



## How do interventions for energy poverty and health work?

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### ARTICLE INFO

#### Keywords:

Energy poverty  
Health  
Interventions  
Energy renovation  
Review

### ABSTRACT

We review the existing evidence on interventions for energy poverty and health with a novel and distinctive focus on how interventions work to produce health outcomes. There is a substantial literature on the impacts of interventions for energy poverty on health, most of which is concerned with substantial energy renovations, and focused on measuring health outcomes. Here we offer a distinctive analysis of this material: using a combination of realist review and process evaluation we use the evidence to articulate the ways in which interventions work. We focus on substantial energy renovations for health, given most of the existing evidence refers to these. Our analysis allows us to identify the logic of intervention design, showing how the practicalities of implementation are shaped by causal assumptions, as well as documenting how participants respond to these interventions. The analysis reveals gaps between intervention design and participant response, which suggest that interventions must work closely with participants to ensure success. Policy recommendations include: energy poverty interventions should take account of how people will respond to technical change, fund support for households to adapt to new technology, offer opportunities for inclusive design processes, and be flexible in delivery.

### 1. Introduction

Energy poverty, or the inability to access adequate energy services (Simcock et al., 2016), is receiving increasing policy attention in high-income nations. A number of broader political factors are currently widening attention to this issue. The planned transition to a low-carbon future in these nations requires a reduction of emissions from fossil fuels; rapidly rising gas prices are particularly detrimental to low-income households and playing their part in a ‘cost of living crisis’; COVID 19 has brought health inequalities into focus, including those associated with living in cold homes; and the war in Ukraine is raising concerns about European reliance on Russian gas. The topic of energy poverty has therefore continued to rise up the agenda for governments, and to be explored in increasing detail by researchers. This has included a specific focus on health, with a number of observational studies documenting the relationship between energy poverty and health. For instance, an independent review, led by Professor Michael Marmot and his team from University College London, reviewed the existing evidence on the (in)direct health impacts of fuel poverty and cold housing. This ‘Marmot Review’ links a range of health conditions to energy poverty namely:

cardiovascular disease, respiratory conditions, anxiety, depression and stress and increased risk of influenza, pneumonia, asthma, arthritis, and accidents at home (Marmot Review Team, 2011). Energy poverty is also linked to excess winter and summer deaths (Healy, 2003; Liddell et al., 2016; Marmot Review Team, 2011; Recalde et al., 2019; Wilkinson et al., 2004; World Health Organisation, 2019).

The causal relationship between health and energy poverty works in two directions. First, energy poverty can create health problems, as articulated above. For example, if you cannot afford to adequately heat your home, living in a cold house can create damp conditions that result in breathing difficulties and allergies. Second, people’s health problems can indirectly result in them experiencing energy poverty. For example, disabled people are more likely to be on low incomes, and therefore less likely to be able to afford adequate energy services to meet their needs (Cronin de Chavez, 2017; Ivanova and Middlemiss, 2022; Snell et al., 2013, 2015). There is therefore something of a vicious circle here in the relationship between energy poverty and health, in which energy poverty causes both physical and mental health problems, and in turn, people experiencing energy poverty are more likely to have existing health problems (Kose, 2019; Lacroix and Chaton, 2015; Thomson et al.,

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<https://doi.org/10.1016/j.enpol.2023.113684>

Received 2 November 2022; Received in revised form 26 May 2023; Accepted 14 June 2023

Available online 30 June 2023

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2017).

Alongside this observational research on the relationship between energy poverty and health, we also see an emerging interest in interventions for energy poverty and health. By an 'intervention for energy poverty and health' here, we refer to deliberate attempts to reduce energy poor households' exposure to the causes of energy poverty, and in doing so improve their health status. A number of existing review papers characterise the effects of interventions for energy poverty on health (Ballesteros-Arjona et al., 2022; Critchley et al., 2007; Liddell and Morris, 2010; Maidment et al., 2014; Thomson et al., 2013; Tonn et al., 2021). These papers draw principally on further quantitative studies to evaluate the success or failure of interventions, finding that health improves for people on average when interventions on energy poverty and health are undertaken, sometimes significantly. This includes improvements in self-reported health, mental health, respiratory health and chronic conditions. They also find reductions in use of health services, and days off school and work associated with interventions (Ballesteros-Arjona et al., 2022).

While existing research focuses on health outcomes, we saw an opportunity to use this relatively large body of evidence to offer more process-driven explanations of how interventions improve energy poverty status and participant health. In doing so we point towards possible mechanisms in how specific energy poverty interventions work to improve or worsen health outcomes. Our contribution here involves uncovering and articulating what is known about why interventions for energy poverty and health succeed and fail in producing outcomes, as opposed to what those outcomes are. We do this using a combination of realist review and process evaluation (Emmel et al., 2018; Moore et al., 2015; Pawson, 2006; Wong et al., 2013), by focusing on intervention logic and design, and by looking more deeply at how interventions are received by those that they aim to help during implementation.

