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Understanding the mechanisms linking holistic housing renovations to health and well-being of adults in disadvantaged neighbourhoods: A realist review

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ABSTRACT

Holistic housing renovations combine physical housing improvements with social and socioeconomic interventions (e.g. referral to social services, debt counselling, involvement in decision-making, promoting social cohesion). This realist review aimed at understanding underlying mechanisms linking holistic housing renovations to health and well-being of adults in disadvantaged neighbourhoods. Following systematic and iterative searching, and relevance and quality appraisals, 18 scientific articles and reports were analysed. We identified three pathways via which physical housing improvements affect health, four pathways via which social and socioeconomic interventions affect health, and two pathways via which both reinforce each other in their health effects. Our findings are theoretically novel, relevant for those conducting holistic housing renovations, and point towards gaps in the literature.

1. Introduction

Large health inequalities exist between neighbourhoods with low and high levels of socioeconomic deprivation (Diez-Roux, 2007; Meijer et al., 2012; Diez Roux, 2016; Swope and Hernández, 2019). Although multiple, interrelated factors contribute to the explanation of these inequalities (Diez Roux, 2016), poorer housing conditions of those living in socioeconomically deprived areas are considered an important contributor (Swope and Hernández, 2019). Therefore, housing improvements (e.g. rehousing, refurbishment, energy efficiency measures) are high-potential mechanisms through which public investment can lead to health improvements of lower socioeconomic groups (Thomson et al., 2001; Thomson et al., 2009, 2013; Thomson and Thomas, 2015), specifically improvements in general health, respiratory health, and mental health (Thomson et al., 2013; Thomson and Thomas, 2015). Physical housing improvements can also increase perceptions of home quality, which contribute to feelings of status and control, resulting in psychosocial benefits (Clark and Kearns, 2012).

Not only built, but also social living environments are known to influence residents' health, especially in low-income public housing communities. Residents of these communities appear more reliant on local social support networks for maintaining their health compared to those living in more affluent areas (Hayward et al., 2015; Arthurson et al., 2016). Objectives of housing renovation policies have accordingly changed from solely improving the physical performance of houses to improvements in other life domains as well, for instance increasing social cohesion (Baek and Park, 2012). Also on a broader neighbourhood level, urban regeneration has changed from being solely physical to including socioeconomic regeneration, e.g. tackling social determinants of health (conditions in the environments where people live and work), such as employment, education, and social cohesion (Droomers et al., 2016; Jongeneel-Grimen et al., 2016), providing social and economic support (Barosio et al., 2016), or investing in social capital and community capacities (Ginsburg, 1999). Asset Based Community

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Development (ABCD) in neighbourhood renewal, which aims to empower communities by mapping community assets to mobilize for community building and connections, has shown to increase social capital and allow communities to support themselves (Bennett, 2017). Social housing organizations therefore increasingly take an integrated, holistic approach, which aims to improve physical housing conditions and social determinants of health in parallel (Bullen et al., 2008; Beck et al., 2010; Barosio et al., 2016; Den Broeder et al., 2018; Kearns and Mason, 2018).

Various authors have emphasized the need of evaluating holistic housing renovations (Ginsburg, 1999; Gruis et al., 2006; Mjörnell et al., 2014; Prochorskaite, 2015; Cleland et al., 2016; Glasgow Centre for Population Health, 2016; Jensen et al., 2018). Although several studies have looked into health effects of 'area-based' approaches, where urban regeneration includes both physical and social interventions to improve area-level health (e.g. Huxley et al., 2004; Kelaher et al., 2010; Jalaludin et al., 2012; Mehdipanah et al., 2013; Mehdipanah et al., 2014), little is known about the health effects of holistic 'resident-focused' approaches e.g. where social housing organizations combine physical housing renovations with social and socioeconomic interventions (described as 'social interventions' in the remainder of this paper for the purpose of readability) to improve residents' individual-level health (Egan et al., 2016). Further, there is little insight into underlying mechanisms via which holistic housing renovations could improve health and well-being of residents of disadvantaged neighbourhoods. Since improving health of residents of deprived neighbourhoods is a key policy objective of public health departments in many cities worldwide, it is important to better understand how holistic housing renovations can contribute to this.

To fill this gap, we conducted a realist review focusing on the health effects of holistic housing renovations combining physical housing improvements with social interventions to improve social determinants of health (e.g. financial situation, community involvement, empowerment). The specific purpose of this realist review is to better understand *what works for whom, in what circumstances, in what respects, and how/why*? (Pawson et al., 2005). The research question we aim to answer is: *What are the health effects of holistic housing renovations among adults living in deprived areas, and via which mechanisms are these effects produced?*

2. Methods

Realist reviews aim at synthesizing existing explanatory evidence for intervention effects into a program theory. The program theory links specific elements of an intervention or program to outcomes by specifying a diversity of potential underlying mechanisms. The realist review entails six steps (Pawson, 2006): 1) Formulate the review question; 2) Develop an initial program theory including a series of specific mechanisms; 3) Search for primary studies; 4) Select relevant studies and assess their quality; 5) Extract, analyse, and synthesize relevant results as described in the selected studies; and 6) Refine the mechanisms as presented in the initial program theory. In the Introduction, the first step of specifying the review question was addressed. Below, we report on the next steps. Our study is reported according to the RAMESES publication standards for realist reviews (Wong and Greenhalgh, 2013).

2.1. Developing the initial program theory

The initial program theory (IPT) was developed based on expert knowledge of the authors and their initial exploration of theoretical and empirical literature about how physical housing improvements and social interventions might impact on health. Relevant contextual factors, mechanisms, and outcomes were grouped, categorized and synthesized. The first (HEKvH) and last author (CBMK) regularly discussed key mechanisms reported in the literature to translate the insights into logically distinguishable pathways, which were adapted iteratively according to new information found. Inclusion criteria for the review (step 3) were refined in light of emerging data and resulted in additional mechanisms. Tables 1–3 describe the pathways of our IPT, including 'if-then-because' statements to clarify how Contexts, Mechanisms, and Outcomes fit together in a causal relationship (C-M-O configuration) (Pawson et al., 2005; Pawson, 2006; Wong and Westhorp, 2013).

2.2. Searching for primary studies

To refine and complement the IPT, we conducted a systematic and iterative search for primary evidence, i.e. studies that have evaluated health effects of holistic housing renovations, i.e. a combination of *physical housing improvements and social interventions*. Since the realist review approach is aimed at explanation (Pawson et al., 2005), quantitative, qualitative, grey, and peer-reviewed sources were all included. An experienced librarian (Bramer et al., 2017; Bramer et al., 2018; Bramer, 2019) developed comprehensive search strings (Appendix A) and performed the search in Web of Science, Embase, Medline and PsycINFO. Databases were searched from inception until March 23, 2021.

Additional search strategies applied were snowballing, backward and forward citation tracking, and searching for relevant primary studies included in existing reviews (for example, in reviews on broader area-based regeneration, we searched for primary studies on housing improvements and social interventions). Following realist review logic, we stopped additional searching when theoretical saturation was reached, i.e. when newly retrieved literature did not provide additional insights (Pawson et al., 2005; Rycroft-Malone et al., 2012; Wong and Westhorp, 2013).

2.3. Selecting relevant studies and assessing their quality

Studies were selected based on their *relevance* in contributing to the research question and their *quality/rigour*. Regarding relevance, inclusion criteria were: 1) focus on an intervention where physical housing improvements (which could also be: physical housing improvements as part of a broader urban or area-based regeneration program) are combined with social interventions mainly targeting residents (although social interventions with collective effects for areas were not excluded); 2) focus on any measure of health, for instance physical health outcomes (like mortality, cardiovascular diseases, respiratory health, overweight, self-reported health) or mental health (like depression, stress, self-reported mental health); 3) focus on adults (18+ years); 4) written in English. Regarding the social interventions, we included intervention(s) aimed at improving social determinants of health. We did not apply strict exclusion criteria with regard to these interventions, because they are all part of the paradigm shift from 'only' renovating physical parts of houses to a holistic approach of housing renovation. The 1712 retrieved titles and abstracts were screened independently by the first and last author. Abstracts selected by both authors were included for full-text reviewing. Abstracts selected by only one author were discussed to decide upon inclusion or exclusion. Full-text screening of the remaining 77 articles was performed by the first author, as well as reference checking. Reasons for exclusion were either practical (full text not available; no English) or based on relevance (no social intervention; no health focus; black box article thus no mechanisms identified; focus on a highly specific population). The last author examined all articles the first author included *and* randomly examined 30% of articles the first author excluded. In both cases, agreement between both authors was high. To illustrate, of the 30% of articles excluded by the first author that were also examined by the last author (n = 20), only two articles needed further discussion, after which these were excluded.

