Appendices

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Appendix 1: How this evidence briefing was prepared

Searching for evidence

Table 1 - PICO for research question

Population	*UK households*
Intervention	Winter Fuel Payment
Comparison	No payments or reduced/increased payments. Home energy efficiency investments? Also Cold Weather Payments?
Outcomes	Warmer houses Colder houses or reductions/increases in temperature Health and Well-being Mental health
Key words	Cold weather payment, cold weather plan, energy poverty, energy justice

An initial broad search was undertaken to identify relevant terminology for the intervention concept of the search. This was followed by a broad search to find examples of interventions intended to reduce the health effects of cold homes in the UK. The database search comprised terms for the intervention and relevant synonyms i.e. winter fuel payment; fuel poverty; energy poverty; energy justice; winter heating etc. After the search was finalised on MEDLINE it was translated appropriately to the other databases. Specific outcomes were not be included in the search to ensure retrieval of the full evidence base. In addition, there could be unintended outcomes of the interventions that it is important to identify which would potentially not be retrieved if we had combined the intervention and outcome terms. No language or date limits were applied to the search.

Table 2 - Databases to search

Database	*Coverage*
MEDLINE	Public Health coverage
EMBASE	Public Health coverage
SSRN eLibrary	Economic Working Papers
Web of Knowledge	Economics and Energy Coverage
Scopus	Economics and Energy Coverage

Additional search methods

Searches were undertaken of the websites of relevant organisations, UK and international, to include government websites, European fuel or heating or housing associations and charities for relevant policy interventions that have not been published in the academic literature. Citation searches were undertaken of included studies using citation chaser.

Reference Management

Search results were downloaded to Endnote.

Evidence Selection

To ensure currency of evidence all potential relevant references published from 2017 were screened by one reviewer and initially coded. The coding was checked by a second reviewer. Any queries around inclusion were discussed within the team.

Inclusion/ Criteria

Table 3 - Inclusion criteria

Population	*UK households*
Intervention	Policy interventions to reduce the health effects of cold homes including: winter fuel payment, warmer homes initiatives
Study type	Will not restrict by study design
Outcomes	Include any outcomes that are reported. These will include health and well-being and mental health outcomes.
Other	Studies from UK and other comparable countries

Evidence Summary

Evidence in the briefing was prioritised according to (i) Relevance to the UK, (ii) Rigour of the Evaluation (iii) Amount of Detail on the Implications (Outcomes and Perspectives) of the policy/intervention.
Data extracted for the evidence briefing focuses on information pertinent to policy makers. Extraction of evidence was performed individually by one of two reviewers (AC, AB), with a 10% sample checked for accuracy and consistency.

Quality appraisal was undertaken for primary studies using the quantitative and qualitative checklists from the Alberta Heritage Foundation for Medical Research (https://era.library.ualberta.ca/items/48b9b989-c221-4df6-9e35-af78208228 0e/view/a1cffdde-243e-41c3-be98-885f6d4dcb29/standard_quality_assessment_criteria_for_evaluating_primary_research_papers_from_a_variety_of_fields.pdf and the CASP checklist for Systematic Reviews (https://casp-uk.net/glossary/systematic-review/)
The evidence from included studies will be summarised narratively and within tables in the evidence briefing for policy makers.

Patient and public involvement (PPI)

The PPI group will advise on production of a briefing summary and other relevant outputs.

Appendix 2: Included Reviews

Table 4 - Table of Included Reviews

Review	Country of Publication	Review Design	Number of Included Studies [Dates covered]	Included Study Types	Target population. Level of analysis [sample size]	Health outcome(s)
Ballesteros-Arjona et al. (2022).	Spain	Scoping review with equity lens	38 studies. [1996-July 2020]	23 observational and 15 intervention. 90% quantitative.	11 studies disaggregate by at least one inequality. 21 target vulnerable group.	All health or health risk outcomes [general health, mental health, respiratory health, chronic conditions, mortality, use of health services and exposure to health risks
Berretta et al. (2021).	NR	Meta-analysis of effectiveness studies	16 studies [2007-November 2020]	Randomised control trials, and quasi-experimental studies	Analysis by intervention/bundle	Energy consumption
Boeri et al. (2020).	Italy	Systematic literature review and general literature review	118 papers [No specific timeframe]	NR	NR	None – Energy poverty