We begin by outlining our review method and summarising the evidence that we draw on. The main analysis in our paper focuses on a specific type of intervention: substantial energy renovations (interventions which improve insulation, heating systems or both), which is the focus of the majority of the existing evidence. We use the example of substantial energy renovations to outline the ways in which interventions work for households, and to uncover how intervention design shapes intervention effect. We find that the causal assumptions made in intervention design do not always match with the ways in which participants respond to interventions. This seems to be resulting in adaptive interventions, which are adjusted in the implementation phase to suit a range of participant responses, and to help to meet differing participant needs. We conclude by arguing that energy poverty interventions need to respond to participant's needs, priorities and expectations by being designed both inclusively and flexibly. This means taking into account how people will respond to technical change, funding support for households to adapt to new technology, offering opportunities for inclusive design processes, and being more flexible in delivery.

## 2. Review method

### 2.1. Overarching approach

This paper reviews the existing evidence, with a focus on identifying the underlying mechanisms active in interventions for energy poverty and health. We chose to focus specifically on energy poverty and health interventions as part of our broader research project on this topic (Wellbased, funded by Horizon 2020, grant number 945097, see Stevens et al., 2022). The health impacts of energy poverty are hugely important, and seen as one of the central challenges for governments addressing this problem (Marmot Review Team, 2011). With household composition, sociodemographic factors, energy literacy, and cultural factors, health is recognised as one of the five macro areas in which households and citizens can be vulnerable. The impacts of energy poverty on health

and well-being are also well recognised, as discussed above. For instance, the EU recognised that adequate warmth, cooling, lighting, and energy to power appliances are essential services that underpin a decent standard of living and health. Moreover, the European Commission urges its members to address energy efficiency targets towards protecting energy-poor households and empowering them by providing healthier living conditions and reducing energy poverty (Directorate-General for Energy, 2022; European Commission, 2020). While this still needs formal adoption by the European Parliament and the Council, the EU has agreed to more robust rules to promote energy efficiency and a stronger emphasis on alleviating energy poverty (European Commission, 2023). Finally, most of the existing academic evaluations of energy poverty interventions have had a focus on health outcomes, as we will see in the 'corpus of evidence' section below.

The review approach that we take is loosely based around a realist synthesis approach (Emmel et al., 2018; Pawson, 2006; Wong et al., 2013), a commonly used approach in health (Pawson et al., 2005; Wong et al., 2013), and emerging approach in energy studies (Fell et al., 2022). The realist approach takes a broader question to evaluation research: instead of asking 'what works', it looks to find out 'what works, for whom, in which circumstances and why?'. This leads to a focus beyond the outcomes of interventions: to answer the 'how do they work' question in the title of this paper we need to understand the logic of the intervention design (the anticipated ways in which the intervention will change people's circumstances and their abilities to act) as well as the known participant responses to interventions. In a realist approach, these are known as programme theory and mechanisms respectively.

Realist review does not aim towards a complete sample of evidence, given its focus on building explanations of how interventions work, rather than calculating outcome probabilities. In essence this approach allows for analytical rather than statistical generalisation. The logic here is that research moves back and forth between empirical material and explanations of that material (Emmel, 2013). This means we enter into the review process with our existing understanding of how interventions work (based on ongoing reading of the literature) (Pawson et al., 2005). We then refine that understanding by integrating empirical insights from studies on the subject.

We complemented the realist review methodology with a process evaluation framework from the Medical Research Council (MRC). Process evaluation provides guidance as to how to assess the implementation of interventions, to enhance the understanding of causal mechanisms and contextual factors associated with variation in outcomes of complex interventions (Moore et al., 2015). Identifying these elements in the reviewed studies enabled us to address how and why interventions had an impact, in line with the realist approach taken in this review.

### 2.2. Corpus of evidence

To identify useful evidence we used Google Scholar to search for research outputs in the English language, and using the terms 'energy poverty' or 'fuel poverty' and health. We also looked at the bibliographies of the documents that we found most relevant, including the existing systematic reviews on energy poverty and health, to identify further eligible studies. We began by looking for research on energy poverty that had health as a key focus: as distinct from the large and growing body of research on energy or fuel poverty more broadly, or indeed a larger corpus of evidence on housing and health. We took a rather narrow approach, drawing on two types of evidence here:

1. Intervention studies that document the ways in which interventions for energy poverty shape respondent health; and
2. Observational studies, including qualitative evidence on lived experience of fuel poverty, which often touches on how people respond to different interventions, as well as quantitative evidence on the links between health and energy poverty.