Regarding rigour, we developed two checklists, one for the quality assessment of qualitative studies, and one for quantitative studies (see Appendix B). We based these on existing checklists, selecting items from the STROBE statement (Von Elm et al., 2007) and Nagelhout et al.'s (2017) checklist. We focused on clear descriptions of elements like the

Table 1
Pathways related to *physical housing improvements*.

Pathway	Pathway number	Context (C)	Mechanism (M)	Outcome (O)
Positive *physical* health impacts of improved physical housing quality	1	Better insulation/energy efficiency/ heating (combined with appropriate ventilation) Especially when targeted at vulnerable individuals with poor health and living in poor housing Upgraded kitchen **Easier cleanable surfaces and materials** Increased size and useable space (due to either structural modifications or improved thermal comfort)	Improved thermal comfort and warmer, drier indoor environment; Less development of damp and mould Increased use of kitchen **Improved housekeeping behavior → reduced amounts of dust and mould** **Reduced mess** More effective use of house for leisure and study	Improved physical health: - improved self-rated health; - improved cardio-respiratory health; - less asthma symptoms; - less self-reported wheezing; - less days off school & work; - less visits to general practitioners; - less hospital admissions for respiratory conditions; - improved physical functioning; - fewer first diagnosis of heart disease or high blood pressure; - lower allergy burden Improved eating patterns **Improved respiratory health** Potential long term impact on determinant of health: education & employment outcomes
Pathway 1: If the house is better insulated or energy efficiency and/or heating is improved in combination with appropriate ventilation, then residents, especially vulnerable individuals with poor health and living in poor housing, may experience improved physical health because the thermal comfort in the house improves, the indoor environment is warmer and drier, and there is less development of damp and mould. Furthermore, if kitchens are upgraded, then residents may experience improved physical health because they make more use of the kitchen and improve their eating patterns. Also, increased size and useable space due to structural modifications or improved thermal comfort **may reduce the amount of mess made in communal areas** and in the long term potentially improve education and employment outcomes by more effective use of the house for leisure and study. **Lastly, easier cleanable surfaces and materials after renovation may improve housekeeping behaviour, which reduces amounts of dust and mould, improving poor respiratory health conditions.** References: (Breysse et al., no date; Critchley et al., 2004; Gilbertson et al., 2006a; Gilbertson et al., 2006b; Barton et al., 2007; Howden-Chapman et al., 2007; 2011; Petticrew et al., 2009; Thomson et al., 2009; 2013; Free et al., 2010; Hickman et al., 2011; Howden-Chapman and Chapman, 2012; Thomson and Thomas, 2015; Curl and Kearns, 2015; Egan et al., 2015; Maidment, 2016; Bray et al., 2017; Milner and Wilkinson, 2017; Poortinga et al., 2017; Rangiwhetu, Pierse and Howden-Chapman, 2017; Grey et al., 2017a; Grey et al., 2017b; Ige et al., 2018; Poortinga, 2019; Swope and Hernández, 2019; Fyfe et al., 2020; Sharpe et al., 2020; Underhill et al., 2020; Fisk, Singer and Chan, 2020)				
Positive *mental* health effects of improved physical housing quality	2	Improved thermal comfort; Increased size and useable space; Improved design; Upgraded kitchens/bathrooms; **Easier cleanable surfaces and materials;** New front doors; Fabric works	Less stress related to leakages/damp/ mould/allergy burden; Visual amenity benefits; Increased housing satisfaction & pride in house; **Improved housekeeping behavior;** Increased emotional security & feeling of being at ease in home; Increased privacy, improved within-household relationships & family functioning; Feelings of status & control; Safety & security benefits; Less social isolation (inviting more visitors); **Enhanced pride of place;** **Improved neighborhood identity;** **Community cohesion**	Improved mental health
Pathway 2: If physical housing quality is improved (e.g. improved thermal comfort, increased useable space, improved design of the house, upgraded kitchens/bathrooms, **easier cleanable surfaces and materials**, new front doors, fabric works) then residents might experience improved mental health. This is because their stress related to leakages, damp, mould, and allergy decreases, they experience more safety and security benefits, are more satisfied with and proud of their house, **improve their housekeeping behavior**, feel more emotionally secure and at ease in their home, experience increased privacy, and within-household relationships and family functioning improve, feelings of status and control increase, and social isolation diminishes because they invite more visitors to their house. **Furthermore, improved physical housing quality can enhance pride of place and improve neighborhood identity and community cohesion.** References: (Critchley et al., 2004; Gilbertson et al., 2006a; Gilbertson et al., 2006b; Barton et al., 2007; Thomson et al., 2009; 2013; Free et al., 2010; Hickman et al., 2011; Kearns et al., 2012; Bond et al., 2012; Clark and Kearns, 2012; Egan et al., 2015; 2013; Liddell and Guiney, 2015; Thomson and Thomas, 2015; Curl and Kearns, 2015; Curl et al., 2015; Arthurson, Levin and Ziersch, 2016; Maidment, 2016; Poortinga et al., 2017; 2018; Rangiwhetu, Pierse and Howden-Chapman, 2017; Grey et al., 2017a; Grey et al., 2017b; Ige et al., 2018; Poortinga, 2019; Swope and Hernández, 2019; Fisk, Singer and Chan, 2020; Sharpe et al., 2020)				
Negative physical and mental health effects of physical housing improvements	3	Environmental nuisances from construction work; Lack of involvement of residents in renewal process	Change & disruption; Increased stress & intense anxiety (not knowing what is going on); Lack of personal control/influence; High degree of disadvantage to be overcome and problems of balancing different obligations	Worsened physical and/or mental health
Pathway 3: If physical housing improvements involve environmental nuisances from construction work, or when residents are not involved in the renewal process, then residents might experience worsened physical and/or mental health. This is because regeneration introduces change and disruption into people's lives (which can be burdensome and stressful and produce negative psychosocial health outcomes) and it can cause stress and intense anxiety often associated with not knowing what is going on or being unable to have any personal control/influence. Additionally, having difficulties coping with the disruptive situation may also result from the high degree of disadvantage which is common among social housing residents (low income, unemployment, lack of social cohesion, other underlying social/economic problems). References: (Allen, 2000; Curtis, Cave and Coutts, 2002; Critchley et al., 2004; Gilbertson et al., 2006a; Bonnefoy, 2007; Hickman et al., 2011; Egan et al., 2015; Baeten et al., 2017; Grey et al., 2017a; Crawford and Sainsbury, 2017; Popay; Dahlgren & Whitehead in Kearns et al., 2020)				

Table 2
Pathways related to *social interventions*.

