivers (given our original research focus on families).

Additionally, both groups of residents (in Tower Hamlets and Islington) consisted mainly of people from non-white English backgrounds, which were prioritised given their higher prevalence within overcrowding statistics and importance of research inclusion enabling us to engage seldom heard voices.(5) For the staff panels, local authorities with an expressed priority for housing problems were approached through our research team's professional networks. A representative from either public health with a remit for the built environment, wider determinants or from housing, was sought. The inclusion criteria for staff were that they must have exhibited:

- recognition of overcrowding as a local problem;
- experience of trying to address overcrowding in some way.

We also sought a diversity of experiences from different geographical areas (Doncaster and Salford in addition to London). We believe the involved authorities provided illustrative cases of overcrowding in urban contexts in England. In a 2018 analysis of London authorities and average occupied floorspace per person,(2) Tower Hamlets, Newham, Camden and Islington ranked lowest, second lowest, seventh lowest and eighth lowest, respectively (and the 2021 Census also suggested a higher overcrowding percentage in Newham and Tower Hamlets in particular(15)), while Salford and Doncaster are non-London contexts reportedly also challenged by overcrowding.(16, 17)

The stakeholder groups took part in two rounds of expert panels each. In the initial panels, we discussed the nature of overcrowding in the local context, as well as initial ideas and experiences of possible interventions, and any prioritised outcomes in their contexts. These discussions guided the review scope and provided any missing terms to our preliminary search strategy. In the second expert panels, categories of interventions identified from the literature, plus questions arising from

gaps or uncertainties in the literature, were shared for validation. We asked the panels how identified evidence resonated with the situation in their local contexts, whether the interventions might be relevant or transferable, if there were any mechanisms for making them work which they felt had not been covered and any contextual barriers that might compromise any observed effects/impacts. To facilitate the discussions, we shared materials such as summaries of literature in advance of all expert panel sessions where we had an email contact address (staff or community hosts). These materials were discussed live with panellists and we offered panellists the opportunity to share further comments afterwards (which were subsequently followed up on where recommended further documents were referred to).

Table 1 gives an overview of the organisation of the expert panel sessions. The staff panels (first on 19.04.23 (n=11 participants); second on 26.09.23 (n=7)) were facilitated as one-hour structured online discussions enabling national participation including non-London authorities. The residents' panels in Tower Hamlets (first on 16.05.23 (n=6 participants); second on 18.12.23 (n=5)) and in Islington (first on 24.05.23 (n=12), second on 08.01.24 (n=6)) were facilitated at local venues associated with the respective recruited community groups (see above). These in-person sessions were longer in duration to facilitate relationship building, familiarisation with the research and translation from non-English languages (e.g. Bengali): initially three hours each to accommodate for crucial background detail in conceptual review stages, while the second panels were two hours each specifically focused on findings and the identified intervention categories.

Please insert here Table 1: Expert panel sessions

Panel members were not considered research participants. The panel members were considered experts in overcrowding, either from a lived experience or policy perspective. Their input was sought to determine the direction of the research initially, then interpretation or contextualisation of the findings. Therefore, ethical approval was not required. This fits within the remit of a rapid realist review to help streamline the process of literature identification and validation,(12) but also more broadly

within established realist review frameworks to support, refute or contextualise the evidence base in the interest of theory development.(13)

However, panel members were still provided with full details including an information sheet on the purpose of the review and panels and they could withdraw at any time without providing any reason. Written consent was also obtained. A consent form was distributed to expert panellists prior to involving them in the project (see Additional file S2). The staff expert panellist consented to take part by email. We carefully explained the form and each item in person with the residents prior to them signing it and taking part (with translation to relevant non-English languages where needed from community hosts).

The consent form also included panel members' consent to be audio-recorded to enable researchers to focus on discussion, which in one case was denied, but permission was given to take notes. Data protection guidance was followed which meant no individual personal data were used from the recordings or stored afterwards, transcripts and audio recordings were securely destroyed after summaries were produced and circulated to panels. Thus, recordings and notes of panels were not subject to analysis of individual responses, and we do not report on any individualised experiences or sentiments, but only on views for which consensus was indicated by multiple voices that provided rationale for the review's focus or added to the contextualisation or interpretation of findings.

2.2 Search terms

We developed a search strategy with terms including both subject heading and free text terms, informed by a previous WHO-review(8) on the health impacts of overcrowding, as well as overcrowding definitions and categories of interventions from expert panel discussions. From the staff expert panels we added a stronger focus on (home) environment and 'congestion' and health, while from the resident expert panels green or play space, communication from housing authorities

and cultural strategies. The search strategy and combination of terms was developed in one database (Ovid MEDLINE) and amended as required for each database or websites, with a sample of the full strategy in Additional file S3.

2.3 Identification of peer reviewed international literature

Due to the complex nature and corresponding solutions to overcrowding, the electronic databases used for peer reviewed literature (MEDLINE, EMBASE, Web of Science, SCOPUS) accounted for multiple relevant disciplines (e.g. health, public services, social science, design, built environment). Searches were conducted by [acronyms anonymised for peer-review] on 01.06.23 (with an updated search following established recommendations for review updates (18) on 07.03.25 that revealed no additional relevant papers). Our searches captured literature from 01.06.12 and onwards, while any relevant peer reviewed literature on overcrowding before this date was carried forward from the previous Cochrane review.(10) Reference lists of published reviews captured were also checked, while tracing subsequent publication of data from any identified protocols and checking any ongoing reviews from PROSPERO. Where needing additional information on contexts and/or mechanisms related to peer reviewed interventions to populate context-mechanism-outcomes configurations (see 2.7 Data synthesis below), we further investigated reference lists of such papers and searched study names in Google Scholar to supplement with any 'sibling' records. Table 2 details eligibility criteria for inclusion/exclusion.

Studies were de-duplicated in Rayyan (Qatar Computing Research Institute) software, assessed on title and abstract by one reviewer [acronyms anonymised for peer-review] (with another [acronyms anonymised for peer-review] assessing 10% to discuss disagreements), while any potentially relevant studies underwent more detailed examination against the eligibility criteria on full-text by two independent reviewers [acronyms anonymised for peer-review]. They resolved all discrepancies

through discussion, but any unresolvable discrepancies would have been adjudicated by a third independent reviewer [acronyms anonymised for peer-review].

2.4 Identification of grey literature from participating UK authorities

Additional grey literature was searched by [acronyms anonymised for peer-review] focusing on participating UK authorities in which expert panel/potential knowledge users lived or worked. This included a targeted search using the same search strategy as in the other databases above, but restricted to the names of the participating local authorities in the grey literature database Healthcare Management Information Consortium (HMIC). In addition, websites of participating authorities were searches and we included local reports suggested by expert panel members. Specific grey literature from participating authorities were all checked for relevance on full-text using the same reported eligibility criteria as for peer reviewed literature in Table 2 (with any divergences reported in the table). To also correspond with the peer reviewed international literature search, we only included grey literature up until 01.06.23 to inform expert panel discussions. An updated sensitivity analysis search was further conducted by [acronyms anonymised for peer-review] on 07.03.25 in key authorities reporting significant overcrowding activity since our initial searches (i.e. Islington, Newham, Tower Hamlets). This revealed no complementary information to add anything new that would have altered our conclusions, so we have only included the grey literature from our initial search up until 01.06.23 for this reason.

Please insert here Table 2: Eligibility criteria

2.5 Data extraction

Data extraction using extraction forms (see descriptions used in Additional file S4) was completed by one reviewer [acronyms anonymised for peer-review] in Excel software and checked by another

(either a researcher [acronyms anonymised for peer-review] or for some local/regional documents expert panel members from these contexts checked). Data was extracted on key features within the review scope and on components considered important for a realist review such as study design, context (e.g. geographical setting, housing tenure, definition and level of overcrowding, populations affected/included), mechanisms/approach/aims and outcomes.

2.6 Relevance and rigour assessments

Following realist review standards,(13) the contribution of sections of data within a document was assessed based on two criteria: relevance and rigour. Relevance was determined based on the criterion of whether sections of text within a document were deemed to be relevant enough to contribute to theory testing and/or building,(13) with particular attention to our inclusion/exclusion criteria. For realist approaches, judgement of rigour may not include an appraisal tool.(13) In our endeavour to standardise assessments across reviewers of 'credibility' and 'trustworthiness' of sources,(13) for peer-reviewed literature, rigour was determined through the Mixed Methods Appraisal Tool (MMAT)(19) adapted to relevant study designs. This was used by two independent reviewers [acronyms anonymised for peer-review] with all discrepancies resolved through discussion, but if they had not been resolvable adjudicated by a third independent reviewer [acronyms anonymised for peer-review]. We tabulated all our final assessments as well as comment in the main text on whether there were any concerns based on the MMAT assessments related to individual studies. 'Incomplete outcome data' was a common criterion with ambiguous interpretation and required agreement on a threshold (we operated with 80 percent completion rate as threshold).

