



Effectiveness of financial support interventions to reduce adverse health outcomes among households in fuel poverty in the United Kingdom

Chithramali Hasanthika Rodrigo^{a,*}, Kusum Singal^a, Phil Mackie^b, Shantini Paranjothy^b

^a University of Aberdeen, UK

^b NHS Grampian, UK

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ABSTRACT

Objectives: This systematic review intended to assess the effectiveness of financial support interventions for household fuel poverty in the UK in terms of reducing adverse impacts on the health and wellbeing of recipients. **Methods:** Bibliographic databases and grey literature sources were searched from the UK for studies that evaluated the health and wellbeing of participants following financial support to optimize indoor heating. Two independent reviewers carried out screening, data extraction and quality assessment of the articles. The outcomes included direct health-related outcomes such as Excess Winter Mortality (EWM), physical/mental health, health services utilization, well-being, and quality of life. Indirect health related outcomes included temperature, condensation/mould/dampness (CMD), fuel efficiency/expenditure and satisfaction with warmth. Due to the heterogeneity of interventions and outcomes, a narrative synthesis of the data was carried out.

Results: Twenty studies were included in the review: randomized controlled trials (n = 1), before and after evaluation of interventions (n = 14), ecological studies (n = 1) and modelling studies (n = 4). Sixteen studies assessed impacts of home energy efficiency improvements (HEEI) only, three studies assessed impacts of Winter Fuel Payment (WFP) only while one study assessed impacts of both HEEI and WFP. HEEI studies reported improved indoor temperatures (n = 4), reduced CMD (n = 6), reduced fuel expenditure (n = 4), improved thermal comfort (n = 7), improvements in general health (n = 4), increased wellbeing (n = 4), improved physical health (n = 2), improved mental health (n = 3), reduced new health events (n = 1) and improved existing medical conditions (n = 2). Two HEEI were reported cost effective with added years to life. During modelling studies WFP was found to significantly reduce EWM (n = 2) and fibrinogen levels (n = 1).

Conclusions: Most financial support interventions included in this review demonstrated positive impacts on health and wellbeing of recipients supporting their implementation with robust evaluations to better understand the cost effectiveness and long-term impacts in the future. Implementation of these interventions will require cross-sector collaborations, with consideration of which populations are most likely to benefit.

1. Introduction

Fuel poverty is a persistent public health problem despite the efforts made to combat it in the last few decades. Generally, a household is in fuel poverty if it spends more than 10 % of its income (including benefits) on all household fuel use to maintain an adequate standard of heating in the home [1,2]. Fuel poverty is driven by complex interactions between multiple factors such as low income, accessibility and affordability of energy services, household energy efficiency and resident behaviours [3].

Indoor temperature in the range of 18–24 °C is recommended for

optimal health and wellbeing [4]. Living in an inadequately heated home could lead to adverse physical, mental, and social outcomes among occupants [5–7]. Those with chronic illnesses, mental health conditions, disabilities, pregnant women, children, and elderly are especially vulnerable to adverse outcomes from cold homes [8]. UK mortality statistics are higher during the winter than rest of the year and this excess winter mortality (EWM) has been linked to cold indoor environments and fuel poverty [6].

The first UK fuel poverty strategy set out in 2001 actions to address poor energy efficient homes, support low-income families, and manage energy prices which, by 2010, had become the leading contributors to

* Corresponding author.

E-mail address: r01ur24@abdn.ac.uk (C.H. Rodrigo).

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fuel poverty [8]. Over the last two decades, with several revised strategies, fuel poverty statistics for the four UK countries remain high. As measured by the Low-Income Low Energy Efficiency (LILEE) indicator, based on household income, energy requirement, and fuel prices [9] 13.2 % (n = 3.16 million) of households in England were in fuel poverty in 2020. Scotland reports 24.6 % (n = 613 000) of households to be in fuel poverty in 2019. In Scotland a household is considered to be in fuel poverty if, after housing costs, the total fuel costs needed to maintain a satisfactory heating regime are more than 10 % of the household's adjusted net income and if, after deducting fuel costs, housing costs, benefits received for a care need or disability, and childcare costs, the household's remaining adjusted net income is insufficient to maintain an acceptable standard of living [10]. Welsh government estimates that 12 % (n = 155 000) households were spending more than 10 % of their income on maintaining a satisfactory heating regime in 2018 [11] while Northern Ireland estimates show 17 % households were in fuel poverty in 2018 [12].

Interventions for fuel poverty could reduce the burden on health services by reducing health service usage for cold associated illnesses [13]. Financial support has been extended to households suffering from fuel poverty by the UK governments over the years through various programmes. These financial support interventions have aimed to alleviate fuel poverty either by increasing household fuel efficiency by public investment in housing or by directly supporting the households to pay their energy bills [14]. The primary research question of the review focused on the effectiveness of these financial support interventions in terms of reducing adverse impacts on physical health and mental health. We also looked to explore how these interventions have been implemented, which population groups are most likely to benefit, and how such interventions can be implemented at scale to reduce health inequalities.

2. Methods

This review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses: PRISMA 2020 statement [15]. The protocol is registered with the International Prospective Register of Systematic Reviews (PROSPERO) under the registration ID CRD42022373819.