Pathway	Pathway number	Context (C)	Mechanism (M)	Outcome (O)
Positive mental health and well-being effects of improved assets *via individual level mechanisms*	4	Asset Based Community Development, mapping and building upon health-enhancing assets, resources, skills, and capacities already present in the community	Being active agent in own/families' life; Sense of control over one's life; Self-efficacy; Personal motivation; Social competence; Resistance; Skills; Commitment to learning; Positive values; Self-esteem; Sense of purpose; Positive reframing of personal identity	Improved mental health and well-being for individuals
Pathway 4: If an Asset Based Community Development approach is taken, residents may experience improved mental health and well-being *via individual level mechanisms.* This is because ABCD makes people active agents in their own/families' life, increases their sense of control over their lives and their self-efficacy, personal motivation, social competence, resistance, skills, commitment to learning, positive values, and self-esteem, gives them a sense of purpose, and positively reframes their personal identity. References: (Smith, Baugh Littejohns and Thompson, 2001; Foot and Hopkins, 2010; Shield, Graham and Taket, 2011; Marmot; Taylor & Repetti; Wilkinson; Egan et al. in Clark and Kearns, 2012; Foot, 2012; Cyril et al., 2015; Bennett, 2017; Heath, Rabinovich and Barreto, 2017; Blickem et al., 2018; Fong et al., 2019)				
Positive mental health and well-being effects of improved assets *via collective/community level mechanisms*	5	Asset Based Community Development, mapping and building upon health-enhancing assets, resources, skills, and capacities already present in the community and/or creating public spaces and improving community centers offering social services and programs Especially important for disadvantaged people, who are more reliant than others on support networks for maintenance of health and well-being	Connectedness; Social networks and relations; Social capital; Social cohesion; Social inclusion; Social solidarity; Reciprocity; Community engagement/ participation; Cooperative relationships within communities; Collective sense of empowerment; Sense of community pride & improved perceptions towards the neighborhood; Perceived safety & security; Community capacity; **Less/mitigated adverse impacts of neighborhood stressors**	Improved mental health and well-being for the community Improved mental health and well-being for individuals
Pathway 5: If an Asset Based Community Development approach is taken, this can improve mental health and well-being for individuals and communities *via collective/community level mechanisms*. This is because ABCD can increase connectedness, social networks and relations, social capital, social cohesion, social inclusion, social solidarity, reciprocity, community engagement/participation, and cooperative relationships within the community, create a collective sense of empowerment, community pride and improved perceptions towards the neighborhood, community capacity, and increase perceived safety and security. **Furthermore, this can in turn mitigate potential adverse impacts of other neighborhood stressors.** References: (Ginsburg, 1999; Smith, Baugh Littejohns and Thompson, 2001; Moobela et al., 2007; Egan et al., 2008; Foot and Hopkins, 2010; Milton et al., 2012; Foot, 2012; Jones et al., 2013; Stead, Arnott and Dempsey, 2013; Borrell et al., 2013; Lightfoot, Mccleary and Lum, 2014; Mehdipanah, Rodríguez-Sanz and Malmusi, 2014; Cyril et al., 2015; Arthurson, Levin and Ziersch, 2016; Henderson et al., 2016; Allik and Kearns, 2017; Heath, Rabinovich and Barreto, 2017; Bennett, 2017; Crawford and Sainsbury, 2017; Jin, Lee and Kim, 2018; Blickem et al., 2018; Den Broeder et al., 2018; Lewis et al., 2019; Xiao et al., 2020)				
Positive mental health effects of participatory bottom-up community-led regeneration via individual and community-level mechanisms	6	Residents/communities are truly involved, included, and consulted in decision-making; **Resident education, e.g. regarding the renovation process and technical elements of renovation changes/upgrades, how to use these, and potential health and cost implications**	Sense of control over one's life; Greater community satisfaction; Sense of community; Solidarity between community members; Reinforced neighborhood identity; Feelings of belonging in the community; Social capital; Social cohesion; Community empowerment; Community capacity **Increased knowledge of residents at these fronts → less confusion regarding the process + increased 'health software'**	Improved health and well-being Improved quality of life Increased happiness
Pathway 6: If residents/communities are truly involved, included, and consulted in decision-making, then their health and well-being, quality of life, and happiness may increase. This is because they experience control over their lives, greater satisfaction with the community, an increased sense of community and solidarity between community members, feelings of belonging to the community, and a reinforced neighborhood identity, and social capital, social cohesion, community empowerment, and community capacity increase. **Additionally, if residents are educated regarding the renovation process and technical elements of renovation changes/upgrades, how to use these, and their health and cost implications, this improves health and well-being because residents experience less confusion regarding the process and their 'health software' increases.**				

(*continued on next page*)

Table 2 (*continued*)

Pathway	Pathway number	Context (C)	Mechanism (M)	Outcome (O)
References: (Allen, 2000; Smith, Baugh Littejohns and Thompson, 2001; Parry et al., 2004; Gilbertson et al., 2006a; Milton et al., 2012; Cyril et al., 2015; Campbell & Jovchelovitch; Laverack in Arthurson, Levin and Ziersch, 2016; Glasgow Centre for Population Health, 2016; Grey et al., 2017a; Crawford and Sainsbury, 2017; Heath, Rabinovich and Barreto, 2017; Jin, Lee and Kim, 2018; Lewis et al., 2019; Swope and Hernández, 2019; Fong et al., 2019)				
Health effects of interventions addressing residents' *social and other needs* and/or referring them to appropriate (social, health care, financial, employment, housing) services and support	7	Social risk screening; Assessment of priority needs and interest in assistance; Referrals (made e.g. via care managers, social workers, community health workers, peer navigators or volunteers) to connect residents to relevant community resources/other appropriate services that address their needs; Increased patient-centeredness and personalization of care	Reduced resident needs; Reduced stress and anxiety related to social and other needs; Improved quality and effectiveness of care; Increased trust in providers and engagement in care;	Improved health
Pathway 7: If social risks are screened, priority needs and interest in assistance is assessed, referrals to the right services are made, and patient-centeredness and personalization of care is increased, then residents may experience improved health. This is because their needs and stress and anxiety related to those needs are reduced, quality and effectiveness of care are improved, and trust in providers and engagement in care increases. References: (Crawford and Sainsbury, 2017; Fichtenberg, Alley and Mistry, 2019; Gottlieb, DeSalvo and Adler, 2019)				

intervention, context, study design, participant selection and characteristics, methods, analysis, findings, limitations, and conclusions. All included studies were independently assessed by the first author (HEKvH) and one other co-author (CBMK, MPP, FJvL, MD, FB). A lot of agreement and no major differences were found between different assessors. Articles were excluded if both assessors agreed that insufficient information was available for multiple elements which seriously hindered a judgement of the study 's quality. This was the case for four policy briefs (Popkin et al., 2010, 2013; Popkin, 2013; Popkin and Davies, 2013) and one article (Cohen and Phillips, 1997).

Fig. 1 displays the search, screening and inclusion process in a flow diagram. A total of 18 studies were included, many of which identified via snowballing or citation tracking, which is not uncommon for realist reviews (Pawson, 2006).

2.4. Analysing and synthesizing relevant studies

Data/evidence from included studies was extracted, analysed and synthesized to refine the mechanisms as specified in the IPT. For all selected articles, the first author extracted information about where the study was conducted, its context, aims, results, and how these substantiated or refined the initial pathways and mechanisms. The last author carefully read a random selection of 50% of the included articles and assessed whether the evidence was used properly in the synthesis. The final synthesis was agreed upon by both authors. Results are synthesized narratively, and key characteristics of included studies are summarized in Table 4.

Table 3
Pathways related to a *combination of physical housing improvements and social interventions*.

Pathway	Pathway number	Context (C)	Mechanism (M)	Outcome (O)
Health effects of physical housing improvements and social interventions combined: the stress-buffering model	8	Physical housing improvement is combined with social renovation (i.e. involving residents in renewal process; providing help and support; ABCD). Especially important for disadvantaged people, who are more reliant than others on support networks for maintenance of health and well-being	Reduced renovation-related stress; Improved ability to handle the physical renovation	Less negative health effects associated with physical housing improvement (IPT4)
Pathway 8: If physical housing improvements are combined with social interventions, then residents will experience less negative health effects associated with physical renovation. This is because the social support buffers residents' renovation-related stress, improves their ability to handle the physical renovation, and reduces their degree of disadvantage to be overcome by providing them with help and support, improving their personal circumstances, involving them in the renewal process, and increasing their positive sense of self from ingroup membership via social identification with the neighborhood, which is a key protector of individual mental health in the context of neighborhood change or renewal. References: (Allen, 2000; Blackman and Harvey, 2001; Curtis, Cave and Coutts, 2002; Ziersch in Arthurson, Levin and Ziersch, 2016; Cleland et al., 2016; Grey et al., 2017a; Heath, Rabinovich and Barreto, 2017; Klijs et al., 2017; Fong et al., 2019; Swope and Hernández, 2019; Wen et al.; Cohen & Wills in Xiao et al., 2020)				
Health effects of physical housing improvements and social interventions combined: the wider determinants of health theory	9	Physical housing improvement is combined with social renovation (i.e. involving residents in renewal process; providing help and support; ABCD) Especially important for disadvantaged people, who are more reliant than others on support networks for maintenance of health and well-being	Simultaneous positive changes in multiple domains of life (housing, financial help, increased social capital, increased self-esteem); Reduced overall disadvantage to be overcome	Reinforced positive health effects Improved physical, mental and social health and well-being
Pathway 9: If physical housing improvements are combined with social interventions, then residents will experience improved physical, mental, and social health and well-being. This is because positive changes occur simultaneously in multiple domains of residents' lives (housing, financial help, increased social capital, increased self-esteem), reinforcing each other in their positive effects on health and reducing the overall disadvantage to be overcome. References: (Blackman and Harvey, 2001; Mullins, Western and Broadbent, 2001; Curtis, Cave and Coutts, 2002; Hickman et al., 2011; Egan et al., 2015; Arthurson, Levin and Ziersch, 2016; Cleland et al., 2016; Swope and Hernández, 2019; Dahlgren & Whitehead in Kearns et al., 2020)				