We identified 27 papers (characterised in Table 1) that explicitly attempt to measure and or monitor the impacts of interventions for energy poverty on participant health, including a mix of primary and secondary, quantitative, mixed method and qualitative research. These papers mostly report quantitative data (16/21 primary studies), are heavily biased towards UK research (13/21 primary studies), and mainly evaluate more substantial energy renovation interventions (23/27 studies). Note that the bias towards the UK is because of the history of fuel poverty: there is a longer trajectory of interest in this topic in the UK due to it coming onto the political and research agenda in the UK before other nations.

We have kept the terms of our review relatively narrow here: focusing on energy poverty and health research, and mainly focusing on intervention research concerning substantial energy renovations. We could have cast our net more widely, for example engaging with a broader literature on health and housing, or including interventions for

**Table 1**  
Summary of existing evidence on interventions for health and energy poverty.

Study type or focus	Key references	# of refs
Quantitative evaluation of effects of interventions on energy poverty and health	(Barton et al., 2007; Braubach et al., 2007; Breyse et al., 2011; Critchley et al., 2007; Curl and Kearns, 2017; Engvall et al., 2003; Free et al., 2010; Grey et al., 2017a; Heyman et al., 2005; Hopton and Hunt, 1996; Howden-Chapman et al., 2007; Peralta et al., 2017; Poortinga et al., 2017; Sharpe et al., 2020; Shortt and Rugkåsa, 2007; Walker et al., 2009)	16/ 27
Qualitative evaluation of effects of interventions on energy poverty and health	(Bashir et al., 2013; Gilbertson et al., 2006; Grey et al., 2017b; Harrington et al., 2005; Willand and Horne, 2018)	5/27
Review papers assessing effects of interventions on energy poverty and health	(Ballesteros-Arjona et al., 2022; Critchley et al., 2007; Liddell and Morris, 2010; Maidment et al., 2014; Thomson et al., 2013; Tonn et al., 2021)	6/27
UK based studies	(Barton et al., 2007; Bashir et al., 2013; Critchley et al., 2007; Curl and Kearns, 2017; Gilbertson et al., 2006; Grey et al., 2017a, 2017b; Harrington et al., 2005; Heyman et al., 2005; Hopton and Hunt, 1996; Poortinga et al., 2017; Sharpe et al., 2020; Shortt and Rugkåsa, 2007; Walker et al., 2009)	13/ 21
Focus on substantial energy renovation	(Barton et al., 2007; Braubach et al., 2007; Breyse et al., 2011; Critchley et al., 2007; Curl and Kearns, 2017; Engvall et al., 2003; Fenwick et al., 2013; Free et al., 2010; Gilbertson et al., 2006; Grey et al., 2017a, 2017b; Harrington et al., 2005; Heyman et al., 2005; Hopton and Hunt, 1996; Howden-Chapman et al., 2007; Liddell and Morris, 2010; Maidment et al., 2014; Poortinga et al., 2017; Sharpe et al., 2020; Thomson et al., 2009, 2013; Tonn et al., 2021; Walker et al., 2009; Willand and Horne, 2018)	23/ 27

Note that our understanding of 'substantial energy renovations' includes interventions which.

1. Improve insulation (adding to roof, floor or wall insulation, or double glazing windows and reducing drafts) (Breyse et al., 2011; Howden-Chapman et al., 2007);
2. Improve heating systems (replacing a boiler, adding central heating or installing a renewable energy source) (Critchley et al., 2007; Free et al., 2010; Hopton and Hunt, 1996; Sharpe et al., 2020; Shortt and Rugkåsa, 2007);
3. Do both of the above (improving both insulation and heating systems) (Barton et al., 2007; Braubach et al., 2007; Curl and Kearns, 2017; Engvall et al., 2003; Fenwick et al., 2013; Gilbertson et al., 2006; Grey et al., 2017a, 2017b; Harrington et al., 2005; Heyman et al., 2005; Liddell and Morris, 2010; Maidment et al., 2014; Poortinga et al., 2017; Thomson et al., 2009, 2013; Tonn et al., 2021; Walker et al., 2009; Willand and Horne, 2018)

energy poverty that do not concern health. We chose not to do this because the corpus of research that directly focuses on substantial energy renovations for energy poverty and health is already relatively substantial and offers ample insights in itself. Indeed we found that we are able to pull out insights for intervention design and good functioning from this direct evidence.

Note that in this review, we are principally concerned with using existing evidence to understand how interventions for health and energy poverty work. This is not the explicit focus of all the papers that we review here, particularly the quantitative studies, which tend to evaluate the health outcomes of energy poverty interventions only. As a result, we also engaged in a broader reading of the literature on energy poverty (an approach recognised in realist synthesis). Specifically, we used the literature on lived experience of energy poverty more extensively in order to characterise people's response to interventions. While these studies might seem at first sight to be observational, interventions are frequently referenced by participants, and often form part of results reported in this kind of study.