2.7 Data synthesis

In the protocol we pre-specified a consideration of meta-analyses, but there was little and heterogenous evidence available so in accordance with our protocol, we conducted a narrative synthesis(20) that examined emerging patterns around the contexts affecting potential mechanisms (as interventions, mediating factors and pathways) which in turn may lead to outcomes.

We grouped evaluated interventions from the peer-reviewed literature into categories. For each category, we constructed initial programme theories formed as CMO configurations, based on our reading of background literature and resident/policy maker engagement before the study took place. For each category, we started with peer-reviewed data to refine the CMO, using additional information from 'sibling' papers (see searches/screening sections) or the grey literature, and as checked against stakeholder consensus in the second 'validation' expert panels (see 2.1 Stakeholder involvement above), to understand the ways in which specific mechanisms of interventions may be implementable in urban contexts in England and any barriers to their success. For each of the intervention categories, we have generated and display figures of the CMO configurations including our initial programme theories and how these were supported or nuanced by insights from the literature (peer-reviewed and grey) and expert panels.

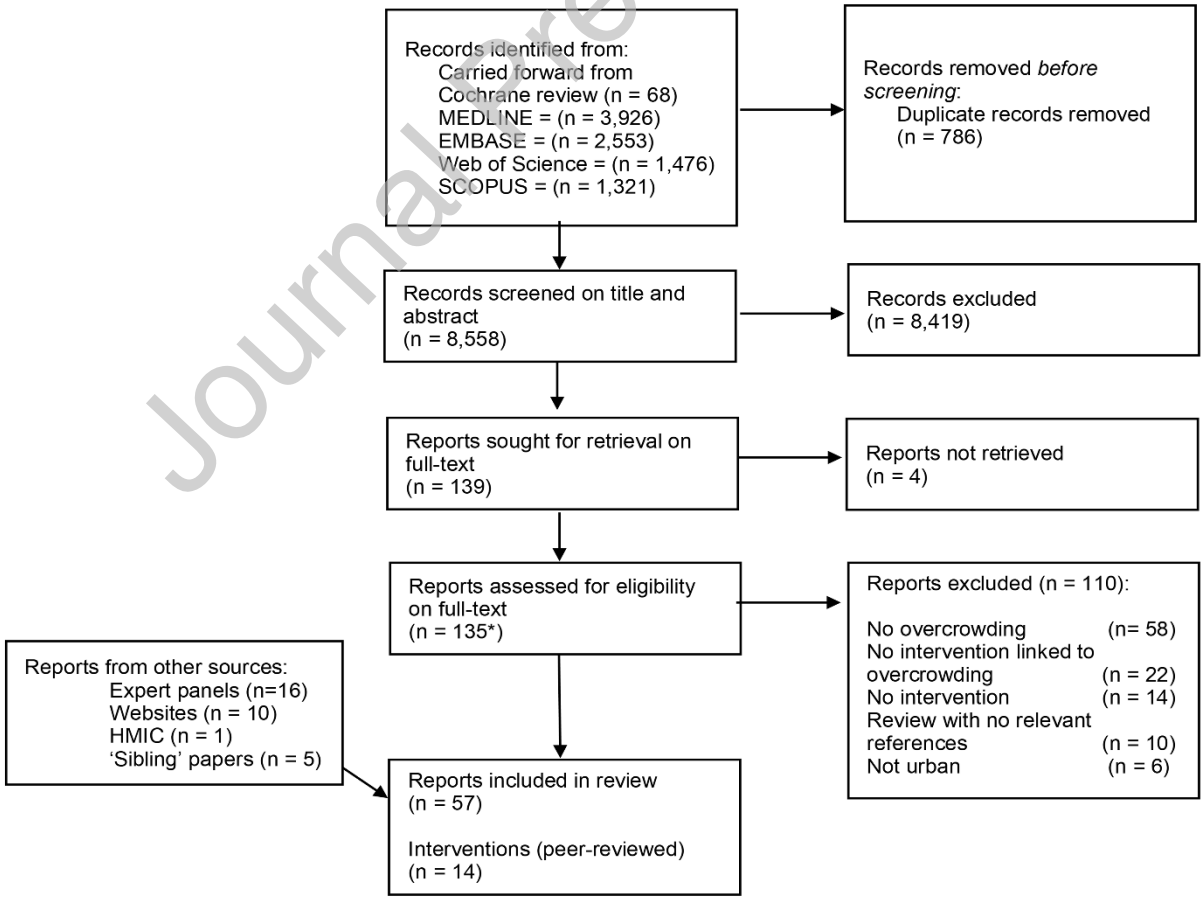
The sources of data to test and develop programme theories are of relatively different origins and, as such, in the main text we present the peer-reviewed literature, grey literature and expert panels in turn within each of the intervention categories. Keeping the narrative presentation distinct may facilitate a better understanding of how each information source contributed to the CMO configurations, and highlights limitations within the peer-reviewed literature in this field.

For the effect measures, we refer specifically to Table 3. We focus on effects from the peer-reviewed literature and not in the grey literature documents, because predominantly the latter consisted of reports of what local authorities had done without a corresponding evaluation evidencing the relative effects/impacts of outcomes as linked to specific interventions.

3. Results

The PRISMA flow diagram of searches and screening is shown in Fig 1. After duplicates were removed, 8,558 records were screened on title and abstract, with 139 of those identified as potentially relevant and requiring full-text screening (four of those could still not be retrieved following contact with authors). 110 records were excluded from the full-text stage. The most common exclusion reason was 'no overcrowding' (n=58) – either that the households reported on were not overcrowded, or with insufficient information to determine this (reasons for full-text exclusion of each individual reference are provided in Additional file S5).

Please insert here Fig 1: PRISMA flow diagram of searches and screening
Figure description: *One identified review(21) contained multiple irrelevant studies, apart from one cited primary study(22) which was included in our review instead



Thirty peer-reviewed reports were included (25 from the initial searches(22-46) supplemented by 5 'sibling' papers(47-51)), in addition to 27 grey literature documents(2, 5, 7, 9, 17, 52-73) related to the involved authorities (as either retrieved from the HMIC database (n=1), suggestions from expert panel members (n=16) or authorities' official websites (n=10)).

We centre the results below on the 14 evaluated interventions from the peer-reviewed literature – of which have also been supplemented by contextual information from the local authority grey literature and expert panels. The 14 interventions revolve around three categories: Rehousing (n=6 interventions(22, 31, 32, 36-41, 45-51); Home improvements (renovations/retrofitting) (n=6 interventions(24, 26, 30, 33, 43, 44)); Multisectoral collaborations (home improvements with health/social care and other coordination) (n=2 interventions(23, 25, 27-29, 34, 35, 42)) (see Table 3, with additional detail on how the grey literature mapped onto these categories in Table 4 and the extracted text of mechanisms from the grey literature documents in Additional file S6). Assessments on each MMAT criteria for the peer reviewed literature can be found in Additional file S7. To note that, informed by the first expert panels, we also searched but did not identify relevant literature on buy-back schemes, government promotions, or alleviation of overcrowding in HMO or hotel settings, as well as for health outcomes relating to COVID-19, the cost-of-living crisis or food insecurity.