2.1. Search strategy

Literature was searched in Embase (via Ovid), PubMed [MEDLINE and In Process], Cochrane Database of Systematic Reviews, Scopus, and Web of Science from their inception until January 2023 with no language restrictions. The key search terms included fuel poverty, energy poverty, energy deprivation, warm homes, energy efficiency, financial support, health, and wellbeing. A search for grey literature was undertaken in relevant websites.¹ The reference lists of selected papers were searched for any related content.

2.2. Inclusion exclusion criteria

The study population included households/members of households in the UK experiencing from fuel poverty and/or physical or mental health conditions because of cold home environments. The interventions considered for the review included any financial support offered for optimizing indoor heating. This was in the form of direct cash transfers or housing upgrades provided nationally or locally. Households in the UK that did not receive any financial support intervention for fuel poverty were considered as controls. The outcomes assessed included direct health outcomes such as physical or mental health and wellbeing and indirect health outcomes such as indoor temperature, cold, damp and mould (CMD) and satisfaction. Any type of study addressing the study question such as Randomised Controlled Trials (RCT), non-RCT, programme evaluation reports, pilot studies etc. with quantitative study findings were included. In mixed method studies, only the

quantitative component was included. The included studies assessed outcomes at varying lengths of duration ranging from immediately following the interventions to several months or years later.

Studies that involved general housing improvements such as improving ventilation, home repairs etc. and included a financial support intervention for fuel poverty as part of their intervention package were excluded as our aim was to assess impact on recipient wellbeing by financial support intervention only [16–18]. Also, studies that did not include assessment of health outcomes were excluded as our main aim was to explore the health benefits of the interventions [19].

2.3. Selection of studies, data extraction and analysis

Following removal of duplicates, the studies were screened for eligibility by title and abstract respectively by two reviewers (CHR and KS) using Rayyan software. Any discrepancies were resolved through discussion with a third reviewer (SP). Full text was screened for articles with eligible abstracts. Two independent reviewers (CHR and KS) extracted data from selected studies using a data extraction template. Data extracted include study characteristics (design, eligibility, description of intervention, setting, funding source), outcomes, effect measures, number of participants in intervention and control groups and number of participants with each outcome. Risk of bias was assessed by CHR and KS independently, using the JBI critical appraisal tools for RCT, quasi experimental studies and cross-sectional studies [20].

Since the studies included a wide variety of outcomes a meta-analysis was considered inappropriate, and data were narrative synthesised. The studies were categorised based on the hierarchy of evidence, type of outcome and quality. The interventions were compared in terms of implementation process, outcomes, and their effectiveness in achieving the desired outcomes. The findings were reviewed systematically to identify lessons for future similar interventions.

3. Results

3.1. Studies included

A total of 4399 references were obtained from searching the databases. Five additional articles were added from hand searching making the number of articles screened 4404. After removing duplicates 3775 references underwent title screening of which 174 were retained for abstract screening. Of the screened abstracts 46 were chosen for full text screening, through which 20 studies met the criteria for inclusion in the review (Fig. 1).

The included studies focused on two types of interventions for fuel poverty: Home Energy Efficiency Improvements (HEEI) and Winter Fuel Payment (WFP). In this review we define HEEI as any physical improvements to housing to maximise heating and prevent heat loss or help with fuel debt/bills and energy efficiency advice. HEEI were assessed in RCTs (n = 1), before and after evaluation of interventions (n = 14), ecological studies (n = 1) and modelling studies (n = 1). These studies focused mainly on immediate and short-term (within 1–2 years) outcomes of HEEI.

The HEEI measures included insulation [21–26], installation of boilers [26,27], provision of new central heating systems [27–33], electric storage heaters [32,34], draught proofing/glazing [26,27, 29–31], home repairs to avoid heat loss [29–31], energy advice [24,35] and help with fuel debt/bills [35]. Most insulation focused intervention packages were tailor made to the requirements of the households.

WFP is an annual cash payment made during winter months to households with an individual(s) over the pension age, with the expectation that it will be used for extra heating costs incurred during winter [33]. The effectiveness of WFP has been assessed in four modelling studies using health survey data [36–39]. These studies model the long-term effects of WFP 14–17 years after its launch.