### 2.3. Process of review

The included studies were reviewed as part of the literature review for a research project on energy poverty and health. We read the 27 papers listed above closely, then performed a form of qualitative analysis on them, using key concepts from realist (mechanisms) and process evaluation (aspects of intervention design, the causal assumptions behind this design, specificities of implementation) as data categories, and identifying insights about these in each of the texts. We organised this analysis using a structured Excel sheet that included columns for each key element. Initial review was performed by one reviewer (MS) and a random sample was checked by a second reviewer (LM). The key elements extracted from the reviewed studies are outlined in more detail below, including a reference for where in the paper we address each one:

1. Intervention design (section 3): this included a description of the intended intervention, and how it will be implemented, as reported by the authors. Existence of public funding and involvement of stakeholders in intervention design or planned implementation were also included.
2. Causal assumptions (section 4): this included the logic behind the design of the intervention and the assumptions of how the interventions will lead to its outcomes, as reported by the authors. Causal assumptions were identified in relation to the implementation and the mechanisms through which the interventions produce change, in a specific context.
3. Implementation features (section 5): this included information on fidelity (was the intervention delivered as intended?), reach (did the intended audience come into contact with the intervention, and how?), and adaptation (was the intervention changed to make it work?), as reported by the authors.
4. Participant's responses (section 6): this included participant's responses to and interactions with the intervention. We specifically searched for people's priorities and expectations that impacted on the outcome of the interventions, as reported by the authors. In addition, we searched for reported mechanisms explaining why people do not engage in interventions.

Once data extraction had been finished, the information under each key element was synthesised into major concepts that represent the content of the majority of reviewed studies. The concepts are presented in the results sections.

### 3. How are substantial energy renovation interventions for energy poverty and health designed?

While the reviewed studies have elements in common, there are also some differences in design between the interventions being studied. It is not clear how these design elements shape the outcomes of the interventions, as this is not directly addressed in the studies. It is useful, however, to document these before we look in more detail at the expectations of how interventions work, and the ways in which they are implemented. We are concerned here with describing who funds, implements and monitors these interventions, and what is the broader context in which they are implemented (other linked interventions). We also begin to explain the role of intervention recipients in the intervention.

Many larger energy efficiency schemes were a major, publicly funded component of government strategy in combating energy poverty (Critchley et al., 2007; Grey et al., 2017a, 2017b; Liddell and Morris, 2010; Peralta et al., 2017; Walker et al., 2014). Given the expense of substantial energy renovations, this is not unexpected. Insulation measures were often free to householders, and installed to government specifications (Grey et al., 2017a, 2017b; Howden-Chapman et al., 2007). Some intervention programmes included elements to improve the wider living environment (Poortinga et al., 2017; Thomson et al., 2009).

The projects differed in who took key decisions, and how people were supported in their engagement. Interventions were often designed by employees of the key stakeholder (usually government) (Grey et al., 2017a, 2017b; Howden-Chapman et al., 2007). In one study, households were allowed to choose their preferred new heater (Free et al., 2010). In another study, residents also received a booklet to support the correct use of the new equipment (Barton et al., 2007).

There is some variation in delivery partners: for instance, the 'FILT Warm Homes Service' was delivered through a tripartite partnership, including a national organisation and charitable network (Bashir et al., 2013). These programmes were often area-based: provided on a street-by-street or community basis (Grey et al., 2017a, 2017b). Households participating in one of the intervention programmes were often in contact with a variety of stakeholders, from community engagement officers to project managers and contractors (ibid.).

### 4. How do studies anticipate that the interventions will work?

Here we detail assumptions made by study authors about how housing improvement interventions work. These are not always formally evidenced, but still worthy of comment as they offer insights into why interventions are designed as they are. Such causal assumptions are summarised in Table 2. In brief, studies assume that substantial energy renovations will increase indoor temperature, reduce exposure to cold and reduce humidity in the home, all of which are known to have positive mental and physical health outcomes. Specifically, mental health improvements noted in these interventions include improvements to perceived quality of life (Grey et al., 2017b) and to overall wellbeing and emotional security (Gilbertson et al., 2006; Poortinga et al., 2017; Sharpe et al., 2020). Physical health improvements include better general health (Gilbertson et al., 2006; Hopton and Hunt, 1996; Poortinga et al., 2017), better respiratory health in children (Breyse et al., 2011; Gilbertson et al., 2006; Hopton and Hunt, 1996; Liddell and Morris, 2010; Maidment et al., 2014) and improved health for those with existing conditions (Gilbertson et al., 2006; Howden-Chapman et al., 2007; Maidment et al., 2014).