Review	Country of Publication	Review Design	Number of Included Studies [Dates covered]	Included Study Types	Target population. Level of analysis [sample size]	Health outcome(s)
Hajat (2017).	UK	Evidence review	NR	Daily time-series regression or case-crossover studies	All populations	All-cause, cardiovascular and respiratory mortality. Morbidity outcomes including hip fractures among elderly.
McAndrew et al. (2021).	NR	Systematic literature review	1990 to November 2019	Empirical work, excluding laboratory experiments, formative work, methodology and mathematical proofs.	All populations or groups of focus	None - Energy efficiency
*Mastropietro et al. (2020).	Spain/Italy	Global review of official legislation, reports from national institutions, policy trackers, press	2020	NR	NR	None – Energy poverty

Review	Country of Publication	Review Design	Number of Included Studies [Dates covered]	Included Study Types	Target population. Level of analysis [sample size]	Health outcome(s)
		releases and newspaper articles				
Powell et al. (2018)	UK (Wales)	Evidence review	2000-2017	Effectiveness studies	5 countries with sufficient evaluation information to enable research team to draw conclusions regarding effectiveness of interventions.	None – Fuel poverty
*Streimikiene, et al. (2020).	Lithuania, Greece, Czech Republic	Systematic literature review	40 papers [1990–2020]	NR	NR	None – Energy poverty
Willand et al. (2020).	UK	Realist review	73 documents referring to 28 intervention	Not specified	Low income households, children and the elderly	Health and health-related outcomes (physiological, mental and social health outcomes)

Review	Country of Publication	Review Design	Number of Included Studies [Dates covered]	Included Study Types	Target population. Level of analysis [sample size]	Health outcome(s)
			programmes in 7 countries			

Review	Study aim	Results	Conclusions
Ballesteros-Arjona, V., et al. (2022).	To synthesize state of knowledge on relationship between energy poverty (EP) and health, analysing the results according to different axes of inequality (gender, age, ethnicity/ country of birth, social class, territory	Energy poverty linked to poorer general health, poorer mental health, poorer respiratory health, more and worse controlled chronic conditions, higher mortality, higher use of health services and higher exposure to health risks, with worse results for vulnerable groups across dimensions of inequality.	Future research must take into account effects of inadequate warm temperatures and social inequalities, especially in current context of climate and social crisis, latter exacerbated by covid-19 pandemic.
*Berretta et al. (2021).	To assess effectiveness of installing REEIs on following primary outcomes: energy consumption, energy affordability, CO_2 emissions and air quality indices and pollution levels.	Three studies examined installation of attic/loft insulation, two studies installation of efficient heat pumps, eight studies the installation of bundle of energy efficiency measures (EEMs), and one study evaluated other EEMs. All other interventions involved heating or cooling, and effects were synthesizised by warmer or colder climate and across climates. Four studies [2 Low RoB] examined impact of attic/loft insulation on energy consumption. Three studies took place in colder climates with gas consumption as outcome. Average impact across all climates small and statistically insignificant. Two studies evaluated effect of installing small amounts (less than 75 mm) of insulation and two studies	16 included studies indicate that installing REEIs can significantly reduce energy consumption. However, the same type of REEI in different studies caused different effects - effects are conditional on implementation and context. Existing research often does not clearly report features of installed interventions. Additional high quality impact evaluations should be commissioned in diverse contexts (only one study from Asia/ Africa—both involved lighting interventions—and no studies conducted in South America or Southern Europe).

		examined the impact of installing electric heat pumps. Average impact across studies not statistically significant. (However, substantial variation between two studies). Replacing older pumps with more efficient versions significantly reduced electricity consumption in a colder climate [High RoB]. One study [Low RoB] found significant increase in electricity consumption from installing new heat pumps. Households also used heat pumps for cooling. Installed heat pumps most likely reduced overall energy consumption across all sources—that is, households used more electricity but less gas, wood and coal. Seven studies examined bundled REEIs where households chose which EEMs to install (in five studies installation followed an energy audit that recommended which EEMs to install). Overall, installing REEI bundle associated with significant reduction in energy consumption. In two studies [Low RoB] of mostly low-income households, installed bundles reduced energy consumption by statistically significant amount.	