One modelling study assessed the impacts of both HEEI and WFP and

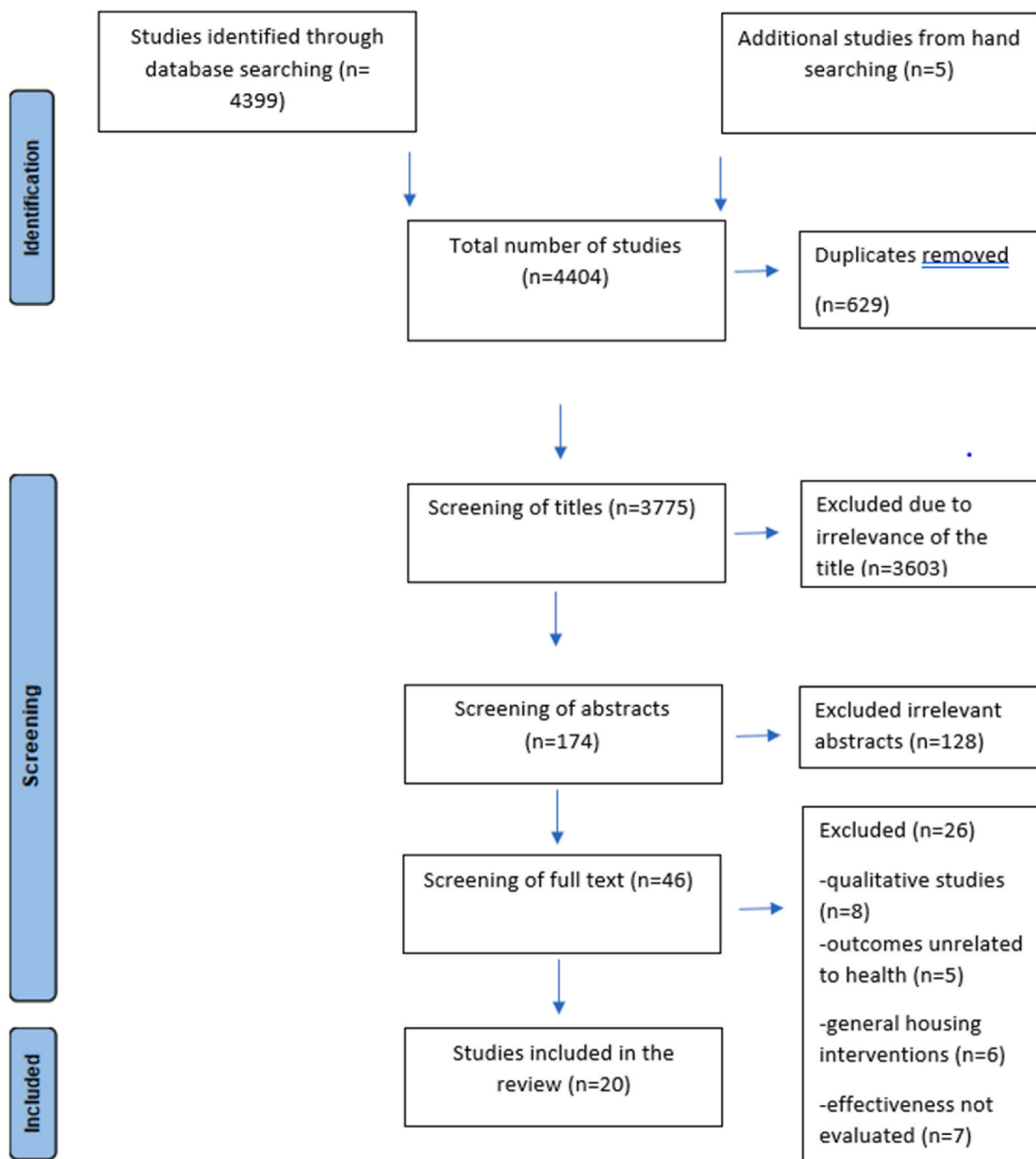


Fig. 1. Study selection process and result.

therefore is referred to in the analysis for both types of interventions [40]. Table 1 summarizes the characteristics of the included studies and the assessed interventions.

¹ https://www.niesr.ac.uk/https://www.povertyalliance.org/https://eprints.whiterose.ac.uk/192853/1/PolicyLeeds-Note7_Fuel-poverty-in-the-cost-of-living-crisis3.pdfhttps://www.nea.org.uk/https://www.eas.org.uk/https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1139133/annual-fuel-poverty-statistics-lilee-report-2023-2022-data.pdf<https://www.gov.scot/publications/tackling-fuel-poverty-scotland-strategic-approach/https://es.catapult.org.uk/project/warm-home-prescription/><https://www.jrf.org.uk/report/not-heating-eating-or-meeting-bills-managing-cost-living-crisis-low-income>[https://www.resolutionfoundation.org/?s=fuel+poverty&filter=cpt_publications](https://greathomesupgrade.org/https://www.resolutionfoundation.org/?s=fuel+poverty&filter=cpt_publications)<https://www.theothinktank.co.uk/research>.

3.2. Eligibility for fuel poverty interventions

Living in or being at risk of fuel poverty was the main eligibility criteria for HEEI. Some studies [21] have used the definition of fuel poverty, as ‘having to spend more than 10 % of household income on fuel to achieve adequate indoor temperatures’ to define the fuel poor households. Others had broadened the eligibility criteria for HEEI including low-income households that would otherwise not be eligible under the traditional fuel poverty definition [25,35,41]. Thus, some studies had targeted recruitment in areas of high deprivation to increase the probability of recruiting low-income households to the sample [25, 36]. The definition of low income was not provided in most studies, except for Bashir et al., which considered annual household income <£ 40 000 as the threshold to define low income [35]. Other eligibility criteria for HEEI included poor quality/hard to heat homes [24,32,34, 36], households with high number of dependents per an economically

Table 1
Summary characteristics of the studies (n = 20).