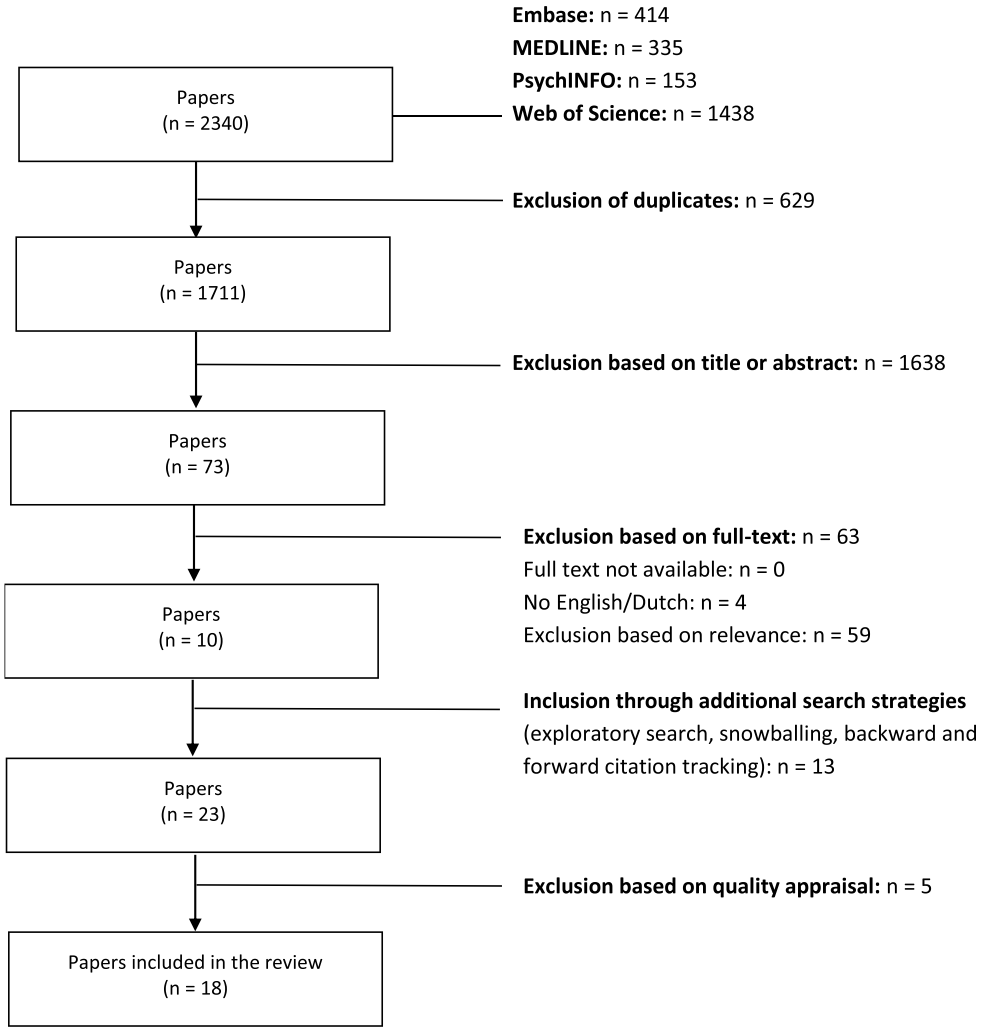

Fig. 1. Flow diagram representing the search, screening and inclusion process of the review.

3. Results

The initial pathways describing hypothesized mechanisms by which physical housing improvements and social interventions are expected to lead to health benefits among residents of deprived neighbourhoods are presented in Tables 1–3. Since specific theories on holistic housing renovations combining physical housing improvements with social interventions appeared to be scarce, we also included theories on how both intervention elements separately impact on health and well-being, since these provide important insights for their potential combined effects. Therefore, we described potential pathways via which physical housing improvements can impact on health (Table 1), via which social interventions may impact on health (Table 2), and potential pathways for their combined effects (Table 3).

The analysis and synthesis of relevant evidence substantiated and refined the initial mechanisms. In this results section, we shortly summarize each initially proposed pathway and narratively describe the evidence as retrieved from the systematic search. Overall, we mainly found evidence confirming initial pathways, and only identified a few *additional* mechanisms, which are displayed **in bold** in Tables 1–3 to distinguish them from initial pathways. Fig. 2 visually depicts a novel conceptual framework developed on the basis of our review findings.

*Social interventions consist of interventions targeting either social circumstances or socioeconomic conditions.

4. Pathway 1: positive *physical* health impacts of improved physical housing quality

Pathway 1 indicates that if the insulation, energy efficiency, heating and/or ventilation of a house is improved, residents may experience better physical health via mechanisms of improved thermal comfort, a warmer and drier indoor environment, and less development of damp and mould. Furthermore, when kitchens are upgraded, residents may experience improved physical health, because they make more use of the kitchen and improve the healthfulness of their eating patterns. Also, increased size and useable space due to structural modifications or improved thermal comfort may lead to more effective use of the house for leisure and study, which in the long term may improve physical health via improved education and employment outcomes.

Evidence/refinement: Several studies evaluating interventions where physical housing improvements and social interventions were combined confirm mechanism 1. Evaluations of the Healthy Housing Programme (HHP), which involves house modifications to reduce overcrowding, insulation and ventilation improvements, and health and social service assessments, referrals, and linkages, found that the housing improvements were associated with several direct physical health impacts: reduced acute hospitalization rates for 0–34 year olds, improvements in self-rated health and use of primary care, reductions in illnesses, particularly asthma and respiratory infections, and possible reductions in the use of secondary care (Clinton et al., 2005, 2006, 2007; Bullen et al., 2008; Baker et al., 2011; Jackson et al., 2011). The value of

Table 4
Included studies.