Boeri, A., et al. (2020).	To provide systematic literature review highlighting major findings on energy poverty, investigating the relationship between spatial and social issues, and looking at state of energy poverty by addressing profiling of users and consequently of services useful to overcome their current vulnerable condition.	NR: Limitations and barriers fall within three categories: economic, social, and technic/ technological. [Structured in two core sections (i) Results of systematic literature review on energy/fuel poverty, (ii) Deepens role of communities and individuals need, crucial in defining new design approaches for supportive solutions to tackle energy poverty]	Many financial schemes and social benefits support reduced energy consumption, but they are not well exploited. Low-income households cannot save necessary funds to cover initial expenses and generally have difficulty obtaining a loan. Energy Poverty involves actions that can be "measured" in social/ sociological terms, such as: difficulty in paying bills; management of how to use heating systems (turning system off and staying in cold to spend less); tolerating conditions of discomfort, cold, for long periods. health conditions, pathologies, etc.
Hajat (2017).	To examine less-biased study designs to determine the best evidence of the acute effects of cold exposure.	A 6% increase in all-cause deaths in England & Wales for every 1 degree C fall in daily mean temperature within top 5% of coldest days. In major Scottish cities, a 1 degree C reduction in mean temperature below 11 degree C associated with increase in mortality of 2.9%, 3.4%, 4.8% and 1.7% from all-causes, cardiovascular, respiratory, and non-cardio-respiratory causes respectively. In Northern Ireland, a 1 degree C fall during winter months led to	Susceptibility to cold weather affected by individual- and contextual-level risk factors. Variations in distributions of health, demographic, socio-economic and built-environment characteristics likely to explain most regional differences in cold risk. Although cold-related health impacts reduced throughout much of previous century in UK, little evidence that

		increases of 4.5%, 3.9% and 11.2% for all-cause, cardiovascular and respiratory deaths respectively among adults. Raised risks observed with morbidity outcomes. Hip fractures among elderly only weakly associated with UK snow and ice conditions. Majority of hip fractures occur indoors.	milder winters due to climate change have contributed to recent reductions. Interventions to minimise cold exposure and reduce fuel poverty likely play key role in determining current and future health burdens associated with cold weather.
McAndrew et al. (2021).	To examine energy efficiency interventions in advanced economies focusing on the household and determine level of evidence regarding their effectiveness and to determine how theory and frameworks are used (or not used) to inform household interventions, the populations or groups of focus, which techniques and activities are used, and how outcomes are measured.	Found equivocal evidence to support specific types of interventions; however, when multiple techniques and activities were used, intervention success more likely.	Outlines policy implications that call for more integrated and methodical explanations of interventions to better support critical decision-making for government.
*Mastropietro et al. (2020).	To review and classify Covid emergency policies implemented in several jurisdictions around the world, identifying potential inefficiencies, but also best practices.	Presents global review of emergency measures and classifies them in six policy groups: disconnection bans, payment extension plans, enhanced assistance programmes, energy bills reduction or cancellation, measures for commercial	Identifies need to target financial aid programs at only those households economically affected by outbreak. Energy bill reductions (or even cancellations) for all customers produce inclusion errors and should be avoided. Aid best channelled

		and industrial users, and creation of financing mechanisms.	through energy assistance programmes already in place, adjusting, if necessary to current circumstances. Brand-new subsidies (including payment extension plans) should be properly targeted and, if not possible during emergency, ex-post validation on eligibility should be considered. Relief measures should be based on proper targeting and consistent financing.
Powell et al. (2018)	To explore interventions to tackle fuel poverty in a range of OECD countries with some reliable evidence about effectiveness.	Large-scale government subsidised activities focus on improving energy efficiency of the housing stock and/or household appliances (i.e. hot water and heating boilers). Investment costs are high, but can have significant long-term benefits, help meet CO2 emissions targets and alleviate fuel poverty. Energy efficiency measures that reduce damp and cold housing stock recognised route to health improvements. Benefits largely unquantified but evidence suggests significant savings in healthcare/medical costs. Energy efficiency improvements also enable more people to pay their utility bills and keep homes warmer thus improving quality of life.	• Alleviating UK fuel poverty requires long-term measures that focus on improvements in housing stock. • New technology offers scope for small-scale community benefits through use of community generated energy and savings through effective energy purchasing. Scope for extending activities of fuel purchasing clubs and opportunities for developing new forms of community energy management. Linking food banks to targeted support for fuel poverty may alleviate some negative effects of