Author, year	Setting	Eligibility	Intervention	Control
Randomised Controlled Trials				
1. Heyman et al., 2011 [22]	Tyne and Wear in NE England	Households in full or marginal fuel poverty ^a	Energy efficiency intervention package of improved heating and insulation (n = 129 households)	Received intervention one year later (n = 108 households)
Before and after evaluation of interventions				
2. Grey et al., 2017 [36]	Wales	Households in areas deprivation, mixed tenure, and hard-to-heat, hard-to-treat homes	<i>Welsh government-led energy-efficiency investment programme</i> (Arbed) (Insulation and heating system upgrades) (n = 364 households)	Received same intervention later (n = 418 households)
3. Welsh government 2019 [23]	Wales	Households in fuel poverty ^a , low income	<i>Welsh government-led energy-efficiency investment Programme</i> (Nest and Arbed Schemes) Nest (n = 33 595 recipients) Arbed (n = 7113 recipients)	Received same intervention later Nest (n = 29 734) Arbed (n = 192 546)
4. Sharpe et al., 2022 [41]	Cornwall, England	Living in fuel poverty or living on a low income and vulnerable to the effects of living in a cold home	<i>Energy Company Obligation</i> Installation of a new first time central heating system (n = 71 households)	Received same intervention later (n = 83 households)
5. Hong et al., 2006 [29]	England	Living in fuel poverty, having a household member aged below 16 or aged 60 or more or disabled or suffering from a long-term illness	<i>Warm Front Program</i> Insulation, new central heating system or repair and replacements, room heaters, draught proofing (n = 3489 households)	–
6. Hong et al., 2009 [30]	England	Living in fuel poverty, having a household member aged below 16 or aged 60 or more or disabled or suffering from a long-term illness.	<i>Warm Front Program</i> Insulation, new central heating system or repair and replacements, room heaters, draught proofing (n = 2399 households)	–
7. Gilberston et al., 2012 [32]	England	Living in fuel poverty, having a household member aged below 16 or aged 60 or more or disabled or suffering from a long-term illness	<i>Warm Front Program</i> Insulation, new central heating system or repair and replacements, room heaters, draught proofing (n = 2685 individuals)	–
8. Sawyer et al., 2022 [24]	East Sussex	poor condition properties with unsatisfactory heating, poor thermal insulation, and poor energy efficiency	<i>Healthy homes program</i> Energy efficiency advice and heating and insulation measures (n = 149 households)	–
9. Bashir et al., 2016 [35]	Oldham, England	Low income, or household member at risk of poor health due to fuel poverty; aged under 16 or over 50, pregnant, suffered from a physical disability/illness anxiety or depression, illness/disability exacerbated by the cold	<i>Warm Homes Oldham scheme</i> Physical energy efficiency improvements, energy use advice, income maximization through relieving fuel debt, help with bills/tariff switches, benefits checks (n = 176 households)	–
10. Bennet et al., 2016 [27]	England	age >60, low income, disability or long term illness	<i>Warm at Home Program</i> draught proofing, fitting reflector radiator panels, replacement of boilers and central heating systems, advice and referral (n = 3678 clients, 2647 measures)	–
11. El Ansari & El Silimy 2007 (40)	Newham, London	Age = />65	<i>Warm Zone project</i> heating improvement grants	–
12. Somerville et al., 2000 [32]	Cornwall, England	Children <16 with asthma and other respiratory conditions living in damp houses with public ownership	Installation of central heating, electric storage heaters (n = 59 households, 72 children)	–
13. Hopton & Hunt 1996 (35)	Glasgow, Scotland	damp, hard to heat homes, temperatures in all rooms below recommended	<i>Heat with Rent scheme</i> Installation of a controlled heating system in all rooms, tenants paid a fixed sum which is incorporated into rent (n = 55 households, 251 children)	–
14. Short & Rugkasa 2007 [25]	Armagh and Dungannon Health Action Zone Northern Ireland	Low-income levels/high benefit dependency, High relative multiple deprivation, high population density	<i>Home is where the heat</i> <i>Is program</i> energy efficiency measures, central heating systems (n = 54 households)	No intervention
15. Walker et al., 2009 [33]	Scotland	Having someone over 60 and under 5 years of age local authority/housing association tenants without central heating, private households with someone aged = />60, and lacked/broken central heating	<i>Scottish Government Central Heating Programme</i> Central heating system (n = 1281)	No intervention (n = 1084)
Ecological studies				
16. Sharpe et al., 2019 [39]	England/Devon	–	Energy efficiency improvements (boiler up-grades, improved insulation, glazing)	–
Modelling studies based on health survey data				
17. Armstrong et al., 2018 [40]	England	Age = />60	winter fuel payment ^b Insulation measures	–
18. Iparraguirre 2014 (43)	England and Wales	Age = />65	Winter fuel payment	–
19. Crossley & Zilio 2018 (44)	England and Scotland	Age = />60	Winter fuel payment Data from HSE ^c , SHES ⁴ , ELSA ¹	–
20. Angelini et al., 2019 (45)	England	Age = />60	Winter fuel payment (n = 12210) Data from ELSA ⁵ 2002–2012	–

^a Fuel poverty is defined as having to spend 10 per cent of disposable income to achieve room temperatures officially designated as adequate. Marginal fuel poverty is having to spend 7.5–10 per cent of disposable income to achieve the same.

^b English Longitudinal Study of Ageing.

^c Health Surveys for England.

^d Scottish Health Survey.

^e Winter fuel payment (WFP) is an annual cash payment to households with someone over Pension Credit age (currently, 65 years) during winter months. [Supplementary Table 4](#) describes the extracted data in detail to show the relevant parameter changes.

productive person and mixed tenure households. Households having a member below 5 years [25], below 16 years [29–31,35], above 60 years [27,35], at risk of poor health due to a cold home [35] or having a long-term illness or disability [27] were also eligible.

Eligibility for WFP has been determined by female state pension age since the intention of the program was to reduce excess winter mortality and morbidity among the elderly. As female state pension age changed over the years eligibility for WFP has also changed [37].

3.3. Effectiveness of HEEI

The outcomes assessed included direct health outcomes such as EWM, physical health, mental health, utilization of health services, well-being, and quality of life. The indirect health related outcomes were mainly concerned with indoor temperature, condensation/mould/dampness (CMD), fuel efficiency, fuel expenditure and satisfaction with the warmth of the homes.