Author and year	City/Country	Intervention details (programme/context/elements)	Provides evidence/refinement for pathway …
Jalaludin et al. (2012)	Sydney, Australia	**Urban renewal program** consisting of: **internal upgrades** (including internal painting; replacement of kitchens, bathrooms and carpets; general maintenance), **external upgrades** (including property painting; new fencing, carports, letterboxes, concrete driveways, drainage and landscaping), **general external maintenance**, and **social interventions** such as community engagement activities, employment activities, and building a community meeting place.	5,9
Jackson et al. (2011)	South Auckland, New Zealand	**Healthy Housing Programme**: **house modifications; insulation and ventilation improvements; health and social service assessments, referrals and linkages.** Three related dimensions to the intervention: 1. **Health:** aimed at improving tenant access to healthcare services in order to improve health outcomes. 2. **Housing:** aimed at reducing the risk of housing related health issues, such as an extension to the house, a transfer to a larger home, housing design improvements or creation of healthy environments, including insulation and ventilation. 3. **Social:** a joint intervention that identified social or welfare issues and provided a link to the appropriate social service agencies.	1,7,9
Bullen et al. (2008)	Auckland, New Zealand	**Healthy Housing Programme:** improving the housing stock and better integrating housing, health and social services. The HHP focuses on families at high risk of infectious diseases, living in neighbourhoods with high levels of deprivation and high concentrations of public- and other low-income housing.	1,2,6,7,9
Kearns et al. (2020)	Glasgow, Scotland, United Kingdom	**GoWell programme. Area-regeneration programme** to bring about improvements to the housing stock in most areas, along with the demolition and redevelopment of several estates. 15 study areas divided into 5 Intervention Area Types: 1. Transformational Regeneration Areas 2. Local Regeneration Areas 3. Wider Surrounding Areas 4. Housing Improvement Areas 5. Peripheral Estates In both TRA and LRA, **housing and environmental improvements** were to be supplemented by **projects addressing other issues, including community engagement and cohesion, financial exclusion and advice, training and employment support, support for children and families, and health behaviours and wellbeing.**	2,3,5
Baker et al. (2011)	Auckland, New Zealand	**Healthy Housing Programme**	1,7,9
Clinton et al. (2005)	Auckland, New Zealand	**Healthy Housing Programme**	1,2,6,7
Clinton et al. (2006)	Auckland, New Zealand	**Healthy Housing Programme**	1,2,6,7
Clinton et al. (2007)	Auckland, New Zealand	**Healthy Housing Programme**	1,2,6,7
Baba et al. (2017)	Glasgow, United Kingdom	**GoWell programme.** 15 Glasgow neighbourhoods undergoing urban regeneration.	6
Beck et al. (2010)	Glasgow, Scotland, United Kingdom	**GoWell programme.** Housing-led regeneration in areas of Glasgow.	1,4,5,6,7,9
Kearns and Mason (2018)	Glasgow, Scotland, United Kingdom	**GoWell programme.** Area-based regeneration. Areas were to receive a mixture of **physical redevelopment** and **housing improvements,** alongside a variety of **neighborhood, social and personal-support interventions.**	2,6
Hernández et al. (2019)	California's Central Valley, United States	**Rental Assistance Demonstration program.** Improve and preserve affordable housing + resident outcomes. Major renovations + residents return to original residence after temporary relocation. Improved living conditions + resources to support human and social capital development (health and sustainability measures) + high degree of tenant protections and resident involvement. - **Improvements to building and unit quality**: upgrades to amenities, appliances, and interior finishes, including the installation of new unit dishwashers, and building washer/dryers, lighting, and recycling stations. Floors were replaced, and kitchen cabinets were also replaced or repainted in a light color. Three- and four-bedroom units were provided an additional bathroom. Structural upgrades were made to the roof, building envelope, landscaping (e.g., new irrigation system and trees), and existing mechanical, electrical and plumbing systems were replaced, including upgrades to the heating, ventilation and air conditioning systems. Energy efficiency gains were anticipated as a result of these appliance and structural changes. - Upgrades to recreational and common areas to accommodate more services, community organizations and gatherings, and other property management functions. Some examples included the expansion of an existing community building, new community centers, and new outdoor play areas and community gardens.	1,2,3,5,6
Aitken et al. (2017)	North Tyneside, United Kingdom	**Safe and Healthy Homes (SHH) service.** Information, advice, support, guidance to residents living in private rented or owner-occupied accommodation who have **housing issues affecting their physical or mental health**. SHH provides information or refers clients to public, private and voluntary services able to help resolve their issues through housing interventions. Focus on **housing issues**, but also information and referrals for **stop smoking, alcohol, drug, weight loss,**	1,2,7,9

(*continued on next page*)

Table 4 (*continued*)

Author and year	City/Country	Intervention details (programme/context/elements)	Provides evidence/refinement for pathway …
		physical activity and social isolation services (e.g. social care services to assist people suffering from social isolation to connect with local activity groups).	
Shortt and Rugkåsa (2007)	Armagh and Dungannon Health Action Zone, Northern Ireland	**'Home is where the heat is', fuel poverty program with dualistic approach:** - **improving energy efficiency of homes** (installation of central heating/improving insulation) - increasing household income by encouraging higher uptake of social security benefits/grants	1,2,9
Rugkåsa, Shortt & Boydell (2004)	Armagh and Dungannon Health Action Zone, Northern Ireland	**'Home is where the heat is', fuel poverty program** Community development model for tackling rural fuel poverty: full participation of local people and community groups	1,6,9
Allen (2000)	United Kingdom	**Estate Action:** Housing refurbishment (replacing doors & windows, rewiring, remodeling kitchen & bathroom, complete redecoration, and, where necessary, installing or replacing central heating), with promise of more involvement of tenants at all stages and enhancing quality of life including health and cultural and sports opportunities. Focus on impact of *renewal process* itself on health and well-being of the individual.	3,6
Kearns and Whitley (2020)	Glasgow, Scotland, United Kingdom	**GoWell programme.** Housing improvements and regeneration + tenant consultation and community empowerment/engagement (consultation about design and delivery of improvements). Focuses on relationship between feelings of empowerment/engagement and mental health and well-being in disadvantaged communities undergoing varying degrees of housing improvement and area regeneration (housing-focused and/or more holistic).	6
Pierse et al. (2020)	New Zealand	**Well Homes Initiative,** a home-based intervention to address housing-related ill health Targeted interventions using social partnerships. Housing assessments by trained community workers + range of housing interventions. Well Homes provides immediate and practical interventions, education, connection with social agencies/services, and advocacy for more substantial structural home improvements to help families keep their home warmer, drier, and healthier. Strength of this intervention is in engaging with families directly.	7,9

warm and dry housing is highlighted as an important pathway between physical housing improvements and improved health in several studies (Bullen et al., 2008; Beck et al., 2010; Aitken et al., 2017), specifically via reduced problems of condensation, mould and damp (Rugkåsa et al., 2004; Shortt and Rugkasa, 2007; Hernández et al., 2019). In the latter study, householders were more satisfied with the temperature of their homes, and both the incidence of arthritis or rheumatism and use of health services decreased after the intervention.

Regarding the size and useable space mechanism, evaluations of the HHP (Clinton et al., 2005, 2006, 2007) found improvements in older children's education due to increased space which enabled them to study without being disturbed as they could now have their own rooms and were happier to spend more time at home. We also found some evidence for increased use of the kitchen and improved eating patterns. A larger or more suitable kitchen led to more cooperative food preparation activities, enabling children to help out. With better housing circumstances some residents began to express agency over other dimensions of everyday health maintenance and appeared to be adopting healthier lifestyles and eating habits (Clinton et al., 2005, 2007).

The literature also provided additional mechanisms. Bullen et al. (2008) found a connection between housing improvements and domestic routines, such as improvements in housekeeping behaviour: increased space led to reduced amounts of mess made in communal areas, and upgraded surfaces and materials were considered easier to clean. Such behaviour in turn can lead to a cleaner house and reduced amounts of dust and mould, contributing to improved respiratory health.

5. Pathway 2: positive *mental* health effects of improved physical housing quality

When physical housing quality is improved (e.g. improved thermal comfort, increased useable space, improved design of the house, upgraded kitchens/bathrooms) residents may experience improved *mental* health. Stress related to leakages, damp, mould, or allergy decreases, residents experience safety and security benefits, are more satisfied with and proud of their house, feel more emotionally secure at home, and experience more privacy. Further, within-household relationships and family functioning improve, feelings of status and control increase, and social isolation diminishes because people invite more visitors to their house.

Evidence/refinement: Evaluations of the Healthy Housing Programme found the strongest connection between the programme and resident health was related to *mental* well-being, i.e. reduced stress, increased happiness, increased connection to family, and increased pride of the house; all of which were associated with tangible changes to the dwelling, e.g. additional bedrooms and bathrooms, structural modifications, improved thermal comfort, decreased dampness, and increased space (Clinton et al., 2005, 2006, 2007; Bullen et al., 2008). Tenants also noted increased sense of empowerment, improved self-esteem, and improved comfort in their homes resulting in improved family functioning and cohesion, leading to a heightened sense of social well-being (Clinton et al., 2005, 2006, 2007; Bullen et al., 2008; Jackson et al., 2011). Other studies showed similar results: housing and environmental improvements increased pride and enhanced self-perception and motivation (Beck et al., 2010; Hernández et al., 2019). Better living conditions improved mood and well-being including feelings of comfort, independence and security (Aitken et al., 2017). Residents felt personal progress as a result of improved housing: psychosocial benefits of an improved home, such as a sense of status and control, were associated with mental well-being, and housing or neighbourhood improvements can give people confidence and optimism which can even also stimulate employment (Kearns and Mason, 2018).