		• Locally delivered projects targeted at localised needs can reach significant numbers of households in fuel poverty. Partnership projects can leverage additional funding/benefits, raise awareness about energy efficiency and help reduce energy consumption through relatively quick/cheap measures to improve quality of life.	fuel poverty for individual households.
*Streimikiene, et al. (2020).	To analyze the energy poverty and climate change mitigation issues in EU households based on systematic literature review and to provide future research paths and policy recommendations.	NR	Paper uses systematic review to develop an integrated framework for addressing energy poverty, just carbon free energy transition and climate change mitigation issues in the EU
Willand et al. (2020).	To explore how programme contexts for residential energy efficiency interventions may have influenced the outcomes.	People's expectations and culturally constructed heating practices influenced indoor temperatures and householder satisfaction. Very deprived households still affected by financial constraints despite intervention measures. Excessive ventilation and limited technical mastery counteracted benefits of intervention measures. Poor workmanship and ineffective handover undermined energy consumption objectives and led to householder dissatisfaction.	Effective intervention design should address householder needs and programme's sociocultural context.

Appendix 3: Included Studies

Table 5 - Table of Included Studies

Study	Design	Location, year	Target population. Level of analysis [sample size]	Study aim	Health outcome
Angelini et al. 2019. (13)	Quantitative, qua si-experimental	England, data from first six waves of ELSA, covering period 2002–12	Sample from English Longitudinal Study of Ageing (ELSA), observational study of community-dwelling individuals aged ≥ 50 years in England. Analyses examining association between household temperature and health (maximum sample of 12,210 adults aged 50–90 years). RD analyses drew on maximum of 5902 observations.	To determine whether or not receiving WFP is associated with raised household temperature levels and/or improved health. Random and fixed effects regression models used to estimate link between ambient indoor temperature and health. Regression discontinuity (RD) design analysis exploiting sharp eligibility criteria for WFP employed to estimate potential impact of payment.	Relevant participant-reported health indicators and objectively recorded biomarkers likely to be affected by indoor temperature: blood pressure, inflammation, lung function, presence of chest infections, subjective health and depressive symptom ratings
Armstrong (2018) (17)	Mixed-methods	England, HEE interventions 2002-2010	Population of England (12 households and 41	To evaluate the impact of home energy efficiency (HEE) interventions on winter- and	Mortality Morbidity

			individuals participated in in-depth interviews from 3 geographical regions	cold-related mortality/morbidity, including assessing the impact of winter fuel payments (WFPs) and fuel costs.	Changes to home indoor environment related to intervention
Crossley & Zilio (2018) (18)	Quantitative, qua si-experimental	UK households with female member aged 60 or over 2003-2009, then eligibility age incrementally increased from 2010	N = 3481	To examine the causal effect of the WFP on health outcomes.	Circulatory and respiratory illness measured by: self-reports of chest infection nurse-measured hypertension two blood biomarkers of infection and inflammation
Curl & Kearns (2017) (31)	Quantitative - longitudinal	Glasgow, Scotland, 2006 (Wave 1), 2008 (Wave 2) and 2011 (Wave 3)	Areas of Glasgow in GoWell project (study of regeneration, health and well-being). Wave 1 survey response rate 50.3% n=6003, wave 2 survey response rate 47.5% n=4869 and wave 3 survey	To examine the effects of warmth interventions on fuel bills and mental health	Mental health

			response rate 45.4% n=4270.		
Davillas et al (2022) (38)	Quantitative - longitudinal	UK households, 2010-2012	Data from Understanding Society: the UK Household Longitudinal Study (UKHLS)	To explore relationship between fuel poverty and wellbeing outcomes	Wellbeing outcomes: self-reported life satisfaction, self-reported measures physical and mental health measures, biomarker data.
Grey et al. (2017)(30).	Quantitative - quasi-experimental	Wales, 2013-2105	Low-income households Sample intervention n=364 and control n=418.	To investigate the impact of a domestic energy efficiency programme on short-term physical and mental health	Physical and mental health, self-reported respiratory symptoms, self-reported asthma symptoms and subjective wellbeing
Hamilton *et al (*2015)(39)	Quantitative - health impact modelling study	England	Modelling of 3 retrofit scenarios in English houses	To model energy efficiency retrofit scenarios and assess potential impacts of changes to temperature and quality of indoor air on public health	Mortality, morbidity, change in QALYs over 50 years
Heffernan (2018)(35)	Qualitative interviews	England 2012-2013	Health and social care managers from 10 local authority (LA) areas.	To investigate the effects of cold weather plan implementation on local planning through interviews with health and social care managers.	Managers experiences of implementing the cold weather plan