3.3.1. Indirect health related outcomes

Five studies assessed changes in indoor temperature after HEEI and out of them four studies reported an increase indoor temperature [21,30,31,40]. The RCT by Heyman et al., reported improvement in living room temperature by 1.4 °C between 6pm and 11 p.m. following the intervention ($p = 0.03$), but failed to detect a change in temperature during other times [21]. The Warm Front program (England) reported an increase in indoor temperature of 1.9 °C in houses installed with gas central heating [30,31].

Seven studies looked at the thermal comfort and all of them reported improved thermal comfort [25,27,30,31,35,36,41]. Out of the 8 studies that assessed CMD, 6 reported a reduction [25,27,31,32,34,41] compared to houses that did not receive the intervention.

Five studies assessed the fuel expenditures of the households and four of them reported reductions [25,27,31,35]. The RCT by Heyman et al., reported a significant increase in fuel expenditure ($p = 0.044$) despite a better fuel efficiency ($p < 0.001$) [21].

3.3.2. Direct health outcomes

Studies included a variety of outcomes directly measuring health and wellbeing such as general, physical, and mental health, quality of life, social functioning, respiratory symptoms, health service usage, new health events and excess winter mortality (Table 2). The RCT by Heyman et al., reports that the intervention did not change the measured health outcomes including overall health, symptoms/conditions, quality of life and health service usage [21]. Among the studies assessing ($n = 5$) participants general health, four reported improvements [24,27,33,35]. Improved mental health was reported by three studies out of the five that assessed mental health [31,35,41]. Among four studies that assessed physical health two reported improvements [33,35].

Five studies assessed respiratory symptoms and out of them three reported a significant reduction [23,32,34]. Out of the four studies that assessed asthma attacks/symptoms two reported a significant reduction [23,32] of symptoms while one reported an increase [41]. The Welsh HEEI study reported significant reductions in respiratory infections and asthma attacks presenting to primary care among those who were known to have a history of respiratory problems. However, this study reports that there was no significant change to the number of GP prescriptions for asthma or respiratory infections [23]. A study conducted among children <16 years, reported a significant reduction in lost school time due to illness ($p < 0.001$) following installation of heating measures [32]. Two studies [25,34] assessed joint problems and one of them reported a significant reduction following the intervention ($p < 0.05$) [25].

Two studies assessed incidence of new health events before and after the interventions, while one of them reported a significant decrease [33]. Two studies assessed existing health conditions, and both showed improvements [25,35]. Bashir et al., reported that 60 % of those with health conditions exacerbated by cold environments claimed their conditions improved following the HEEI [35].

Five studies assessed quality of life/wellbeing of participants and four of them reported improvements [24,27,35,36]. Bennet et al., reported that following the Warm at Home Program there was a significant improvement in quality of life of participants contributing to an additional 121.8 Quality Adjusted Life Years (QALY). The program was cost effective with a cost per QALY of £14984 and greatest health/wellbeing benefits were seen among recipients of highest cost interventions (£1000 or more) [27]. The Warm Front Program reports that 0.56 months of combined life could be saved for a 65-year-old couple per year at the average cost of £30449 through insulation and heating of their home [31,42].

Two HEEI studies looked at the effect on EWM [38,40]. Modeling study by Armstrong et al., reports that following implementation of HEEI in England between 2002 and 2010 there was an increment in indoor temperatures of around 0.09 °C which they estimate could have contributed reductions in EWM of approximately 280 per year [40].

3.4. Effectiveness of WFP

Two modeling studies have evaluated the effectiveness of WFP in reducing EWM and both have shown a significant reduction [40,43]. Armstrong et al., reports that following implementation of WFP gradient association between winter cold and mortality has declined compared to previous years [36]. The modelling study by Iparraguirre has found that WFPs could have contributed to almost half of the reduction in EWM in England and Wales since 1999/2000 [37].

Among the two [44,45] studies that looked at the relationship between WFP and fibrinogen levels one study [44] has shown a significant reduction in serum fibrinogen as a health benefit associated with WFP. They further report that raising the eligible age for WFP with changing state pension age has adversely affected the health of those who lost the benefit [44]. There were mixed findings on the effectiveness for the other outcomes (Table 3).

Table 4 summarizes the main facilitators and challenges/barriers we have identified from the included studies.

3.5. Quality of included studies

Supplementary Table 1,2 and 3 illustrate the quality of the studies assessed according to JBI tools for RCT, quasi experimental studies and cross-sectional studies [20]. The studies had high to moderate quality. Risks of bias was due to poor generalizability (since the studies mostly included special groups such as those from highly disadvantaged backgrounds, elderly, children, and those with chronic illnesses), uncertainty in representativeness of volunteer participants, lack of clarity if the intervention and controls were comparable at baseline, lack of adjustment for confounding factors and impossibility of blinding or allocation concealment due to the nature of the intervention. There were high dropout rates post-intervention limiting the numbers available for analysis and most studies did not consider loss to follow up in the analysis.

Table 2
Effectiveness of home energy efficiency interventions.