Further, the design, character and quality of housing seemed to influence the type of interactions occurring within families and neighbourhoods, which in turn influenced trust, safety and cohesion, and

created better communities (Clinton et al., 2005, 2006, 2007; Bullen et al., 2008; Beck et al., 2010). Multiple studies found increased useable space impacted on social functioning and familial relationships, for example by reducing sibling rivalry and tensions (Shortt and Rugkasa, 2007; Bullen et al., 2008). Housing improvement also reduced social isolation: families felt more comfortable welcoming others into their renovated homes, which was attributed to both increased pride in the house and an additional mechanism identified, i.e. improved ability to keep the home tidy (Bullen et al., 2008).

6. Pathway 3: negative physical and mental health effects of physical housing improvements

If physical housing improvements involve environmental nuisances from construction work (noise, stench), or when residents are not involved in the renewal process, this may lead to stress which may negatively impact physical and mental health. The stress and anxiety is often associated with not knowing what is going on and lack of any personal control/influence. The disruptive situation may be even more difficult to cope with for social housing residents due to their already high levels of disadvantage (e.g. financial scarcity, unemployment, lack of social support).

Evidence/refinement: Relatively few studies focused on or mentioned negative health effects of physical renovation. Two studies found that, even before actual refurbishment started, *anticipated* disruption and lack of control and information already made some residents feel stressed, anxious and depressed, and caused sleeplessness or physical symptoms (Allen, 2000; Kearns et al., 2020). In contrast, feeling well-informed about the renewal process was significantly associated with not experiencing adverse health effects (Allen, 2000).

7. Pathway 4: positive mental health and well-being effects of improved assets *via individual level mechanisms*

Whereas community development for a long time focused on communities' *problems, deficits, and needs* (Mathie and Cunningham, 2003; Foot and Hopkins, 2010; Lightfoot et al, 2014), ABCD builds upon individuals' *strengths* and community *assets* to develop the community and improve health or respond to ill-health (Foot and Hopkins, 2010; Foot, 2012). Residents may experience improved mental health and

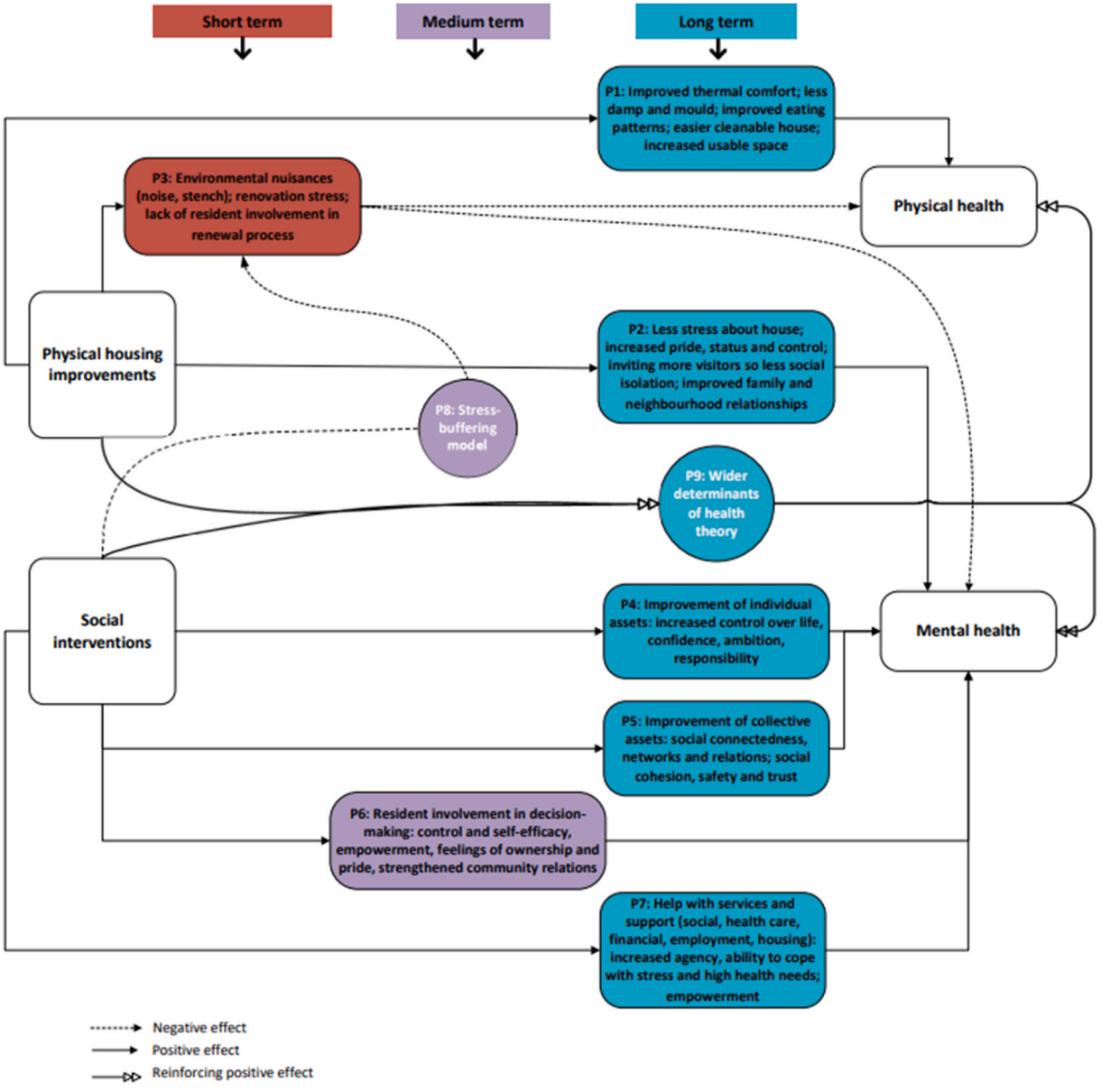

Fig. 2. Conceptual framework of the review findings, showing how holistic housing renovation impacts on health.

well-being at the individual level, because ABCD makes them active agents in their own/families' life, increases their sense of control, self-efficacy, personal motivation, social competence, resistance, skills, commitment to learning, positive values, self-esteem, and sense of purpose, and positively reframes their personal identity.

Evidence/refinement: Compared to the abundance of theoretical literature on ABCD detected in the exploratory search (Foot and Hopkins, 2010; Foot, 2012; e.g. Bennett, 2017; Blickem et al., 2018), we found little empirical evidence for Pathway 4 in evaluation studies. Beck et al.'s (2010) analysis of policy documents and interviews with key informants on links between regeneration elements and health, showed a desire for a more person-centred approach to renewal that increases people's confidence and raises their aspirations (Pathway 4), ultimately leading to greater social cohesion at the community level (Pathway 5). An individual regeneration approach was considered important because success depends on more than just community engagement and participation: many individuals in regeneration areas are so disempowered they need one-on-one help and stimulation to achieve greater confidence, higher aspirations, and more positive mental health, allowing them to take more responsibility for their choices. A more individual approach can empower people, encourage them into paid/voluntary work, and stimulate them to put their energies into the community (Beck et al., 2010).

8. Pathway 5: positive mental health and well-being effects of improved assets *via collective/community level mechanisms*

ABCD can also produce individual and collective mental health effects *via mechanisms and changes at the community level*. Examples of such community-level mechanisms that may lead to such positive mental health effects are increased connectedness, social networks and relations, social capital, social cohesion, social inclusion, social solidarity, reciprocity, community engagement/participation, cooperative relationships within the community, a collective sense of empowerment, community pride and improved perceptions towards the neighbourhood, community capacity, and increased perceptions of safety and security. Such mechanisms can emerge for example by improving shared spaces and community centres offering social services.

Evidence/refinement: Local services and shared spaces for community engagement and activities were crucial during renewal: community meeting places increased neighbourhood connectedness and contributed to mental and social well-being (Jalaludin et al., 2012). Community cohesion, trust and safety, which can be stimulated by community building and strengthening activities, proved important for mental health in regeneration areas (Kearns et al., 2020), and social regeneration fostered community spirit, trust and mutual cooperation (Beck et al., 2010).

An additional mechanism retrieved showed that strengthened neighbourhood social cohesion and relationships between residents could in turn mitigate potential adverse health impacts of other neighbourhood stressors (Browning et al., Donnelly et al. in Hernández et al., 2019).