They also expect that increased indoor temperature, reduced exposure to cold and reduced humidity will have positive knock-on effects on financial and social life, leading to fewer financial difficulties and stress (Curl and Kearns, 2017; Gibbons and Singler, 2008; Gilbertson et al., 2006; Grey et al., 2017b) and improved family relations and social life (Bashir et al., 2013; Gilbertson et al., 2006; Grey et al., 2017b).

**Table 2**

Causal assumptions in the literature about the ways in which the interventions impact on health and other key parameters.

Intervention outcome	Causal assumption	References
<b>Increased indoor temperature due to better energy performance</b>	Increased comfort will positively affect health and wellbeing	(Ballesteros-Arjona et al., 2022; Bashir et al., 2013; Braubach et al., 2007; Breyse et al., 2011; Critchley et al., 2007; Free et al., 2010; Grey et al., 2017a, 2017b; Harrington et al., 2005; Howden-Chapman et al., 2007; Maidment et al., 2014; Poortinga et al., 2017; Sharpe et al., 2020) (Grey et al., 2017a, 2017b)
<b>Reduced indoor cold</b>	Improved subjective thermal satisfaction will improve mental health Reduced cold leads to less harm to physical health	(Liddell and Morris, 2010; Peralta et al., 2017; Poortinga et al., 2017; Walker et al., 2009) (Peralta et al., 2017; Walker et al., 2009)
<b>Reduced indoor humidity</b>	Reduced cold leads to decreased effect of cold on blood viscosity, thereby decreasing the risk of thrombus formation and cardio-/cerebrovascular disease occurrence Reduced cold leads to reduced susceptibility to infection, such as bronchitis Reduced humidity will reduce incidence or worsening of respiratory illness (e.g. asthma)	(Peralta et al., 2017; Poortinga et al., 2017)
<b>Lower energy bills</b>	Reduced humidity will be associated with reduced exposure to indoor pollutants and dampness-related allergic agents Lower bills lead to less financial stress and sense of better value for money	(Free et al., 2010; Gilbertson et al., 2006; Poortinga et al., 2017; Sharpe et al., 2020)
<b>Increased sense of control and autonomy Better family relationships, functioning and routines</b>	Less financial stress positively affects mental health Lower bills lead to more money to spend on other necessities such as food Mental health improvement This is closely linked to increased privacy, improved comfort and less financial stress. These factors act both as potential reasons and results of better family relationships and contribute to mental health improvement. Expanded living space will improve mental health, due to improved family relationships	(Ballesteros-Arjona et al., 2022; Curl and Kearns, 2017; Gilbertson et al., 2006; Grey et al., 2017a, 2017b; Harrington et al., 2005; Howden-Chapman et al., 2007; Liddell and Morris, 2010; Poortinga et al., 2017; Sharpe et al., 2020; Thomson et al., 2009, 2013) (Sharpe et al., 2020) (Howden-Chapman et al., 2007) (Curl and Kearns, 2017; Liddell and Morris, 2010) (Free et al., 2010; Gilbertson et al., 2006; Liddell and Morris, 2010; Shortt and Rugkåsa, 2007; Thomson et al., 2009, 2013) (Gilbertson et al., 2006; Harrington et al., 2005; Liddell and Morris, 2010;

(continued on next page)



Table 2 (continued)

Intervention outcome	Causal assumption	References
	Reduced cold leads to reduce school absenteeism among children, due to reduced incidence or improvement in respiratory diseases	Shortt and Rugkåsa, 2007; Thomson et al., 2009, 2013) (Ballesteros-Arjona et al., 2022; Bashir et al., 2013; Free et al., 2010; Liddell and Morris, 2010)
New household appliances (e.g. electrics, kitchen)	Contribute to mental health gain.	Poortinga et al. (2017)

Interventions are expected to reduce financial stress with reduced costs of energy to the household. This leaves more money for the household to spend on other necessities such as food (Howden-Chapman et al., 2007). In addition, both family life and people’s sense of control are thought to be boosted by these kinds of interventions. With regards family life, privacy is especially important for teenagers, whose intergenerational relationships are under pressure at this age. Interventions are expected to expand household living space in the winter resulting in better family relations (Gilbertson et al., 2006; Harrington et al., 2005; Liddell and Morris, 2010; Shortt and Rugkåsa, 2007; Thomson et al., 2009, 2013).

5. How are interventions implemented and how does this shape outcomes?

Drawing on MRC guidelines, we would expect interventions to be implemented with different degrees of flexibility depending on unforeseen events and the way that plans are actually put into practice (Moore et al., 2015). The key concepts we use from the MRC guidelines here are *fidelity* (to what extent the intervention was delivered as intended), *adaptation* (things that needed to be changed to make the intervention work), and *reach* (whether the intended audience is reached by the intervention).