Please insert here Table 3: Data extraction and summary of interventions (peer-reviewed literature)

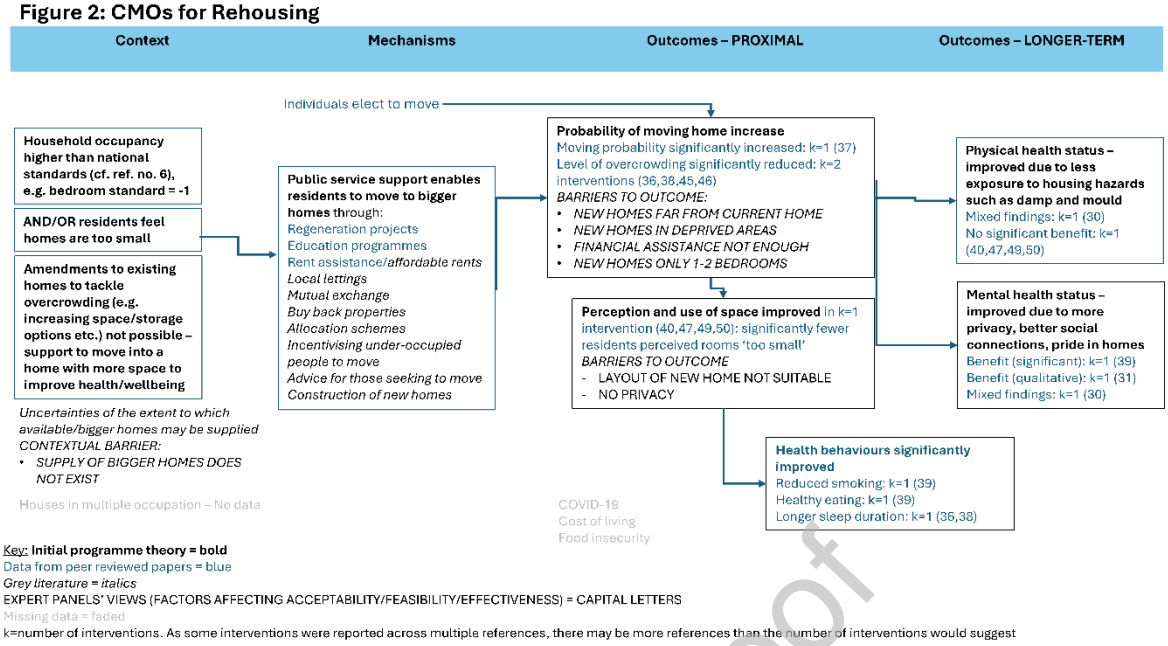
Please insert here Table 4: Local authority mechanisms (grey literature) mapped to the intervention categories

3.1 Rehousing

First, we tested/refined below the programme theory that people living in overcrowded housing (context) supported to move into a home with more space (mechanism) would no longer be exposed to an environment which harmed their health and wellbeing. As a result, their health and wellbeing would improve (outcome) (see Fig 2 for the CMO configuration).

Please insert here Fig 2: CMOs for Rehousing

Figure 2: CMOs for Rehousing



3.1.1 Peer-reviewed literature (n=6 interventions)

In the peer-reviewed literature, various interventions helped households to move out from overcrowded dwellings to (in theory) better quality dwellings, through regeneration projects (31, 32, 41, 48, 50, 51), provision of additional educational/behavioural programmes to integrate residents into new settings (40) and financial assistance to help with rent and housing costs (22, 36-39, 45-47, 49)).

Three of the six studies in this category are from the UK.(31, 32, 40, 41, 48, 50, 51) In the Scottish Housing Health and Regeneration Project's (SHARP) quantitative evaluation, there was a significant reduction in residents (by 10.8%) agreeing that their 'rooms are too small'.(41) Incomplete outcome data was a concern; however, overcrowding was reportedly reduced also in the qualitative interview evaluation(32) for this project – with no identified quality concerns – in which residents reported more space both inside and outside including gardens. Another interview study(31) with no quality concerns from Scotland (GoWell) showed a mix of reported outcomes across three themes: 'no perceived improvements'; 'perceived improvement in environment but not health'; 'perceived improvements to environments and health' (see Table 3 for details). In a mixed methods study from

Plymouth (England)(40) the quantitative evaluation showed significant improvements in mental wellbeing (mean difference= 1.22) and health behaviours such as healthy eating and reduced smoking (Wilcoxon two-tailed test, Z= −5.563) after one year in their new homes. In contrast to the SHARP project,(50) this intervention did not only consist of rehousing, but also of adequate follow-up of residents in their new dwellings with a behavioural programme of education and training to build skills to address housing issues.

There were three remaining non-UK interventions from USA, Norway and Spain, all of which provided financial assistance. The US federal rental assistance Section 8 programme was the most evaluated. It sought to help residents move from one unit to another of (in theory) better quality.(22, 36, 45-47) In the randomised controlled trial (RCT) component of a mixed methods study(46) with no detectable quality concerns, level of overcrowding was significantly reduced (by 48%). In a panel study(36) with some concerns of representativeness and intervention administration, and a cross-sectional study(22) with no similar concerns, there was a decrease in the number of persons per room, but this was only significant in the panel study(36) for 'overcrowded' households (Coefficient (standard error)= −0.0820 (0.0224)) and not so for those previously in 'severely overcrowded' conditions. For health outcomes, less 'cluttered' conditions were experienced by children with asthma in an RCT(45) (albeit it failed to blind outcome assessors to the intervention and did not retain significance), while the other RCT(46, 47) showed mixed findings and no conclusive evidence for child wellbeing.

Evaluation of the Norwegian welfare system, which provides a housing allowance to everyone who is entitled to it, focused on mobility patterns as the outcome, rather than impacts of the wellbeing of residents.(38) A controlled pre-post evaluation showed that the probability of moving homes significantly increased (by 14.3%), but that around half move into another situation of crowdedness rather than escaping it. Although no *detectable* concerns, there was a lack of information to make up an assessment on three of the five MMAT items. Finally, a non-governmental organisation in

Barcelona, Spain (Caritas Diocesana)(37, 39, 49) provided economic assistance as well as support from a social worker for families in substandard dwellings which included overcrowded conditions. The pre-post evaluation,(37, 39) affected by low sample size and loss to follow-up, showed significantly reduced overcrowding (by 16%) as well as better sleep duration (32.4% improved vs. 15.7% equal or worse).

3.1.2 Grey literature

Out of the 27 included grey literature documents, 24 provided information relevant for rehousing in England, helping us to understand the mechanisms by which public services have sought to help people to move (see Table 4). This revealed schemes such as e.g. local letting opportunities and mutual exchanges to support residents to move,(65) constructions of new homes(67) or buying back abandoned and poorly managed property from the Right-to-Buy scheme – which had allowed previous tenants to buy rented properties – to free these up for residents in need.(59, 69, 73) However, space constraints, particularly in dense urban environments such as inner-city London, were highlighted.(2) As such, rehousing within London was not always an option and either resulted in residents having to move elsewhere, being temporarily rehoused to hotel facilities, or waiting as long as decades on social housing registers.(9) Allocation schemes did not always reward enough 'points' to households to be prioritised for housing allocation, as their overcrowding was not seen as 'severe' enough or considered in the same imminent need as e.g. homeless people.(9) Alternatively, 'affordable' private rent schemes may not be within the price range of all households.(54) Some other schemes were therefore set up to move residents for example to seaside and country homes,(60) prioritising under-occupying residents in e.g. London that had more bedrooms available so that their move could free up sufficient space for overcrowded residents within the city. Although the majority of grey literature documents (k=17) discussed how to increase supply, there were also examples (k=4, see Table 4) of local authorities supplementing rehousing initiatives with support for

integration into the new setting. As such, although increasing supply/access to homes with more space might reduce overcrowding, to affect wellbeing, integration support might also be needed.

3.1.3 Expert panel validation

The staff panel concurred with caveats from the literature in reporting that proposed rehousing sites were often away from residents' communities and only some had been willing to move to these.

Members of the lived experience panel confirmed that more space in general was usually only available outside of London, with additional outdoor space being a specific need for children with neurological conditions such as autism. However, prospective rehousing sites were often in relatively socioeconomically deprived neighbourhoods and with a prospective break-up of their communities affecting both available support networks and their sense of belonging. A further concern was not only the location, but the actual dwellings they were rehoused to, with open plans offering insufficient room for privacy. Combined with this, they were frustrated by the fact they had to accept the offer immediately without having a chance to see inside dwellings first. There was a lack of tailoring to households' needs and inadequate accommodation for special needs prevented some households from moving in the first place.