9. Pathway 6: positive mental health effects of participatory bottom-up community-led regeneration via individual and community-level mechanisms

Participatory bottom-up community-led regeneration can be seen as social intervention, and means that residents are truly involved in decision-making concerning the housing renovation and considered as equal players. The involvement of residents distinguishes this pathway from pathway 3. It can increase residents' health, well-being, quality of life, and happiness via individual level mechanisms (via the experience of greater control and greater satisfaction with the community), as well as community level mechanisms, e.g. increased sense of community and solidarity, feelings of belonging to the community, reinforced neighbourhood identity, and increased social capital, social cohesion, community empowerment, and community capacity.

Evidence/refinement: Multiple studies highlighted control and self-efficacy as important mechanisms (Allen, 2000; Beck et al., 2010; Kearns and Mason, 2018). Whereas a perceived lack of control resulted in stress, worry and anxiety, feeling well-informed and empowered contributed to mental health and well-being and more positive attitudes towards housing providers (Allen, 2000; Baba et al., 2017; Kearns and Whitley, 2020). Opportunities to choose colours and fittings in their renovated homes enhanced residents' sense of identity, security, inclusion and empowerment, and fostered feelings of ownership and pride (Clinton et al., 2005, 2006, 2007; Bullen et al., 2008). Being kept informed, and being listened to improved well-being and mental health (Kearns and Whitley, 2020). Community participation through community representatives who were full and equal partners and took active part in decision making and agenda setting, increased social interaction and trust and strengthened community relations, which can also positively impact health (Rugkåsa et al., 2004).

One additional mechanism was retrieved from the literature: several studies showed a need for resident education both *pre-renovation*, to minimize confusion regarding the process and clarify challenging administrative aspects, and *post-renovation*, providing resident manuals, educational videos, and apartment walkthroughs to increase 'health software', i.e. knowledge of renovation changes e.g. regarding technical elements of certain upgrades, how to use these efficiently, and potential health and cost implications for residents (Rugkåsa et al., 2004; Clinton et al., 2007; Hernández et al., 2019).

10. Pathway 7: health effects of interventions addressing residents' *social and other needs* and/or referring them to appropriate (social, health care, financial, employment, housing) services and support

Another social intervention type are programs addressing residents' social and other needs, e.g. by referring them to appropriate services. If social risks are screened, priority needs and interest in assistance are assessed, referrals to the right services are made, and patient-centeredness and personalization of care is increased, this may lead residents to experience improved health because their needs, and related stress and anxiety, are reduced, quality and effectiveness of care are improved, and trust in providers and engagement in care increases.

Evidence/refinement: Multiple studies showed that social needs assessment for making referrals to the right services was important and positively contributed to resident health in a renovation context, for example by giving households a greater sense of agency in their lives and improving their ability to cope with stress and high health needs (Clinton et al., 2005, 2006, 2007; Bullen et al., 2008; Baker et al., 2011; Jackson et al., 2011; Rangiwhetu et al, 2017). Help from social workers establishing links with service providers and volunteer organizations and helping residents consider their options and obtain supports like unemployment benefits or public assistance, was important as residents most in need of support were often incapable of seeking services on their own (Aitken et al., 2017). Facework and trust allowed on-site social workers to establish relationships with residents and provide personalized care, functioning as an access point into a complex welfare system by navigating residents through a network of professionals, services and organizations (Aitken et al., 2017). Many people in regeneration areas are so disempowered they need one-on-one help, and therefore an individual approach to regeneration, where individual needs are assessed, was considered necessary in order to empower the most vulnerable people (Beck et al., 2010).

11. Pathway 8: health effects of physical housing improvements and social interventions combined: the stress-buffering model

Based on the stress-buffering model (e.g. Cohen & Wills in Xiao et al.,

2020) it is argued that if physical housing improvements and social interventions are combined, residents will experience less negative health effects associated with physical renovation (described in Pathway 3) because social support buffers their renovation-related stress, improves their ability to handle the physical renovation, and reduces their degree of disadvantage to be overcome. Residents are offered help and support, their personal circumstances improve, and they are involved in the renewal process. Also, social renovation increases residents' positive sense of self from ingroup membership via social identification with the neighbourhood, which is a key protector of individual mental health in the context of neighbourhood renewal.

Evidence/refinement: We did not find any studies that specifically tested or mentioned this hypothesis in the context of holistic housing renovation. However, considering the evidence described under pathways 3, 6, and 7, it seems likely that combining housing renovation with social interventions can alleviate negative health effects associated with physical renovation: social interventions that inform, engage, prepare, and support residents in various ways throughout the renewal process, both prior, during and after the actual physical renovation, can alleviate renewal-related stress, anxiety and worry. Also, one study mentioned that strengthened neighbourhood social cohesion and relationships between residents (which social regeneration can stimulate) could mitigate potential adverse impacts of other neighbourhood stressors (Browning et al., Donnelly et al. in Hernández et al., 2019).

12. Pathway 9: health effects of physical housing improvements and social interventions combined: the wider determinants of health theory

Based on the wider determinants of health theory (Curtis et al, 2002; Arthurson et al., 2016; Cleland et al., 2016; Dahlgren & Whitehead in Kearns et al., 2020), it is argued that if physical housing improvements and social interventions are combined, residents will experience improved physical, mental, and social health and well-being because positive changes occur simultaneously in multiple domains of residents' lives (e.g. improved housing, financial help, increased social capital, increased self-esteem), which can reinforce each other in their positive health effects and reduce overall disadvantage.

Evidence/refinement: Combining physical renovations (house modifications; insulation and ventilation improvements; internal and external upgrades) with social interventions (health and social service assessments, referrals and linkages; community development interventions) had additive effects that improved many aspects of families' lives and well-being (Bullen et al., 2008; Baker et al., 2011; Jackson et al., 2011; Jalaludin et al., 2012; Pierse et al., 2020). Various studies argued that multiple factors should be addressed simultaneously, because residents of neighbourhoods targeted for renewal often suffer from multiple deprivations: besides poor housing conditions, they often are also socially and economically deprived (Bullen et al., 2008; Beck et al., 2010; Jalaludin et al., 2012; Pierse et al., 2020). Studies indicated added or reinforced health effects following combinations of physical and social interventions. For example, combining energy efficiency interventions with efforts to increase household income by encouraging higher uptake of social security benefits, led to lower levels of fuel poverty and in turn benefitted residents' health: increased income enabled residents to heat their entire house instead of just one or two rooms, which increased their living space and improved their living conditions in a health-enhancing way (Rugkåsa et al., 2004; Shortt and Rugkasa, 2007).

Physical and social regeneration were found to reinforce each other in contributing to health and well-being. Physical improvements to the built environment were able to stimulate feelings of empowerment, but in turn, mental health gains were necessary precursors to physical ones, as participants' self-efficacy, confidence and coping behaviours enabled them to shape factors that in turn benefitted their physical health (Baba et al., 2017).

13. Discussion

This realist review examined underlying mechanisms via which holistic housing regeneration may affect the health of adults living in deprived areas. We found much evidence for the mechanisms in our program theory in studies that evaluated *only* physical housing improvements or *only* social interventions, as demonstrated in Tables 1–3 by the abundance of references from our exploratory search. Fewer studies actually evaluated a *combination* of physical renovation and social interventions. Furthermore, studies that did evaluate such combinations often only discussed separate effects of physical renovation and social interventions and hardly ever commented on additive health benefits of combining them or how the whole of 'holistic housing renovation' was more than the sum of its parts (Trickett et al., 2011; Rutter et al., 2017).

Nine pathways were identified. Seven pathways showed how either physical housing improvements *or* social interventions impact on health. Physical housing improvements can improve physical and mental health (less noise/odour nuisance, improved living environment, less stress, increased pride in the home) and social interventions can improve mental health (less stress due to increased control, higher empowerment, more social contacts, less financial problems). Further, two pathways showed how a combination of physical renovation and social interventions can have added or reinforced health effects. One, based on the stress-buffering model, argues that if physical renovation is combined with social interventions, residents will experience less stress and anxiety associated with the renovation. Social support and interventions that inform, engage, prepare, and support residents throughout renewal alleviate stress, worry, and anxiety associated with physical renovation. However, we did not find much empirical evidence for this pathway in evaluation studies, likely due to a lack of focus on the health of residents *during* the renovation process. The second pathway, based on the wider determinants of health theory, showed that health improvements are greater if improvements are made in multiple life domains simultaneously (additive effect), and that improvements in one domain can strengthen the positive effects in other life domains (reinforcing effect). Addressing vulnerable residents' socioeconomic and other needs while improving their housing conditions can reduce their overall disadvantage and reinforce health benefits.