Outcome	Association	References
Indirect health related outcomes		
Temperature	Increase	Heyman et al., 2011*, Hong et al., 2009, Gilbertson et al., 2012**, Armstrong et al., 2018
	Decrease No association	Short & Rugkasa 2007 ^f
Thermal comfort	Increase	Grey et al., 2017***, Hong et al., 2009, Gilbertson et al., 2012**, Bashir et al., 2016*, Bennet et al., 2016, Short & Rugkasa 2007***, Gilbertson et al., 2012**
	Decrease No association	
CMD	Increase	
	Decrease	Sharpe et al., 2022**, Bennet et al., 2016, Gilbertson et al., 2012**, Somerville et al., 2000, Hopton & Hunt 1996***, Short & Rugkasa 2007**, Heyman et al., 2011, Bashir et al., 2016
Putting up with cold	No association	
	Increase Decrease	Grey et al., 2017*, Sharpe et al., 2022**, Bennet et al., 2016, Somerville et al., 2000, Hopton & Hunt 1996***,
Financial difficulties	No association	
	Increase Decrease	Grey et al., 2017**, Sharpe et al., 2022**, Bashir et al., 2016, Bennet et al., 2016,
Fuel expenditure	No association	
	Increase Decrease	Heyman et al., 2011* Gilbertson et al., 2012**, Bashir et al., 2016, Bennet et al., 2016, Short & Rugkasa 2007** Hong et al., 2006
Fuel efficiency	No association	
	Increase	Heyman et al., 2011***, Hong et al., 2006, Gilbertson et al., 2012**, Bashir et al., 2016, Somerville et al., 2000***
Satisfaction with the intervention	Decrease No association	
	Increase	Heyman et al., 2011**, Grey et al., 2017***, Gilbertson et al., 2012**, Bashir et al., 2016*, Bennet et al., 2016, Hopton & Hunt 1996*
Direct health Outcomes		
General health	Increase	Sawyer et al., 2022***, Bashir et al., 2016, Bennet et al., 2016, Walker et al., 2009 ^{f**}
	Decrease No association	Heyman et al., 2011
Mental health	Increase	Sharpe et al., 2022**, Gilbertson et al., 2012**, Bashir et al., 2016 ^b
	Decrease No association	Heyman et al., 2011, Grey et al., 2017
Wellbeing/QOL	Increase	Grey et al., 2017**, Sawyer et al., 2022***, Bashir et al., 2016*, Bennet et al., 2016 ^c
	Decrease No association	Heyman et al., 2011

Table 2 (continued)

Outcome	Association	References
Social isolation	Increase Decrease	Grey et al., 2017*
	No association	
Physical health	Increase	Bashir et al., 2016, Walker et al., 2009**
	Decrease No association	Heyman et al., 2011, Grey et al., 2017
Respiratory infections/symptoms (self-reported/GP records)	Increase Decrease	Sharpe et al., 2019*** Welsh government 2019, Somerville et al., 2000***, Hopton & Hunt 1996*
	No association	Short & Rugkasa 2007, Grey et al., 2017
Asthma attacks/symptoms (self-reported/GP records)	Increase Decrease	Sharpe et al., 2019* Welsh government 2019, Somerville et al., 2000***
	No association	Hopton & Hunt 1996, Grey et al., 2017, Short & Rugkasa 2007
Joint pains/arthritis/rheumatism	Increase Decrease	Hopton & Hunt 1996* Short & Rugkasa 2007*
	No association	
Health Service usage	Increase Decrease	Short & Rugkasa 2007 Walker et al., 2009, Heyman et al., 2011
	No association	
Emergency admissions (asthma, CVD, COPD)	Increase Decrease	Sharpe et al., 2019* Walker et al., 2009
	No association	
Prescriptions for respiratory infections	Increase Decrease	Welsh government, 2019
	No association	
Prescriptions for asthma	Increase Decrease	Welsh government, 2019
	No association	
New health events	Increase Decrease	Walker et al., 2009* Welsh government, 2019
	No association	
Existing health conditions/ Mean number of illness episodes	Increase Decrease	Bashir et al., 2016, Short & Rugkasa 2007*
	No association	
Excess winter mortality	Increase Decrease	El Ansari & El Silimy 2007
	No association	

p = significance, denoted by *p < 0.05. **p < 0.01. ***p < 0.001. Thermal comfort is defined as “a condition of mind that expresses satisfaction with the thermal environment” (ISO 7730).

- ^a SF 36 Physical functioning Subscale.
- ^b General Health Questionnaire.
- ^c EQ5D quality of life tool.
- ^e Temperature data logger readings classified based on World Health Organization and British Geriatric Society guidelines for indoor temperature levels.
- ^f SF-36 General Health Scale.

4. Discussion

4.1. Summary of findings

This review assessed the effectiveness of financial support interventions for fuel poverty and explored the lessons that could be learnt for future interventions. Twenty studies evaluating financial support interventions for fuel poverty were included in the review. The interventions assessed home energy HEEI only (n = 16), WFP only (n = 3), while one study assessed effects of both HEEI and WFP.

Table 3
Effectiveness of winter fuel payment.

Outcome	Association	References
Indoor temperature	Increase Decrease No association	Angelini et al., 2019
Excess winter mortality	Increase Decrease	Iparraguirre 2014*, Armstrong et al., 2018*
General health	No association Increase Decrease	Angelini et al., 2019
Mental health	No association Increase Decrease	Angelini et al., 2019
Respiratory infections	Increase Decrease No association	Crossley & Zilio 2018, Angelini et al., 2019
BP	Increase Decrease No association	Angelini et al., 2019** Crossley & Zilio 2018,
CRP	Increase Decrease No association	Angelini et al., 2019, Crossley & Zilio 2018
Fibrinogen	Increase Decrease No association	Crossley & Zilio 2018* Angelini et al., 2019

p = significance, denoted by *p < 0.05, **p < 0.01, ***p < 0.001.