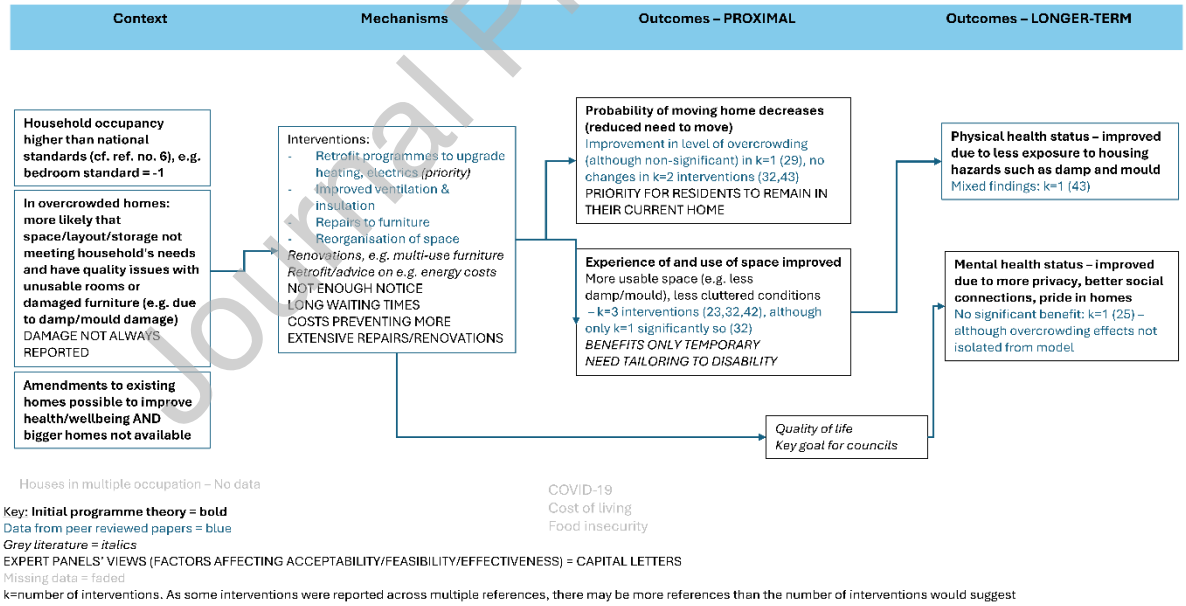
As such, the need for support for integration in a new setting was stressed. This may include focus on the wider environment of the new location, to ensure that this may not be counterproductive to the maintenance or new formation of key social networks (which are pivotal for mental wellbeing and a sense of belonging, as well as for informal childcare enabling parents to stay in work). With regard to the homes themselves, support may especially be needed towards residents' capacity (and adequate time provided) to plan and consider the right move according to their own circumstances.

3.2 Home improvements

Our initial programme theory proposed that in overcrowded homes it is more likely that the space/layout/storage fails to meet the household's needs and that quality issues affect dwellings including unusable rooms or damaged furniture (e.g. due to damp/mould damage, or other housing hazards such as rodent infestation) (context). Improvements to space (mechanisms) in residents' current dwelling or their surrounding environments – either quantitatively in actual physical space or qualitatively as experienced amount of available space – could offset the need to move elsewhere (proximal outcomes) and improve health/wellbeing (longer-term outcomes) by making the home environment safer and use of space better (proximal outcomes) and enabling households to carry out routine activities at home (see Fig 3 for the CMO configuration).

Please insert here Fig 3: CMOs for Home improvements

Figure 3: CMOs for Home improvements



3.2.1 Peer-reviewed literature (n=6 interventions)

Two home improvement interventions related to retrofitting, concentrating on upgrades to heating systems, ventilation, insulation, and electric efficiency to address functional issues such as dampness and mould;(33, 43) two related to renovations or re-organisation of space, repairs to or addition of

furniture to increase the qualitative amounts of usable space;(24, 44) and two combined retrofitting and renovations for general home improvements with overcrowding outcomes.(26, 30)

A longitudinal study from Scotland(33) retrofitted all rooms with a heating system with no significant differences in overcrowding, but improvements in useable space by addressing dampness in 11% of homes. Based on available information, the study fulfilled all MMAT criteria apart from incomplete outcome data. A controlled pre-post evaluation from Portugal(43) of thermal insulation (roof), full replacement of windows and improved ventilation evidenced a non-significant increase in the perception that the 'house has enough space', but only one MMAT criterion was fulfilled.

For renovations, a controlled pre-post evaluation from Sweden(44) of partial improvements to kitchens and bathrooms showed no significant differences in the level of overcrowding, while self-reported health of children showed signs of improvements in both the intervention and comparison area. However, the study did not fulfil any MMAT criteria. A theoretical postulation from China(24) – not fulfilling any MMAT criteria albeit with key information missing – proposed how design features can increase the sense of extension and fluidity of space to combat the experience of overcrowding. This could be important as children of different genders grow older, where e.g. a bathroom split up into sections (shower, sink, toilet) facilitates separation of intimate spaces.

A cross-sectional study from Scotland(26) combined renovation and retrofitting measures with reportedly no effects on overcrowding or wellbeing – albeit in this study less than half of the sample had received the home improvements. A repeated cross-sectional study over almost ten years of primarily Mexican migrants in USA,(30) also included a mixture of renovations (remodelling of rooms, improvements to the garden) and retrofitting (floor and roofing repairs to retain warmth). It demonstrated a non-significant reduction in overcrowding (although outcome data was incomplete) and reported no data on wellbeing.

3.2.2 Grey literature

Eleven out of the 27 included grey literature documents provided information on or revealed similar home improvement initiatives in England as those evaluated in the peer-reviewed literature (see Table 4). For example, for retrofitting local authorities recognised that quality of life depends on ventilation and heating,(63) while measures to combat damp and mould included informal advice to manage energy costs.(67) Renovation strategies included funding for space-saving furniture or multi-use home adaptations (e.g. to alleviate shared sleeping arrangements).(67) Trialling of innovative architectural practices was indicated,(63) with for instance moveable walls to roll rooms like the kitchen forward when needed and then back into space when not needed.

3.2.3 Expert panel validation

Both staff and residents expressed an interest in designs to generate homes that could be adapted as residents aged and developed according to changing needs, so that families did not have to keep moving. Staff also considered planning and implementing such solutions when designing new builds, rather than retrospectively as 'emergency solutions.' Despite such aspirations, it was expressed that local funding is an issue, so that smaller or traditional initiatives of retrofit and renovations that are already available, might be prioritised.

Home improvements were valued as potentially enabling residents to stay – the preferred option for most residents rather than having to move – with home improvements alleviating some of the worst impacts of overcrowding. Yet, an overriding feeling amongst residents was that although such interventions themselves were not the issue, how they were delivered, or not delivered, was a concern. Residents expressed that waiting times may be long, or conversely that they are not given enough notice for inspections. Residents may refrain from asking for improvements in the first place, as they may be anxious that they will be wrongly accused of being responsible for any issues.

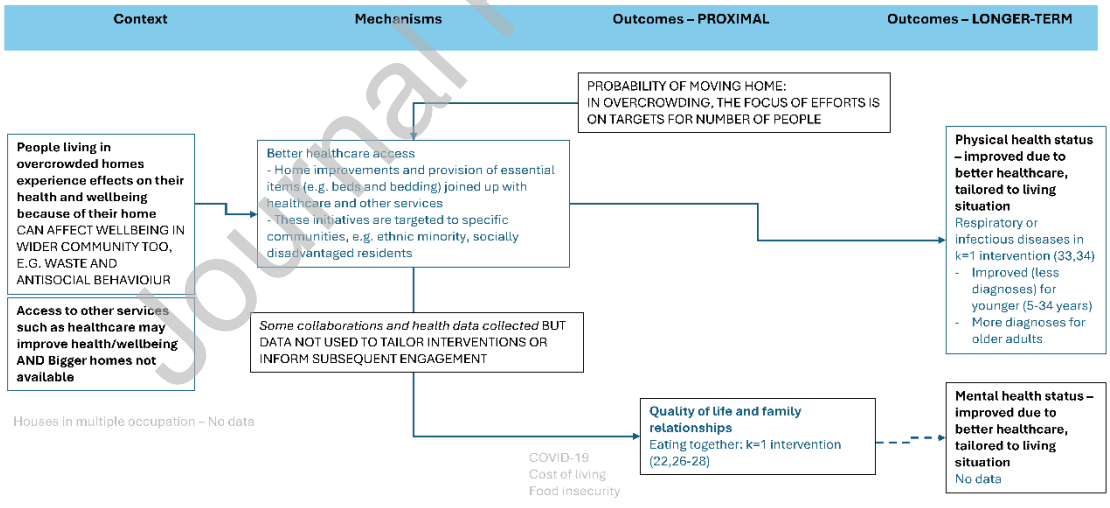
Consistent with findings from the literature, although minor repairs might help in the short term, they are only a temporary solution if e.g. damp/mould keeps coming back. Some home improvements failed to be adequately tailored, for example disabled residents needing specially designed toilets.

3.3 Multisectoral collaboration

Our initial programme theory was that the health of residents living in overcrowding may be affected (context). Residents' wellbeing may be improved (longer-term outcome) by better access to other services, such as healthcare, particularly when such services are tailored to consideration of the effects of overcrowding on wellbeing (mechanism) (see Fig 4 for the CMO configuration).