Reading the items in Table 3 suggests that while substantial energy renovations seem like technical interventions, when implementation starts the intervention becomes shaped by social factors. This is not unexpected: the realist approach would anticipate that people will respond to interventions in different ways. The key points from Table 3 are that participants have varied needs and therefore, interventions need to have some degree of flexibility. In addition participant responses to interventions will shape outcomes, where, for instance, participants do not understand how to use technology or where the technology does not meet household needs. Involving participants in design and delivery seems to help in successful implementation by reducing stress associated with interventions, and by resulting in adaptive interventions as challenges are recognised and overcome. We also see concerns about equity in implementation expressed under the ‘reach’ category, where participants can be suspicious about why they are involved in an intervention or perceive the way interventions are distributed as unfair. To illustrate, an onerous and complicated application process might hinder potential beneficiaries, who are often less educated, from accessing the intervention. In that case, the application process to the intervention programme becomes a source of inequity.

6. How do participants respond to interventions for energy poverty and health?

Tables 4 and 5 characterise a number of different types of mechanisms shaping intervention outcomes including:

- People’s awareness priorities and expectations that shape responses to interventions (Table 4)

Table 3

Features of intervention.

Implementation feature	Reported elements	References
<b>Fidelity</b>	Participants in intervention faced difficulties in using new technology (heating system). Interventions were tailored to individual needs, which can result in better interventions, but also in considerable variations across each intervention.	(Critchley et al., 2007; Walker et al., 2014)  (Thomson et al., 2009, 2013)
<b>Adaptation</b>	Authors note the importance of involving participants in implementation and decision-making. This directly improves feelings of control and alleviates stress, but also results in an adapted interventions. A single approach to fixing home heating might not match household needs. Adaptation of interventions to individual thermal preferences is therefore needed. Householders need support and advice regarding the use of their new heating system. This enhances feelings of control, associated with improved mental health.	(Bal et al., 2021; Grey et al., 2017a, 2017b; Sharpe et al., 2020; Thomson et al., 2009, 2013)  (Critchley et al., 2007; Grey et al., 2017a, 2017b; Willand and Horne, 2018)  (Bashir et al., 2013; Curl and Kearns, 2017; Grey et al., 2017a, 2017b; Sharpe et al., 2020)
<b>Reach</b>	Participants perceived it as luck rather than judgement whether or not they would participate in the intervention. The application process to the intervention programme was a potential source of inequity. Effective targeting important.	Bashir et al. (2013)  (Dubois, 2012; Willand and Horne, 2018)

- Mechanisms explaining why people do not engage in interventions (including understanding, fears, stigma and structural barriers) (Table 5)

Each mechanism is characterised in these tables as having positive or negative effects on intervention outcomes. Note that people’s responses to an intervention could be due to deep-seated priorities, expectations and fears that are not always within the control of the intervention. Unpicking these is helpful to understand the power and limits of an intervention. It is also useful in thinking about the precise design of interventions. For instance, if interventions take place in the context of particular widespread misplaced beliefs (that living in the cold is healthy) they may need to be designed to develop communication messages to counteract these.

One of the key characteristics of the evidence we find here is that it tends to be rather negative: explaining why people do not get involved in interventions, or do not respond positively to interventions, rather than explaining why people do engage or respond positively. This documentation of negative responses is useful - in the sense that it allows us to anticipate the barriers that interventions might face to successful implementation at the household level. It would be helpful to also have more detailed evidence on why people do get involved in interventions.

We also note that most of these mechanisms refer to people’s reasoning in the face of the intervention, and how this shapes responses, as opposed to how the resources made available have an effect. We can assume that given the relatively positive evaluations of intervention outcomes seen in the broader literature, that there are also positive mechanisms in action, as well as further mechanisms that are triggered by resource availability rather than shifts in reasoning. Our analysis therefore suggests a gap in the literature on explaining positive