Table 4
Summary of facilitators and challenges/barriers.

Facilitators	Challenges/barriers
Delivery of the intervention through partnerships between government/local authorities, energy services, health services and community support organizations [25]	Movement of the intervention recipients/loss to follow up hinders assessment of long-term impact
Use of stringent criteria to identify most eligible populations	Moderate quality studies
Implementation of a package of interventions that can be tailored to the needs of the households	Inconsistencies in outcomes assessed impairs comparisons between interventions
Inclusion of community/recipient perspectives to the intervention design [25]	Area based programs/evaluations programs have the potential to miss households needs/impact [38]
Engagement of community nurses to identify patients who were suffering from health conditions exacerbated by the cold [27]	Assignment to intervention/control groups was not randomized because the researchers had no control over inclusion in the program [36]
Effect of combinations of measures was higher than single measures [40]	Unintended or worsened problems following intervention [41] such as poor ventilation

The review included only one RCT which delivered a tailor-made HEEI package of heating and insulation measures for households living in full or marginal fuel poverty. This study reported a small yet significant improvement in evening living room temperatures and improved fuel efficiency. Social functioning of recipients was significantly correlated with the living room temperatures but there was no effect detected for other measured direct health outcomes [21].

Several studies reported that HEEI improved indoor temperatures and reduced CMD. Many studies reported a reduction in financial difficulties in the recipient households, increased satisfaction with the

interventions and improved thermal comfort. There were significant improvements to general health, wellbeing, physical health, mental health following HEEI. Studies reported a reduction in the number of new health events, respiratory/asthma symptoms, improvement in existing medical conditions and reduced use of health services. Two HEEI were reported cost effective with added years to life [27,42]. One study that evaluated the effect on EWM reported no significant association with HEEI [38].

WFP was found to significantly reduce EWM during two modelling studies [40,43]. One study reported a significant reduction in fibrinogen levels attributable to WFP [44]. Studies evaluating effectiveness of WFP failed to elicit a significant impact on indoor temperature, health, and other physiological markers.

4.2. Interpretation of results

Studies included in this review reported a positive indirect impact on recipients' health by increasing indoor temperatures, reducing CMD and providing thermal comfort. High levels of reported recipient satisfaction showed that financial support interventions were highly acceptable to the recipients [21,25,27,33,35,41]. The direct health benefits were mainly improvements in general health and wellbeing, mental health and reduction in respiratory symptoms. Our findings are consistent with two previous reviews reporting mental health benefits, improvements in general health and reductions in respiratory symptoms following fuel poverty interventions [46,47]. This finding is important considering that fuel poverty has been linked to poor mental wellbeing, general and respiratory health [47].

Cost effectiveness evaluations are important to determine if the health benefits received are worth the money spent for the interventions. The Warm at Home Program was observed to be cost effective. The program maintained the cost per QALY between £ 20000 to £ 30000 as recommended in the National Institute for Health and Care Excellence (NICE) guidelines. So warm at home program can be recommended to be implemented on a larger scale based on its cost effectiveness [27].

However, within a HEEI a wide variety of measures such as heating, and insulation are installed. Most studies report these installations were tailored to the specific household needs. Since a variety of measures have been implemented within each HEEI the health outcomes cannot be attributed to any specific installation measure. More robust evidence is needed before making recommendations on which installation measures within HEEIs is/are better and making policy decisions for implementation in a wider scale.

Some studies on HEEI failed to report a significant direct impact on participant health. One reason for this could be that the time between the HEEI and post-intervention survey was insufficient to observe an improvement in health. Better heating may have contributed to control of health conditions rather than improving them [25,34]. It is argued that HEEI with a focus on better insulation might impair the ventilation of the home giving rise to high respiratory and cardiovascular events [39]. The effectiveness of a HEEI should not solely be measured based on achievement of direct health outcomes alone since many reported significant improvements in indirect health related outcomes [21,25,27,33,35,41]. The recipients of the interventions were vulnerable subgroups of the population from areas of high deprivation and included those having low incomes, living in poor quality hard to heat homes, having co-morbidities affected by the cold, recipients of benefit schemes, children, and the elderly. The vulnerable groups are subject to a multitude of other factors impairing their health and home conditions that could have diluted the effects of the interventions. To ensure maximum benefit from the interventions recipients should be carefully selected among those most in need and those most likely to benefit. The generalizability of the findings is limited to those of low income and living in fuel poverty.

4.3. Strengths and limitations

We have followed a robust systematic process to search, screen, and extract data from available literature. We attempted to narratively synthesize the results by categorizing them according to hierarchy of evidence, type of intervention and outcomes. The recipients have been selected for the interventions based on stringent criteria to capture those in fuel poverty and the interventions have been evaluated trying to identify health effects from these interventions. The included studies were of moderate to high quality.

There was only one RCT included in this review. More RCTs need to be conducted in this area to generate robust evidence. General housing interventions that are effective in improving thermal and health outcomes were not included in this review because our focus was to study financial support interventions for fuel poverty. It is also possible that not all interventions for fuel poverty are evaluated and reported and hence not included in our review. Most studies did not assess cost effectiveness in terms of NICE recommendations which would have enabled us to provide stronger recommendations on alleviating the burden of cold related morbidity and mortality.