Please insert here Fig 4: CMOs for Multisectoral collaboration

Figure 4: CMOs for Multisectoral collaboration



Key: **Initial programme theory = bold**
Data from peer reviewed papers = blue
Grey literature = italics
EXPERT PANELS' VIEWS (FACTORS AFFECTING ACCEPTABILITY/FEASIBILITY/EFFECTIVENESS) = CAPITAL LETTERS
Missing data = faded
k=number of interventions. As some interventions were reported across multiple references, there may be more references than the number of interventions would suggest

3.3.1 Peer-reviewed literature (n=2 interventions)

Positive results were indicated by two programmes from New Zealand(23, 25, 27-29, 34, 35, 42) when home improvements were joined up with healthcare particularly for ethnic minority and socioeconomically disadvantaged residents.

The longest evaluation between 2001-2009 of the programme in Auckland(34, 35) – with no clear quality concerns – considered principal diagnosis of acute respiratory or infectious diseases including where "a strong causal link between the housing intervention and the illness could be postulated through reducing overcrowding" (p. 589).(35) The evaluation had mixed results depending on age. The programme aimed at improving conditions particularly for younger groups and had a significant reduction in respiratory diagnoses for those aged 5-34 years (Hazard Ratio (95% confidence intervals) = 0.73 (0.58, 0.91)) and a non-significant reduction for those aged 0-4 years. However, there were increased diagnoses for those aged 35 years or over. Qualitative interviews with no quality concerns,(23, 27-29) suggested better health overall, and stronger family connectedness such as eating dinner together.

A quantitative evaluation of a multisectoral programme in Wellington(42) was included, that aimed to deliver interventions and advocacy to improve health for residents. It focused on the identification and delivery of interventions rather than wellbeing outcomes resulting from them. It reported high levels of delivery of equipment such as beds and beddings (although had incomplete outcome data), but more problems with delivery of ventilation and delivery of any interventions in privately rented homes. Staff in qualitative interviews(25) with no detectable quality concerns expressed how a multisectoral team had a range and depth of advice and knowledge that could be tailored to what the family needed. Moreover they observed that provision of equipment -– heaters, bedding, draught-stoppers, draught-tape and mould-cleaning kits – made an immediate difference to people's housing environment. They also raised challenges, including landlords' unwillingness to improve homes and residents' fear that advocacy on their behalf could result in reprisals.

3.3.2 Grey literature

Ten of the 27 included grey literature documents incorporated some recognition of multisectoral working, which could include recognition of the association between quality of housing and health and corresponding measures to mitigate adverse health impacts (see Table 4). This could e.g. be through acknowledging the health concerns related to more severe levels of overcrowding (not only with a focus on the household *per se*, but also around the wider community in terms of the potential accumulation of waste and anti-social behaviour(56)), as well as overcrowding definitions that prioritised residents with certain diagnoses in councils' allocation policies,(53) or in more integrated ways with the role of healthcare highlighted in strategic plans for the future.(69, 71) However, at the same time the grey literature pointed more towards the need to gain an understanding of the problem (i.e. through acknowledging links) than tangible actions that could be taken. This is reflected in Table 4, in which five documents incorporated examples of actual collaborations taking place, whereas six documents spoke more of *hypothetical* future scenarios or authorities' *suggestions* for improved collaborations.

3.3.3 Expert panel validation

Some staff noted they had a mandated task to reduce the number of people officially categorised as 'overcrowded' in their local authorities. This meant that initiatives that peer-reviewed literature suggest could improve health or wellbeing might not be considered if they did not change numbers living in overcrowding.

Residents expressed that councils might be aware of the impact on health. A lot of screening measures prevailed including councils collecting and using data for health and safety, according to residents, without listening to or following up with them. Further, residents felt that currently they

are not joined up sufficiently with healthcare services as they are either unsure of how systems work or may give up anyway as they feel they cannot book an appointment with the doctor when needed.

4. Discussion

4.1 Main findings

This rapid realist review of peer-reviewed and grey literature combined with resident and staff involvement, found three main types of interventions to support people in overcrowded housing: rehousing, home improvements and multisectoral approaches. While rehousing most consistently reduced levels of overcrowding, it did not always result in improvements to health and wellbeing. Most studies captured proximal impacts, including levels of overcrowding or perceptions of space, but fewer studies reported on health and wellbeing outcomes.

4.2 Comparison with previous research

This review updates the evidence base of the 2013 Cochrane review on housing interventions,(10) providing a stronger focus on overcrowding. In the Cochrane review many interventions of potential relevance to overcrowding focused on rehousing. This left some questions unaddressed about what can be done when residents cannot move. Our review adds to this while providing a broader overview including alternative mechanisms that may be available for councils to reduce overcrowding or alleviate its negative health impacts when rehousing is not an option. We acknowledge that a more recent and full realist review has been published on the topic of holistic housing renovations,(74) but this concerns adults in disadvantaged neighbourhoods more broadly than the specific issue of overcrowding. In fact, of the nine pathways to improved health that those

authors presented, only one mentioned addressing overcrowding as a subset of multiple actions to support the particular pathway of physical housing improvements combined with health referrals – and, as such, gives further validation to our key finding on healthcare co-ordination. Another relatively recent review (although not systematic or realist)(75) is also of relevance to the findings on how improved layout and space can have a positive impact on overcrowded children, in which this may provide private space to be alone and serve a protective wellbeing effect enabling children to regulate negative stimuli in the house due to overcrowding, such as stressful social interactions or noise. The importance of the home for children cannot in this sense be overestimated, with other literature highlighting that children often have less of a world outside the home than adults and may need private space to concentrate on schoolwork.(76, 77)

4.3 Limitations

There are some limitations. Firstly, time and resource constraints necessitated a 'rapid' review format. As this resulted in a shorter window for iteration or the possibility of adding further documents, the present review may not be as comprehensive as a *full* realist review. However, we conducted a comprehensive search in electronic databases similar to systematic review standards and benefited from key stakeholders pointing us to potentially missing literature, as well as further searching the grey literature on participating authorities' websites. 'Sibling' papers were then identified to provide any additional information on context and/or mechanisms related to interventions evaluated in the peer-reviewed literature. Another caveat is that some care should be taken in generalising to urban contexts in England in general. For example, practical considerations and the need to facilitate in-person events to enhance participation, necessitated restriction of the residents' expert panels to two councils within London. We do believe though that the expert panels and particularly accounting for residents' perspectives including of seldom heard voices of ethnic minority residents, may be considered a strength. Finally, although the grey literature directed us to

interventions implemented in participating contexts, and may suggest more evidence can be found in the grey compared to academic literature, these were typically not evaluated or as robustly evaluated as the peer-reviewed literature. Hence, the ways in which these have an impact or not, may not invariably be as certain despite the expert consultations and comparisons with similar evaluated interventions from the peer-reviewed (and occasionally international) literature.

4.4 Recommendations for research

A realist review format was deemed necessary, with studies lacking specific outcome measures for overcrowding and using multiple study designs of variable quality and across contexts. As such, the present review benefitted from complementary information from the grey literature and stakeholder groups – enhancing local relevance and the prospect of achieving intended impacts of interventions.

In light of this observation, we offer four research recommendations. Firstly, more research is needed into the effects on wellbeing of interventions that are not concerned with rehousing only, but also other alternatives that allow residents to stay in their current homes such as home improvements. Secondly, evaluations should incorporate consideration of both the intervention itself as well as its implementation, from residents' perspectives. This will help focus on a wider set of outcomes of importance to residents themselves and their qualitative amount of usable space, rather than merely through housing registers/metrics quantifying the numbers of people per rooms. Thirdly, findings need to be disaggregated by population groups. There were only a few examples of this, such as e.g. where home improvements combined with health and social care links appeared to have a stronger preventative effect in younger age groups with less prior exposure to overcrowding, when compared to older household members. Primary studies should therefore improve assessment of outcomes across multiple sociodemographic characteristics such as age and gender (etc.) and do so consistently across all intervention categories for comparison. Finally, the lack of evidence on some intervention categories suggested by the expert panels on buy-back schemes, government

promotions, or alleviation of overcrowding in HMO or hotel settings, as well as overall measurement of health outcomes across any intervention categories relating to recently prominent issues in the UK such as the COVID-19 pandemic, cost-of-living crisis or food insecurity, should also be explored. For example, further insights might be provided in the context of a relative absence of data in this review on temporary accommodation both as a cause of overcrowding and relocation to temporary accommodation as a potential strategy to addressing it.