**Table 4**  
People's awareness, priorities and expectations that shape responses to energy interventions for health.

Driver	Detail	Direction of influence
Awareness	People are aware that warmth has positive health effects (Harrington et al., 2005)	positive
	People are not aware that warmth is linked to health (Bouzarovski et al., 2013; Critchley et al., 2007; Harrington et al., 2005; Willand and Horne, 2018)	negative
	People don't see unhealthy coping practices as problematic (Bouzarovski et al., 2013; Chard and Walker, 2016; Critchley et al., 2007)	negative
	People do not know how to work new technology (Walker et al., 2014)	negative
Priorities	People prioritising spending on energy over other goods and services (Berger and Hötl, 2019; Harrington et al., 2005)	positive
	People prioritising spending on other needs (e.g. food, rent, entertainment) rather than on energy (Berger and Hötl, 2019; Bouzarovski et al., 2013; Harrington et al., 2005)	negative
	People prioritising thriftiness: being careful to avoid waste (Waitt et al., 2016)	negative
	The home is warmed for the most vulnerable person in the household (Middlemiss and Gillard, 2015; Willand and Horne, 2018)	positive
	People heat to the lowest budget in the household (in shared occupancy) (Bouzarovski et al., 2013)	negative
Expectations	People's environmental values lead to frugal energy consumption (Bal et al., 2021)	negative
	People have expectations of or preferences for a warmer home (Harrington et al., 2005)	positive
	People have expectations or preferences for a colder home (Bouzarovski et al., 2013; Critchley et al., 2007; Harrington et al., 2005)	negative
	People accept sub-standard work because it is free (Gilbertson et al., 2006)	negative

**Table 5**  
Mechanisms that explain why people do not engage in interventions.

Driver	Detail	Direction of influence
Understanding	People don't understand the benefits of measures (Gibbons and Singler, 2008)	negative
Fears	People are scared of getting into debt or of more general financial risks associated with measures (Liddell and Guiney, 2015)	negative
	People are scared that energy costs will increase as a result of the measure (Bashir et al., 2013; Harrington et al., 2005; Walker et al., 2014)	negative
	People are scared that they will lose control of their energy system (Walker et al., 2014)	negative
Stigma	People lack the confidence to ask for help, in the context of previous hostile responses (Bartiaux et al., 2021)	negative
	People are embarrassed to ask for help (Bashir et al., 2013)	negative
Structural barriers	People don't want to accept the intervention because it is free (Reid et al., 2015)	negative
	The household's tenancy type/agreement prevents them engaging in the intervention (Gibbons and Singler, 2008; Middlemiss and Gillard, 2015)	negative
	The household is not eligible for the intervention (Middlemiss and Gillard, 2015)	negative

household responses to interventions, whether triggered by reasoning or resources. Such evidence would allow us to better understand what positive experiences look like, and ultimately to design better interventions which more reliably produce positive effects.

## 7. Conclusion and policy implications

Our review aims to understand how interventions for energy poverty and health work. We have uncovered a number of studies in this field, which aim to understand the impacts of interventions for energy poverty and health. By interrogating the processes and mechanisms active in the interventions in studied, we offer new insights into how interventions for energy poverty and health work.

As we have outlined, the evidence is characterised by: a tendency to focus on more substantial energy renovations as interventions (our focus in this review), a dominance of studies undertaken in the UK, and more quantitative than qualitative evidence. Despite these limitations, our review offers some important learning points for energy policy. We have documented the causal assumptions about how these interventions work (the rationale of the intervention), how participants respond to such interventions (both positively and negatively) and the ways in which implementation shapes success. Bringing these three elements together reveals some interesting challenges for intervention policy in the area of substantial energy renovations and health. We summarise these findings in Fig. 1 which shows each of these three elements in turn working from left to right in the diagram.

An important causal assumption is that substantial energy renovations will increase indoor temperature or reduce exposure to cold (Table 2). Bringing this together with evidence on how participants respond (Table 4), immediately reveals the limitations of this assumption. If, for instance, people are not aware that warmth is linked to health, and choose to use the financial savings associated with energy renovation to pay for something other than additional warmth, there may be no increase in indoor temperature and no associated improvement in cold-related ill health in the household. Intervention design needs to take account of how people will respond, what their priorities are in household budgeting, and whether they need informing about the links between health and energy consumption. The broader lesson for energy poverty policy here, is that interventions in this space are never purely technical, and are likely to need an accompanying community engagement or user education component to ensure success. A systemic approach to energy poverty, which takes into account these possible unforeseen consequences by addressing the bigger picture (household debt, health, lifestyle) is the most likely to succeed here (Bouzarovski, 2018; Middlemiss, 2020). Even then, it may be impossible to override very reasonable budgeting priorities: for example participants putting feeding the family above keeping warm (with associated positive nutritional health outcomes).

We can also learn something by bringing together the mechanisms that explain why people do not engage in interventions (Table 5), and the evidence about how interventions were adapted during implementation (Table 3). Comparing these, leads us to the conclusion that the way participants respond to interventions is critical to their success. For instance, when someone is scared of going into debt, losing control of their heating, and potential increases in costs as a result of an intervention, the intervention will need to be adapted to address these concerns if we want to persuade them to be involved. The fact that interventions are already adapting to be more inclusive in design, more flexible in delivery, and are aware that not everyone will be able to benefit (as we saw in Table 4), suggests that some of this adaptation is already happening. It would be helpful for energy poverty policy funding streams to also be made aware that this softer side of implementation is critical to successful outcomes. This might mean that funding has to be open to adaptive interventions: changing the way that interventions work in the process of delivery in order to ensure success.