This is the first study to systematically provide insight in the mechanisms underlying the health effects of holistic housing renovation. The realist approach chosen results in a rich synthesis which provides a greater theoretical understanding of the intervention process itself, rather than reporting whether an intervention is effective or not (Ogilvie et al., 2020). The findings are therefore transferable across a range of interventions and useful for logical, evidence-based development of effective interventions. Every pathway in our program theory allows an understanding of the causal relationships which make up the pathway. While different pathways exist independently from each other, it is reasonable that holistic housing renovations work best when C-M-O (Context – Mechanism – Outcome) configurations of various pathways are activated simultaneously. In other words, our program theory shows the various mechanisms via which physical housing renovation and social interventions can impact on health when implemented simultaneously.

A strength of our program theory is the differentiation between individual-level and community-level mechanisms. Further, our systematic search for literature not only substantiated and refined the mechanisms hypothesized in the initial program theory, but also complemented these with additional mechanisms.

13.1. Limitations of contemporary literature

Existing urban regeneration or area-based intervention studies often report health effects of broad, extensive interventions or programs, without paying attention to the underlying mechanisms causing these

effects. Studies lacking insight into underlying mechanisms explaining the health effects reported could not provide evidence for our pathways and were therefore excluded. Also, in included studies, a certain level of detail was often missing. A lack of detail in descriptions of interventions and participant information limited our ability to answer the 'what works *for whom*' part of the research question (Pawson, 2006). Some studies lacked clear descriptions of how health was measured and at which point in time, impeding us to draw more specific conclusions about the outcomes-component of C-M-O configurations. Further, the studies included were conducted in only four countries. While we believe that important mechanisms have been identified, it cannot be excluded that additional mechanisms exist. Thus, studies on the health impact of holistic renovations conducted in other countries are certainly needed. To gain insight into underlying mechanisms, more studies are needed combining qualitative methods with quantitative (mediation) analysis. At this point, little is clear about the *combined* effects of physical and social renovation: we identified two pathways and only found evidence for one.

13.2. Limitations of our realist systematic review

The realist approach is inherently interpretive and subjective. Since the search process cannot be pre-structured to the same extent as in traditional systematic reviews, outcomes may depend more on choices made by authors. We therefore combined systematic and iterative searching and regularly discussed decisions between two authors to increase reliability. Eight out of the eighteen included studies were identified via additional search strategies (instead of via the systematic search), which is not uncommon for a realist approach. Although maybe less reproducible, an important strength of combining systematic and iterative searching is that it reduces the risk of missing out on important insights, especially when reviewing literature on relatively new, under researched phenomena.

When entering the step of searching for primary studies, we discussed whether or not to also include studies on moving to better quality housing or neighbourhoods, demolition and new build, or social mixing. We decided to not include these types of studies, as those approaches are aimed at, of have the side effect of, breaking down the social environment (e.g. by replacing low SEP with higher SEP residents), while one of the goals of holistic housing renovation is precisely to build, stimulate, expand, and improve the social environment of low SEP residents (Swope and Hernández, 2019). Moreover, whereas housing refurbishment likely leads to improvements in health, rehousing and mixed-tenure approaches have less clear impacts on health and carry risks of social disruption, gentrification and higher rents (McCartney et al., 2017; Swope and Hernández, 2019). However, excluding those studies might also have limited our findings, as some mechanisms underlying holistic housing regeneration could also be expected in those studies. For example, environmental nuisance (air and noise pollution) and other renovation-related inconveniences, likely also play a role in demolition and new build contexts.

13.3. Recommendations for future research

More studies are needed that evaluate the health effects of holistic housing renovations. Effort should be put into investigating the underlying mechanisms explaining how program components affect health outcomes, to provide insight in how, in which contexts, in what time frame (short- or long-term), and for whom holistic housing renovation can improve health. Our program theory provides a starting point for future studies to test the different pathways, and thus hopefully contributes to the evaluation of future holistic housing renovations, with investments and activities assembled in line with a clear theory or hypothesis about 'what works', instead of the assumption that 'every little bit helps' (Kearns et al., 2020).

Further, our review indicates a need for research into possible *negative* health effects of the stressful renovation process residents often go through. The negative health effects described in studies about demolition and new build or rehousing (Critchley et al., 2004; Crawford et al, 2015; Crawford and Sainsbury, 2017; e.g. Abbott et al, 2018), which we came across during our review process, might also be expected during housing *renovation*. Negative health effects of noise and dust nuisance and renovation stress during neighbourhood regeneration were also recently reported in Dutch media (Zembla BNNVARA, 2018; RTV Utrecht, 2021). In our review however, only two studies mentioned this (Hernández et al., 2019; Kearns et al., 2020). Also, the diminishing effect social interventions may have on the negative health effects from renovation, is important to further investigate, given that little evidence from the literature was found for two pathways (3 and 8), although supported by general health models and indications from daily practice.

13.4. Recommendations for practice

Residents of poor housing in areas targeted for renewal are often also socially and economically deprived. From the field of psychology, we know that home improvements are significant life events and that vulnerable groups are less capable of handling these (Cleland et al., 2016). Therefore, to support these residents, housing renewal should not solely be physical, but should also include social interventions. In practice, social housing associations increasingly take an integrated, holistic renovation approach, which also aims to improve other social determinants of health, strengthening residents' capabilities, and support them in multiple life domains (Bullen et al., 2008; Beck et al., 2010; Barosio et al., 2016; Kearns and Mason, 2018). Also in the Netherlands, several social housing associations are experimenting with their own variations of holistic housing renovation ('sociaal renoveren' in Dutch). Holistic approaches can produce inter-related outcomes and positive interactions between housing-related events and other life events, provided that the latter are more positive than negative (Campbell, 2011, Taylor, 2008 as cited in Cleland et al., 2016). This underlines the importance of partnerships in health promotion, e.g. between social housing associations, health organizations, and welfare advice and advocacy (Chisholm et al., 2020). Although holistic housing renovation requires increased investments compared to traditional housing renovation, improvements in public housing are more likely to be enacted and scaled, and may prove cost-effective given additional gains in health and quality of life, and cost-offsets in health care, energy, and education (Hernández et al., 2019; Braubach et al. in Swope and Hernández, 2019). Therefore, holistic housing investments may be significantly lower-cost than they appear in the short run (Swope and Hernández, 2019).

Finally, our review stresses the importance of keeping residents well-informed and involving them in decision-making in renewal processes, in order to increase their control and influence and decrease stress levels. Procedural justice elements of providing information (transparency and accountability) and engaging end-users in the process (due consideration) have been deemed vital in renovation processes (Bal et al., 2021). The growing shortage of social housing in the Netherlands forces housing associations to renovate apartments *while* they are inhabited as temporary alternative accommodations are not available. This stresses the importance of effectively involving residents throughout the process even more. Also, healthy housing education or "housing literacy" is needed: residents should be educated about technical elements of upgrades, how to use these efficiently, and their potential health and cost implications (Rugkåsa et al., 2004; Clinton et al., 2007; Hernández et al., 2019; Chisholm et al., 2020). More research is needed to develop effective methods to involve residents in renovation processes and facilitate the use of technical upgrades after the renovation.

14. Conclusion

Holistic housing renovation, i.e. a combination of physical housing improvements and social interventions, can improve physical health, mental health and well-being. We identified nine pathways via which holistic housing renovation can affect residents' health: three pathways via which physical housing improvements affect physical and mental health, four pathways via which social interventions affect mental health, and two pathways via which physical housing improvements and social interventions reinforce each other in their health effects. The findings of this review are both theoretically novel and relevant for those designing or experimenting with holistic housing renovations in practice. The review provides recommendations for academic researchers, health professionals, housing associations, community development workers, and social workers, and can hopefully guide professionals to develop holistic housing renovations with the largest possible health gains for residents of deprived areas.

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Declarations of competing interest

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Appendix A. Supplementary data

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