4.5 Recommendations for policy/practice

This review focused on interventions that could be implemented at a local level in England. Our findings however also clearly demonstrate that local policy needs to be supported by national policy and needs to take into account local and national context. For example, staff described how councils need to balance limited resources to tackle overcrowding alongside other housing priorities such as shelter for a growing homeless population,(59) which may be tackled through national prioritisation of affordable housing supply (e.g. building of social housing).(78) However, a lack of or reduced funding over many years from central and more regional structures(66) have potentially worsened the 'housing crisis'. The accumulating challenges of post-pandemic recession, unemployment, increased living costs and rents, lack of discretionary housing payments and inappropriate benefit caps for those in need, as well as unfair evictions from the private rented market,(52) speak to the larger concerted effort needed to tackle broader socio-economic inequalities – probably far beyond investing in effective and relevant overcrowding measures alone.

We offer four recommendations for policy and practice available to councils in the short term. Firstly, a more explicit consideration can be made of health and wellbeing, beyond prevalence of overcrowding. Our review has suggested home improvement initiatives that may alleviate the worst impacts of overcrowding and improve family health and wellbeing whilst still being in overcrowded conditions. Secondly, overcrowding should be considered as a council-wide issue that may not be

tackled within the housing sector alone. Thirdly, the grey literature revealed that some of the evaluated interventions and mechanisms from the peer-reviewed literature are in place within local authorities – as such it may not be necessary to 're-invent the wheel' completely, but ensure these are more closely aligned to residents' needs (for example longer time to prepare for inspections or selection/move to any rehousing opportunities). To maximise opportunities (not just to reduce prevalence of overcrowding but also achieve improvements in wellbeing), this might include better signposting to organisations that support residents in their current or new environments. Finally, more accurate and ongoing communication is needed, such as regular status updates on residents' applications and available options to alleviate overcrowding in the immediate as well as the longer-term. Ensuring that residents experience communication and any messages as appropriate may necessitate further co-design of engagement campaigns with the affected communities themselves. As the evidence shows that ethnic minority people are disproportionately affected by overcrowding in urban contexts in England,(5) it is also pivotal that potential language barriers are addressed and sufficient translation services provided for non-English languages widely spoken within local communities.

5. Conclusions

Household overcrowding is a complex problem which is closely interconnected with other determinants of health. Strategies to address its effects on wellbeing do not lie solely with housing. The scarcity of robust evaluations in this field, and the multifaceted nature of the problem, mean that traditional systematic review methods and meta-analysis of the effects of interventions would not provide conclusive evidence to support policy decisions to address this problem. In contrast, we believe that the RRR approach with programme theory and CMO configurations has enabled us to make significant contributions to an important evidence gap. The combination of peer-reviewed and

grey literature, contextualised through expert panels, lent themselves well to teasing out the nuances of this complex and interconnected field to offer evidence based and up-to-date policy and practice recommendations in the context of a rapidly changing situation of overcrowding in urban England.

In particular, in this review we found that reducing the prevalence of overcrowding requires national level and long-term policy changes to increase the supply of affordable homes. Therefore, rehousing will not be a feasible solution in the short term for many residents living in overcrowded homes. Moreover, this review found that rehousing alone is not always the optimal solution for the wellbeing of residents in overcrowded homes. The review also suggested how other interventions such as home improvements and multisectoral working could improve wellbeing when residents in overcrowded accommodation cannot or do not wish to move.

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Table 1: Expert panel sessions

	Staff (online sessions)	**Tower Hamlets residents (in person)**	**Islington residents (in person)**
Round 1	19.04.23 (n=11 panellists)	16.05.23 (n=6 panellists)	24.05.23 (n=12 panellists)
Round 2	26.09.23 (n=7 panellists)	18.12.23 (n=5 panellists)	08.01.24 (n=6 panellists)

Round 1 = discussions of nature of overcrowding in local contexts, initial ideas and experiences of interventions and prioritised outcomes, guiding review scope and supplementing search strategy.

Round 2 = comments on identified literature, whether resonated with local contexts and relevance of interventions, mechanisms not covered and/or contextual barriers compromising effects/impacts.

Table 2: Eligibility criteria

Dimension	Included	Excluded
Population/type of residents	Families or residents in HMOs (house in multiple occupation)[a] in all physical house types that are static, inclusive of sheltered houses.	Residential care homes, mobile homes such as house boats or caravans used primarily for recreation, prisons/correctional facilities.
Setting	Peer reviewed: UK or comparable OECD/partner countries(79)) Grey literature: UK authorities participating in expert panels (Greater London Authority, Tower Hamlets, Newham, Camden, Islington, Salford, Doncaster).	Peer reviewed: Non-OECD/partner countries, circumstances of little transferable relevance such as rehousing from slums from the previous Cochrane review(10). Grey literature: Non-participating authorities (see inclusion)
Intervention/exposure	Strategies provided by an agency with an explicitly stated aim (wholly or partially) to address housing overcrowding and/or where it had an effect on overcrowding or residents' experience of it.	- A change of housing conditions due to other life events such as natural disasters; - *ad hoc* improvements if outside of a housing programme addressing overcrowding (such as housing redesign or decorations initiated by householders themselves); - minor repairs such as fixing of leaking pipes and broken windows; - standard fire or injury prevention measures; - modifications needed *irrespective* of overcrowding for e.g. mobility/medical reasons.
Comparator(s)/control	Assessment of outcomes before and after overcrowding interventions, comparable areas where certain interventions were not tried or different interventions were tried.	Comparator(s)/control may not be needed if the report only provided information on context(s) and/or mechanism(s) (and no outcomes as such) related to the relevant intervention(s).

Outcomes	If outcomes reported: - any direct measures of health or mental and physical illness as well as self-reported wellbeing and quality of life; - health service use[b]; - any impact upon overcrowding *per se*, i.e. changes to physical environment and/or residents' perceptions/experiences of environment as an output (e.g. changes to occupancy levels, space or use of space, satisfaction with dwelling)[c] - additional social and socio-economic outcomes if acting as potential determinants of health such as social inclusion/exclusion, education, employment measures, food insecurity[d] - Adverse effects were also included	If outcomes reported, we excluded reports were no outcomes directly measured or could act as potential determinants of health/wellbeing (as defined under inclusion).
Types of studies	Qualitative, quantitative and mixed-methods evaluations, as well as position papers, editorials or commentaries that did not report empirical results but that theorised (formally or informally) about the relative effects of particular strategies (may in realist reviews be used to fill evidential gaps).	Position papers, editorials or commentaries that did <u>*not*</u> theorise about the relative effects of particular strategies.
Publication type	Peer reviewed: Any report where it was indicated that it had been peer reviewed. Grey literature such as conference papers, policy documents, project initiation documents (etc.).	Peer reviewed: No indication that it had been peer reviewed as such. Grey literature: Book chapters or academic thesis records were excluded due to the retrieval time and costs and the rapid, resource-limited nature of the review.
Language	English	Non-English[e]

[a] HMOs were initially not included, but in consultation with the expert panels it was agreed to also include this population in addition to families.

[b] Health service use was originally not considered an included outcome, but due to the association with overcrowding and health conditions – which healthcare access may help alleviate(11) – it was also included.

[c] Housing condition outcomes considered as relevant to health as there is extensive literature that has demonstrated the association between housing conditions and various health outcomes (11).

[d] Food insecurity added following suggestion by expert panels.

[e] This restriction was applied due to the rapid format of the review while the focus on literature of relevance to the UK meant that although some relevant literature may have been available in non-English languages, it is likely that a significant proportion would have been reported primarily in English as such.

able 3: Data extraction and summary of interventions (peer-reviewed literature)