Our study has its strengths and weaknesses, and findings should be understood in this light. Our focus on the process of interventions instead of their outcomes (using a combination of realist and process evaluation) is novel, and results in new insights from this review of existing literature. Specifically: we identify key drivers which shape the direction of influence of interventions and mechanisms that explain

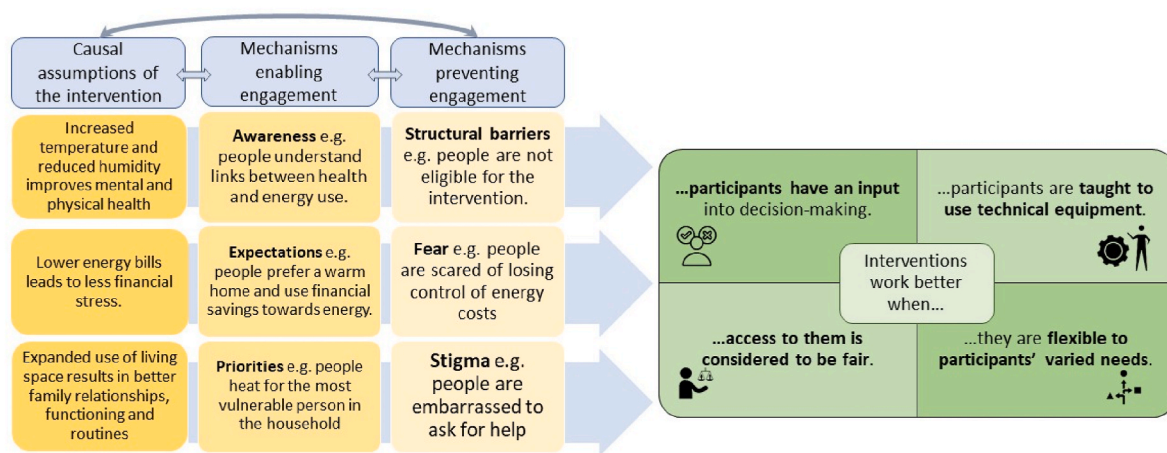


Fig. 1. How do interventions for Energy Poverty and Health work?.

engagement of recipients. Our findings highlight the need to shift focus towards interventions that are more inclusive in design and flexible in delivery. Our attention to the process of interventions results in insights about 'how to do' interventions, which we hope can be useful to policy-makers and practitioners in this field.

Our study also has two key limitations. First, it was difficult to establish a direct link between our process-driven explanations and their associated health impacts, given that these links were not directly made in the studies concerned. Most of the evidence that concerns the process of interventions comes from qualitative studies that do not report quantitative health impacts, and as such we were not able to establish whether mechanisms that explain how interventions work were identified in studies that also found positive health impacts. Second, we have kept the scope of the review relatively narrow, looking only at literature that directly concerns energy poverty and health, and further narrowing to literature that evaluates substantial energy renovations. We recognise that we might have gained further insights from broadening the scope of the review.

We hope that this paper will help to shape further research on interventions for energy poverty and health, and to inform policy on this topic. There would be value for future research in addressing some distinct gaps in the literature. First, there is a need to broaden the evidence base, to assess a wide variety of possible interventions and to better understand both their impacts on health, and how these impacts come about. Second, there is potential for considerable divergence from the UK experience in other nations, and as such, there is a need for evaluation of more cases beyond the UK. Outcomes and experiences will likely differ according to the broader politics of a nation, as well as the social, economic and cultural context of participants (Middlemiss, 2022). This implies the need for more inclusive research in this area. Finally, we encourage a further focus on processes of interventions rather than merely the outcomes that they produce. Given our insights that people respond differently to interventions according to their priorities, and expectations, understanding how we can design more effective processes for maximum inclusion is a critical next step.

#### CRediT authorship contribution statement

**Lucie Middlemiss:** Writing – original draft, Conceptualization, Visualization, Investigation, Formal analysis, Methodology. **Merel Stevens:** Writing – original draft, Conceptualization, Visualization, Investigation, Formal analysis, Methodology. **Pepa Ambrosio-Albalá:** Conceptualization, Writing – review & editing, Visualization. **Victoria Pellicer:** Writing – review & editing. **Amy van Grieken:** Writing – review & editing, Supervision.

#### Declaration of competing interest

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

Lucie Middlemiss reports the WELLBASED project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 945097. This funding source had no role in the design or results of this study.

#### Data availability

No data was used for the research described in the article.

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