The studies report HEEI of different types, methods, and the duration making comparisons difficult. Most studies had no control groups limiting the internal validity. Also, the health outcomes were objectively measured in only a few studies and most outcomes were self-reported and could be highly subjective. Objective measures such as medical records and tests should be used to validate the self-reported observations in future studies. Blinding of participants was not possible given the nature of the intervention and individual households had received different interventions. The enthusiasm to receive the interventions could have biased the self-reported findings. Only a few studies objectively measured the use of HEEI/WFP by households. Indoor temperature and energy efficiency ratings are proxy measures of the actual utilization of the interventions by the recipients and is only indirectly related to their health.

Loss of follow-up/non-response to post intervention surveys could have introduced a bias to the findings. Interventions in short-term rented houses make measurement of outcomes difficult due to population movements. Findings related to health outcomes such as asthma symptoms need to be interpreted with other confounders such as smokers living in the household etc. Future studies could provide valuable information on long-term outcomes, especially for HEEI by increasing the duration of follow up. Improving the eligibility criteria to include the most vulnerable will ensure that those who need the interventions most will receive them.

4.4. Implications for policy and practice

The WHO housing thermal comfort meeting report 2007 recommends that HEEI would help reduce excess winter mortality, and morbidity, reduce the burden on health services and reduce impact on climate change [3]. Studies suggest both heating and insulation measures should be implemented together to provide an optimal increase in temperature [25,31]. Armstrong et al., suggest that the effect of HEEI on indoor air quality should also be considered when interpreting results [40]. A whole-house approach for a healthier environment which incorporates both heating and ventilation improvements is ideal. Boiler replacements have the potential to improve energy efficiency and home warmth without impairing the ventilation. However, this is an area that needs more evidence and is beyond the scope of this paper.

WFP was first introduced in 1997 in the UK. Long term impact of interventions such as WFP must be interpreted with caution since many other factors such as housing quality and disease management that could have contributed to EWM have also improved over the years. However, given the estimated benefits of WFP it is an important intervention that should be continued [43] despite the high cost to the government and preferably not changed with increasing retirement age [44]. Labeling

this cash pay as WFP has markedly increased the utilization of it for heating purposes [47]. Controversial findings from modeling studies suggest that interventions beneficial at individual level may not always be beneficial at population level indicating the need to stringently choose population groups that will most benefit from the interventions [45]. Cold Weather Payments (CWP) is another benefit paid by the UK government based on low indoor temperature records which could augment the benefits of WFP.

It is important to analyze how the recipients of the fuel poverty interventions utilized the interventions at a household level [25,46]. Recipients of HEEI were mostly from deprived communities. They might lack understanding on how to maximally utilize the HEEI. This could be overcome by providing sufficient advice and training while periodically assessing utilization. Further, fuel poverty interventions are best carried out as multidisciplinary partnerships between local authorities and health sectors with inputs from local communities and those in fuel poverty. Given the nature of publicity received by the interventions and political and media influences a robust unbiased evaluation is necessary. Some parties have argued against the use of public funds such as NHS funds for preventive measures instead of acute care [32].

Even after the interventions some participants were still suffering from fuel poverty demonstrating that the interventions were insufficient in addressing the problem totally despite the health benefits observed [25]. This is probably because fuel poverty and health are both contributed by multidimensional factors with complex interactions. A financial support intervention per se is unlikely to solve the problem of fuel poverty unless other factors that affect fuel poverty are also improved. It is also possible that not all eligible opt to use the benefits offered to them and reaching out to the eligible people to ensure that they maximally utilize the benefits is important. Larger-scale changes are required to the housing stock to improve their overall condition and ability to heat. Long term program of monitoring is essential for sustainability and maximum benefits.

Dedication to alleviation of fuel poverty differ between countries and applicability of interventions for fuel poverty also differ. The European Union initiated mandatory energy efficiency certificates for housing in 2002 which could explain the reduction in space heating consumption in member countries in the ensuing years [48]. Even European countries with old, high energy consuming residential housing stock have experienced a positive impact from energy efficiency regulations [49].

Although this review was focused only on literature from the UK, there are reported health benefits of fuel poverty interventions from outside the UK. A study from United States reports that children from households receiving a low-income home energy assistance program had low malnutrition and acute hospitalization rates [50]. The Housing, Insulation and Health Study from New Zealand had insulation and draught-proofing installed in selected households with at least one person suffering from cold and damp induced illness. This study has reported improvements in general health, reduced respiratory symptoms and fewer days off work following the intervention [51]. New Zealand government has taken up interventions to improve housing standards such as 'Warm up New Zealand' based on local evidence [52].

5. Conclusions

Most studies in this review reported that financial support interventions for fuel poverty have positive impacts on thermal comfort, health, and wellbeing of recipients while a few studies failed to demonstrate a positive impact on health. Given the inconsistent study findings, long term health gains and cost effectiveness need to be studied before forming further conclusions of effectiveness of interventions. Financial support interventions are not the sole solution to fuel poverty and would not totally eradicate fuel poverty. However, they have provided relief and comfort to recipients in terms of mental and physical wellbeing, and the current evidence base supports their implementation with robust evaluations to better understand the cost effectiveness and

long-term impacts in the future.

Ethical approval

Ethical approval was not considered necessary since no human or animal subjects were used.

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Declaration of competing interest

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

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Appendix A. Supplementary data

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