REHOUSING					
NTERVENTION LOCATION)	**OVERCROWDING DEFINITION (LEVEL)**	**AIMS/MECHANISMS**	**EVALUATION (DURATION)**	**SAMPLE**	**OUTCOMES (in bold) & RESULTS**
GoWell (Glasgow, cotland) (31)	'Inadequately sized homes' (7 interviewees reported living in overcrowded conditions – results connected to these residents)	Rehousing to nearby areas in newly built homes or recently refurbished to meet national standards	Qualitative interviews study (one year)	**N**=23 households **Age**=N/A **Gender**=N/A **Ethnicity**=N/A **Tenure**=Social housing	**'No perceived improvements'**= e.g. moved from high-rise flat with major damp to cottage flat with more localised damp problem. **'Perceived improvement in environment but not health'**= e.g. physical and psychosocial environment improved, but insufficient to alleviate longstanding anxiety & depression. **'Perceived improvements to environments & health'**= e.g. friends visited children without feeling unsafe & garden space for physical activity (play, gardening)
New Home, New You (Plymouth, ngland) (40)	N/A (N/A)	Rehousing followed by behavioural intervention of 'capability, opportunity and motivation' consisting of: (1) Education (information to improve capability); (2) Persuasion (motivational interviewing); (3) Incentivisation (e.g. fortnightly vegetable bag); (4) Training (cooking lessons to improve capability); (5) Enablement (access to resources/opportunities)	Mixed methods study (one year)	**N**=111 residents **Age**= Mean: 36.63 years **Gender**= Female: 68.5% **Ethnicity**= White British: 92.8% **Tenure**=Social housing	**Wilcoxon two-tailed test of HAY [How Are You?] quiz for health-related behaviours=** 12 months vs. baseline: Z= −5.563***** **Mean difference of the Short Warwick-Edinburgh Mental Well-being Scale=** 12 months vs. baseline: 1.22*****
					Residents' perspectives: feeling that new dwellings released residents from overcrowding in previous accommodation
cottish Housing Health and Regeneration Project Glasgow, cotland) (32, 41, 8, 50, 51)	Whether 'rooms too small' in residents' view (N/A)	Rehoused into newly developed general-purpose socially-rented home let with accompanying improvements in indoor conditions such as greater warmth, eradication of damp & more space	Quantitative pre/post study (2004-2005) (41, 48, 50, 51)	**N**=731 residents **Age**= Mean: 43.2 (intervention) **Gender**= Female: 76.9% **Ethnicity**= White: 97.9% **Tenure**=Mainly social housing	**Percentage difference that agreed that 'rooms too small'**= −10.8%* **P-value of changes in common symptoms=** Gain vs. no gain/loss in dwelling space: 0.13 **P-value of changes in wheezing=** Gain vs. no gain/loss in dwelling space: 0.14
			Qualitative interview study (2007-2008) (32)	**N**=22 households **Age**= Range: 30-70+ years **Gender**= Female: 86.4% **Ethnicity**=N/A **Tenure**=Mainly social housing	**Households' perspectives=** decrease of problems vs. previous accommodation, in addition to overcrowding including associated issues such as damp, surrounding anti-social behaviour & unsuitable conditions for health

REHOUSING (continued)					
NTERVENTION LOCATION)	**OVERCROWDING DEFINITION (LEVEL)**	**AIMS/MECHANISMS**	**EVALUATION (DURATION)**	**SAMPLE**	**OUTCOMES (in bold) & RESULTS**
ection 8 Housing Voucher (across he USA) (22, 36, 5-47)	Greater than 1 persons per room (3.74%),(36) less than 1 room per person in household (average size of household = 4),(46) 'rooms 'cluttered' (N/A),(45) number of persons per room undefined (N/A)(22)	US federal rental assistance to help residents move from one unit to another of (in theory) better quality. It involves residents receiving a certificate or housing voucher from an administering agency to be able to afford rent in a privately owned apartment, with the intervention providing a monthly subsidy covering the difference between the cost of rent & housing utilities (approximately 30% of residents' income) & what they can afford to pay	Mixed methods study including RCT (18 'quarters') (46, 47)	**N**=8,573 households **Age**= Mean: 30.7 years **Gender**= Female: 91.8% **Ethnicity**= Non-Hispanic White: 19.6%; Non-Hispanic Black: 49.8%; Hispanic: 21.4% **Tenure**=Majority rent (56.3%)	**Mean crowding reduction** vs. control= −48%***** **Intent-to-Treat impact on level of overcrowding** (unemployed heads)= −0.055 **Households' perspectives=** more living space, allowed some women to escape unhealthy relationships, with associated stress reductions. Mixed results on child wellbeing
			Quantitative (RCT) (1994-2002) (45)	**N**=3,537 residents **Age**= Range: 12-19 years **Gender**= Female: 50.1% **Ethnicity**= African American: 62.8%; Hispanic: 30.0% **Tenure**=Social & private housing	**Beta (standard error) of whether 'rooms cluttered' (in association with asthma)=** Total sample: −0.091 (0.199); Boys: −0.012 (0.282); Girls= −0.197 (0.237)
			Quantitative panel study (1997-2003) (36)	**N**=84,782 households **Age**=N/A **Gender**=N/A **Ethnicity**=N/A **Tenure**='Owned & rented'	**Coefficient (standard error) between voucher increase & people per room=** Total sample: −0.0081 (0.0028)*****; 'Overcrowded' = −0.0820 (0.0224)*****; 'Severely overcrowded' = −0.1603 (0.2369)
			Quantitative cross-sectional study (1996) (22)	**N**=102,003 households **Age**= Mean: 38.7 years **Gender**=N/A **Ethnicity**= 'Foreign-born': 54% **Tenure**=Private housing	**Mean Number of Persons Per Room=** Raw mean: 0.68; adjusted mean: 0.63 (compared to 0.70 for all low-income renters)
Norwegian Housing Allowance (38)	Living in one-room flat or housing with lower number of rooms (excluding kitchen & bathroom) than persons (11.4%)	Welfare entitlement calculated based on a 'gap formula' of income & housing expenses mirroring regional variations in housing costs as well as variations in the cost of good standard housing depending on the size of the households	Quantitative controlled pre/post study (2009-2010)	**N**=93,154 households **Age**= Mean (household head): 52.61 years **Gender**=N/A **Ethnicity**=N/A **Tenure**=Social & private renting	**Marginal effects of moving probability=** 14.3% higher vs. baseline***** NB: 50.8% who move out of a crowded situation also move into crowdedness
Spanish charity Assistance Caritas Diocesana Barcelona) (37, 9, 49)	More than one person per room (excluding toilets) but including members of other families (56.7%)	Assisted by a social worker & could receive economic/social assistance for families with housing affordability problems &/or in substandard dwellings	Quantitative pre-post study (one year)	**N**=140 households **Age**=Majority aged between 30 and 44 years **Gender**=Majority women **Ethnicity**= Foreign-born: 94.8% **Tenure**=Private rental	**Level of overcrowding=** 58% (pre) vs. 42% (post)***** **Bivariate associations between changes in overcrowding level & hours of sleep=** Improved: 32.4% vs. Equal or worse: 15.7%***** NB: No significant improvements in self-reported health; GHQ-36; migraine or frequent headaches; respiratory problems

HOME IMPROVEMENTS					
NTERVENTION LOCATION)	**OVERCROWDING DEFINITION (LEVEL)**	**AIMS/MECHANISMS**	**EVALUATION (DURATION)**	**SAMPLE**	**OUTCOMES (in bold) & RESULTS**
GoWell (Glasgow, cotland) (26)	People per room (max=5, mean=0.85, standard deviation=0.47)	Impact of five housing improvements: external/structural; security; warmth; internal; unspecified	Quantitative cross-sectional study (2005-2007)	**N**=3,738 residents **Age**=N/A **Gender**=N/A **Ethnicity**=N/A **Tenure**=Social housing	**Relationship people per room & perceived housing quality + psychosocial benefits**= Reportedly no effects (but overcrowding effects not isolated from model)
Heat with Rent Glasgow, cotland) (33)	N/A (21.7% overcrowded of initial sample of 254)	Installation in all rooms of controlled heating system responding to external temperature. Tenants paid a fixed sum incorporated into their rent. The scheme addressed both dampness and cold in dwellings & problems associated with budgeting & fuel poverty	Quantitative longitudinal study (one year)	**N**=132 residents **Age**= 0-4 years: 36% 5-11 years: 44% 12-15 years: 20% **Gender**=N/A **Ethnicity**=N/A **Tenure**=Social housing	**Level of overcrowding=** Intervention: 23.6% (pre) vs. 23.6% (post); Comparison: 15.6% (pre) vs. 18.2% (post) **Would not use rooms due to damp=** Intervention: 20.0% (pre) vs. 9.1% (post)*****; Comparison: 26.0% (pre) vs. 35.1% (post)
Housing sustainability, elf-help and Upgrading (Texas, JS) (30)	More than 2 persons/bedroom (N/A)	Title regularisation of informal housing, followed by self-help & formal market loans: 72% had major home improvements, 32% of remodelled one or more rooms, 26% & 25% with flooring & roofing improvements, respectively, & between 15% & 18% improvements to garden or parking area	Quantitative repeated cross-sectional study (2002-2011)	**N**=106 **Age**= Mean: 52.43 years **Gender**= Female: 73% **Ethnicity**= Mexican: 83% **Tenure**= Private (albeit regularising informal) housing	**Level of overcrowding=** 17 % (pre) vs. 7% (post)
Housing enovation roject (Malmö, weden) (44)	According to Swedish Statistical Agency corresponding to more than 2 inhabitants per bedroom (75%)	One neighbourhood affected by substandard housing & needed renovations (court-mandated partial repairs of kitchens & bathrooms), compared to neighbourhood not receiving similar renovations	Quantitative controlled pre/post study (2010-2012)	**N**=51 families with 127 children **Age**= Mean: 7.4 (intervention) **Gender**= Female: 47.8% **Ethnicity**= Swedish-born: 80% **Tenure**=Mainly social housing or subsidised rent	**Level of overcrowding=** Intervention: 75% (pre) vs. 80% (post); Comparison: 57% (pre) vs. 50% (post) **Self-reported positive health of children=** Intervention: 74% (pre) vs. 86% (post); Comparison: 78% (pre) vs. 80% (post)*****
Housing etrofitting roject (Porto, ortugal) (43)	Usable space as measured in survey item "house has enough space" (N/A)	Main upgrades of buildings on roof with thermal insulation added, windows with full replacement & ventilation with addition of dedicated devices such as mechanical extraction & self-regulating inlets	Quantitative controlled pre/post study (one year)	**N**=82 residents **Age**= Median: 57 years **Gender**= Female: 52.2% (intervention) **Ethnicity**=N/A **Tenure**=Social housing	**Post-intervention agreement only with statement that 'house has enough space'=** 88.9% (intervention) vs. 79.2% (comparison)
Optimisation Design for nterior Space Changchun City, China) (24)	Lack of indoor functional unit space as mainly concentrated in hall, kitchen, balcony & storage space (92%)	Partially open & overlap space to have more than one function, arranging furniture according to evolving needs & relationships; if area cannot be increased, insert partitions for use by multiple people while retaining privacy, adding corridor, door, window to create 'spatial loop' & feel same space from multiple perspectives (as if it was larger)	Theoretical (N/A)	**N**=100 households **Age**=N/A **Gender**=N/A **Ethnicity**=N/A **Tenure**= Private (small housing)	**Perception of space=** Postulate that proposed design features increase sense of extension & space fluidity