Hughes & Natarajan (2019)(40).	Qualitative	UK, 2018	People over 65 years, living alone on low incomes n=11	To document older people's experiences of living in cold homes and explore how they manage to keep warm.	Participants experiences of their thermal comfort and health, strategies to deal with the cold and opinions on energy efficiency measures
Iparraguirre (2015) (12)	Quantitative - time series analysis	England	People aged 65 or over.	To present a time series analysis of the direct effects of WFPs on EWM in England and Wales.	Excess winter mortality
Longhurst & Hargreaves (2019)(41).	Qualitative	Broadland Housing Association, a social landlord based in Norwich, UK, managing 5000 properties, 2014-2019.	16 semi-structured interviews with social housing tenants, 10 interviews and focus group (n=8) with housing association employees.	To explore how emotions can shape energy vulnerability	Emotions - fear, worry, care embarrassment, stigma and trust
Murage et al (2018) (36)	Quantitative	England, 2007-2015	Households entitled to cold weather plan	To assess the impact of the cold weather plan on cold-related mortality	Cold-related mortality
Pollard et al (2019) (10)	Quantitative - cross-sectional pilot study	Cornwall, UK, 2016/17	34 households already assisted by Community Energy	To assess if raising occupants' awareness of indoor temperatures in the home	Health and well-being assessed by questionnaire

			Plus received telemetry devices 22 households completed questionnaires	could improve health and well-being	
Poortinga et al (2018a) (42)	Quantitative - quasi-experimental	Wales, 2013-2016	5 low-income areas 99 households started intervention households (n=50), control households (n=49) Final sample at follow-up of 88 households intervention households (n=48), control households (n=40)	To evaluate the impacts of a policy-led energy performance investment programme on indoor temperature, relative humidity and household gas usage	No health outcomes - study outcomes were indoor temperature and relative humidity and gas usage
Poortinga *et al* (2018b) (34)	Mixed-methods study	Wales, 2013-2016 Link with above	Low-income areas Multiple studies comprising data linkage (25,908 individuals living in 4968 intervention homes), a quasi-experimental study (intervention,	To determine the health and psychosocial impacts of energy performance investments in low-income areas	Hospital admissions for cardiorespiratory conditions, respiratory symptoms, mental health status, household psychosocial outcomes, cost consequences to the health system

			n = 418; control, *n* = 418), analysis of internal conditions (intervention, *n* = 48; control, *n* = 40) and health economic assessment.		
Rodriguez-Alvarez et al (2021) (43)	Quantitative - modelling study	30 European countries including UK 2005-2018, data from EU-SILC survey	Households in energy poverty	To propose a new model for analysing energy poverty and test this approach on a sample of European countries.	No health outcomes - outcome energy poverty
Sawyer *et al.* (2022).(32)	Mixed-methods	East Sussex, England, UK, 2016-2018	Area of high fuel poverty	To explore the impact of a fuel poverty programme on health and wellbeing.	Mental wellbeing (Warwick-Edinburgh Mental Wellbeing Scale WEMWBS) Health - 2 questions on how beneficiaries would describe health before/ after measures installed.
Sharpe, R.A. et al. 2019.(33)	Quantitative - cross-sectional study	England household data from Household Energy	Households in England Households in Devon	To explore population data on housing energy efficiency measures and hospital admissions within an area.	Hospital admissions for Asthma, COPD and Cardiovascular disease

		Efficiency Database (HEED) 2007-2014. Data from Hospital Episode Statistics (HES) for hospital admissions, 2011-2014. Devon using data from Devon Home Analytic Portal for area-level analysis Hospital admission data comparable to HES from NHS Northern, Eastern and Western Devon Clinical Commissioning Group 2014-2017.			

Tammes et al. (2018). (44)	Quantitative - case-crossover analysis	UK, data from Clinical Practice Research Database, 2012-2014	34,777 patients aged 65 years or over.	To investigate cold-related mortality could be predicted by sociodemographic characteristics, clinical factors and house energy efficiency characteristics.	Cold-related mortality

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