MULTISECTORAL COLLABORATION					
NTERVENTION LOCATION)	**OVERCROWDING DEFINITION (LEVEL)**	**AIMS/MECHANISMS**	**EVALUATION (DURATION)**	**SAMPLE**	**OUTCOMES (in bold) & RESULTS**
lealthy Housing Programme Auckland, New ealand) (23, 27-9, 34, 35)	New Zealand Census of Populations and Dwellings – bedrooms needed based on demographic composition (but house visits revealed that the tenancy data did not capture full extent of overcrowding & all households in catchment area therefore included)	Reduce risk of meningococcal disease & other conditions associated with crowding, broadened to other domains e.g. social importance of home, housekeeping skills, improving linkages & co-ordination with social & health services. Consisted of initial assessment visit by public health nurse, subsequent action plan developed, reviewed by community clinician & discussed with household members. Solutions ensured houses incorporated design elements critical to health. Consultation throughout process, with referral to health & social welfare agencies also facilitated	Quantitative case-control study (2001-2009) (34, 35)	**N**=9,736 residents **Age**=weighted in favour of younger age groups **Gender**=N/A **Ethnicity**=almost exclusively Pacific Islanders **Tenure**=Social housing	**Principal diagnosis of respiratory or infectious diseases (Hazard ratios, 95% CIs)**= Age 0-4 years: 0.88 (0.74, 1.05); Age 5-34 years: 0.73 (0.58, 0.91)*****; Age 35+ years: 1.31 (1.09, 1.56)*****
			Qualitative interview study (2000-2003) (23, 27-29)	**N**=30 households, 19 programme providers **Age**=N/A **Gender**=N/A **Ethnicity**=Pacific Islands & Maori people **Tenure**=Social housing	**Householders' perspectives**= feeling ownership & more control, more rooms as well as space to move facilitating harmonious interactions (e.g. less sibling rivalry) & better reported health as 'downstream effect'. **Providers' perspectives**= enhanced study spaces for children means education was re-prioritised, accommodating cultural needs
Vell Homes Wellington, New ealand) (25, 42)	Identified by assessor where average number of people sleeping in a room exceeded two (66.5% overcrowded in study population, compared to 5.1% in total New Zealand population)	Families referred to relevant outreach organisations meeting housing & health needs, who carried out home visits, supplied necessary items to help residents make best use of their space such as beds, heaters & draught-stoppers, while requesting landlords to make any repairs & improvements. Further assistance provided to register on wait-list for social housing, checked that the residents received sufficient welfare entitlements, other services e.g. ventilation & budgeting advice	Quantitative cross-sectional study (2015-2018) (42)	**N**=895 residents **Age**= <5 years: 56.6% 5-14 years: 22.9% 15-28 years: 10.3% **Gender**= Female: 55.8% **Ethnicity**= Māori: 43.9% Pacific people: 32.0% **Tenure**= Private rental: 40.4% Social housing: 47.3%	**Provision of bedding**= 96.1% **Provision of beds**= 83.3% **Delivered social housing relocation**= 11.1% of those with action attempted
			Qualitative interview study (N/A) (25)	**N**=21 programme providers **Age**=N/A **Gender**=N/A **Ethnicity**=N/A **Tenure**=Mainly residents assisted in private rental	**Providers' perspectives**= residents placed on social housing register, while in the meantime provision of beds & bedding, advice about heating & sleeping arrangements, may be protective. However lack of social housing meant many could not be rehoused, or experienced long waiting times – providers often had to manage expectations rather than be able to promise residents anything

***** = significant at p-value of 0.05; CIs = confidence intervals; GHQ = General Health Questionnaire; RCT = randomised controlled trial

NB: As most of the overcrowded samples from the literature were from lower socioeconomic backgrounds, the table does not include socioeconomic characteristics

Table 4: Local authority mechanisms (grey literature) mapped to the intervention categories

REHOUSING		
Mechanism category	**Specific mechanisms/example**	**Local authority documents featuring this mechanism**
Increasing supply	Build more, i.e. incentivise building and acquisition of homes	(5, 7, 9, 53, 66, 67)
	Acquire existing homes – e.g. returning 'Right-to-buy' homes to councils for rehousing purposes, seeking larger affordable homes for rehousing	(54, 59, 61, 64, 69, 72, 73)
	Convert buildings – new homes/flats generated within former non-housing/'unsuitable' building	(68, 69)
	Incentivising downsizing (of under-occupied homes) to free up space for overcrowded families	(9, 60, 64, 65, 67, 69)
	Facilitation of mutual exchanges, including translation for those on the list unable to exchange with others due to language barriers	(64, 65)
Reviewing priority for relocation/homes	Higher priority to those facing overcrowding	(58)
	Higher priority to those facing more severe overcrowding	(52, 55, 57, 70)
	Higher priority for those facing more severe overcrowding and who also have one other reasonable issue such as medical	(53)
Support for residents to relocate	Subsistence allowance and support throughout any move processes	(9, 67)
	Advice for residents seeking to be moved to more appropriate accommodation due to overcrowding	(65-67)
Other	Encourage affordable and social rent options	(7, 9, 61, 63)
	Encourage better quality and use of data to reduce overcrowding	(7, 9, 61, 62, 64)

HOME IMPROVEMENTS		
Renovation	Space standards implemented for new homes	(2, 68)
	New architectural practices and innovative approaches to address density within homes, e.g. multi-use functions, merging of rooms, etc.	(54, 63, 69, 73)
	Financial support for or provision of space saving furniture, additional storage space, etc.	(65, 67, 69)
Retrofitting	Financial support for or provision of adaptations that improve quality of homes, e.g. that address damp and mould	(69)
	Protection of residents from 'bad' landlords, including inadequate repairs	(52, 66)
	Residents encouraged to report any issues of damp and mould	(54)
	Information on energy utilisation and mould/damp prevention	(65, 67)
Renovation & retrofitting	Working with overcrowded households (including home visits) to find solutions in existing homes (potentially while waiting for a larger home)	(67, 71)
MULTISECTORAL COLLABORATION		
Actual collaboration taking place	Providing community platforms to discuss housing issues face-to-face through e.g. housing hubs, housing liaison officers, tenant and leaseholder forums, etc.	(52, 63, 64)
	Partnership work to best address overcrowding including liaison meetings e.g. with Adult Social Care, Health, Children's Services, etc.	(64)
	Mapping of and signposting to other (non-housing) services	(65, 69)
Suggestions for improved collaboration	Acknowledging links between community around (potential waste and anti-social behaviour) and housing	(56)

	Recommendation to join up with financial bodies to ensure additional payments to those struggling to pay housing costs	(9)
	Acknowledging links between health and housing (suggesting better collaboration with healthcare in particular)	(17, 55, 63, 66)

Declaration of interests

☒ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☐ The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: