EVIDENCE REVIEW & ECONOMIC ANALYSIS OF EXCESS WINTER DEATHS

for the National Institute for Health and Care Excellence (NICE)

Review 2

Interventions and economic studies

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Abbreviations

A&E	Accident and emergency
BMI	Body Mass Index
CGE	Computable General Equilibrium (model of the economy)
CI	Confidence interval (95%)
CMD	Common mental disorder
COPD	Chronic obstructive pulmonary disease
COLD	Chronic obstructive lung disease
CVD	Cardiovascular disease
EHS	English Housing Survey
EHCS	English House Condition Survey
EWD	Excess winter death
EWM	Excess winter mortality
F	Female
FEV_1	Forced expiratory volume in 1 second (lung function)
GHQ	General Health Questionnaire
HSE	Health Survey for England
ICD	International Classification of Diseases ('ICD-9': 9th revision, 'ICD-10': 10th revision)
M	Male
MTS	Mental test score
OR	Odds ratio
PEF	Peak exploratory flow (rate)
PM	Particulate matter (air pollutant)
QoL	Quality of Life
RH	Relative humidity
Rn	Radon
RR	Relative risk
SAP	Standard Assessment Procedure
Tmax	Maximum daily temperature
Tmin	Minimum daily temperature
VOC	Volatile organic compound
YLD	Years Lived with Disability
YLL	Years of life lost

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Executive summary

Background The large burden of winter-and cold-related mortality/morbidity in the UK is widely recognised and is a target for public health action. Various national and local strategies have been and continue to be developed with a view to reducing those burdens through a range of strategies and policy initiatives. They include interventions relating to infrastructure, especially housing quality, behavioural responses and effectiveness of health protection measures. The aim of this review was to gather quantitative evidence of the effect of interventions and approaches to prevent excess winter deaths and morbidity and the health risks associated with cold weather and cold homes, including unintentional consequences and outcomes.

Methods A literature search was undertaken in October 2013 on a wide range of databases and grey literature sources including, among others, MEDLINE, Social Policy and Practice, Social Science Citation Index, HMIC, PsycINFO, Avery Index and ICONDA International. The search strategies were developed using a combination of subject indexing and free text search terms. Searches were limited to the last twenty years (1993-2013) and to English language publications only. Studies reporting quantitative or qualitative results relating to interventions in OECD countries were selected for inclusion. Studies were summarized and assessed for quality of evidence by two independent assessors, and their results reported by narrative synthesis.

Results In most areas, there is limited evidence on the effect of interventions to reduce winter or cold related health burdens. The evidence appears most developed, but is still limited, in relation to housing and specifically the energy efficiency upgrade of housing. There is now evidence from a number of high-quality randomized controlled trials and other controlled observational studies both from the UK and internationally, especially New Zealand. The results of this evidence, though far from conclusive, suggests potential benefits to health in respiratory symptoms and the symptoms of other chronic disease, mental well-being, reduced contacts with the health service and absence from school or work. However the balance of costs and benefits appears to vary appreciably (e.g. in relation to target population, type of intervention etc). The evidence in relation to most other forms of intervention is even more limited. Specifically, there is as yet an inadequate base to judge the effectiveness of health forecasting and alert systems for the protection of high risk population groups, such as those with COPD. We also identified only fragmentary evidence in relation to anti-slip and gait-stabilisation devices. Although this review was not targeted at assembling the evidence on the efficacy of influenza vaccination, available evidence suggests likely benefit from improving the uptake of vaccination particular among the elderly and those with chronic disease. Evidence on the economic assessment of interventions to reduce winter-and cold-related mortality/morbidity is largely limited to housing interventions and is very heterogeneous. Overall it supports the view that there are health benefits to be obtained from improvements in household energy efficiency. However, if viewed

solely as means of improving health these investments would (usually) not be justified; but once a wider range of benefits are considered they appear to be worthwhile investments.

Conclusions Evidence on interventions to reduce winter-and cold-related mortality/morbidity remains limited. There is sufficient evidence to conclude that home energy efficiency interventions can be of health benefit to some population groups, and may be more widely beneficial to the population as a whole. However, a widespread national strategy of housing upgrades is most readily justified if the health, social, environmental and economic objectives are considered together. The overall economic assessment of those interventions is likely to depend in large measure on how health and non-health costs and benefits are counted. Further evidence is needed before full assessment can be made of the potential costs and benefits of interventions in other areas including, health forecasting and alert systems, and the use of anti-slip devices. It is unclear what impact variations in fuel price and the prevalence of fuel poverty have on health risks, and how those risks might be modified through measures aimed at reducing fuel costs to low income families.

1 Introduction

1.1 Context

This review builds on the previous evidence presented on vulnerability to winter and cold related mortality/morbidity (*Review 1: Factors determining vulnerability to winter- and cold-related mortality/morbidity*).

Its key focus is intervention studies, drawing on both quantitative and qualitative evidence, and the economic analysis of such interventions.

Much of the focus on interventions for winter-/cold mortality/morbidity relates to housing-related interventions and interventions related to fuel poverty (often through housing adaptations). However, there are many forms of action that can be taken to try to protect those most vulnerable to the effects of cold and adverse winter conditions in general. Those actions may include attempts to identify and anticipate periods of vulnerability (e.g. periods of severe or prolonged cold) and to ensure appropriate precautionary steps are taken by people themselves, and by health and social care professionals, friends and neighbours and others with opportunity to help at-risk individuals.

Whereas the epidemiological literature about winter- and cold-related mortality/morbidity is heavily influenced by studies based on analysis of large routine data sets including mortality and hospital admissions, such outcomes are much less often the focus of intervention studies which usually seek to record effects on more minor disease outcomes, including measures of well-being, mental health status, thermal comfort and social interactions.

1.2 Aims

(1) To review quantitative and qualitative evidence of the effect of interventions and approaches to prevent excess winter deaths and morbidity and the health risks associated with cold weather and cold homes, including unintentional consequences and outcomes.

Interventions could include:

- *Activities that aim to increase the internal temperature of the home (or to expand the area of the home that is warm enough to live in). For example, energy efficiency measures and heating measures, including insulation*
- *Measures to make it affordable to maintain a warm enough temperature in the home. For example, activities to encourage uptake of benefits and to boost income, and fuel pricing tariffs*
- *Activities to support healthy behaviours among those at risk due to cold temperatures, e.g:*
  - *Encouraging the use of appropriate clothing - particularly out of doors*
  - *Information/mass media activities*
  - *'Neighbourliness' initiatives*
- *Other activities and interventions to address the negative health outcomes of cold weather and cold homes, for example:*
  - *medication checks*

- *vaccination programmes and other healthcare services*
- *technological interventions (for example, alarms, fall alarms, distance temperature monitoring, weather warnings to professionals)*
- *snow and ice clearance and gritting of roads and pavements*

(2) Review of the cost-effectiveness of interventions and approaches to prevent excess winter deaths and morbidity and the health risks associated with cold weather and cold homes (this would include unintentional adverse consequences and outcomes).

This may include any forms of interventions listed above.

1.3 Research questions

Specific questions

- *How effective are interventions and approaches to reduce excess winter deaths and morbidity and the negative health consequences of cold weather and cold homes?*
- *What is the comparative effectiveness of these interventions?*
- *How does effectiveness vary with socio-economic, demographic, health, geographic and housing characteristics?*
- *What are the impacts of these interventions on health inequalities?*
- *What impact do these interventions have on the wider determinants of health (for example, carbon dioxide emissions)?*
- *What adverse effects are associated with changes to energy efficiency or costs of heating (for example, reduced ventilation associated with increased levels of radon, over heating of homes)?*

For all forms of intervention we will aim to assemble and summarise quantitative data on:

- Input costs (of the identification of at risk individuals, of warning systems, and of operational and other actions in the health service or social care systems)
- Effectiveness of intervention (taking account of the effectiveness of the targeting strategies as well as the intervention) and quantified health impacts
- Variations in costs and benefits by population (patient) group

Roles in the review process

The search strategy was developed by Steve Duffy and Paul Wilkinson in consultation with NICE. The selection of studies to include in the review was made by James Milner and Paul Wilkinson. All contributed to summarizing of the research evidence and the assessment of the quality of published studies, with individual contributors assessing studies in their area of expertise. All studies were independently reviewed two members of the review team, and assessment scores agreed (PW, JM, MP, LJ, NS). Professor Armstrong was responsible for calculating effect ratios and other statistics for graphical presentation of data (forest plots). Economic analyses were agreed by JC and ZC.

Conflicts of interest

All members of the research team undertake research relevant to the subject of this review, and have received and continue to receive, research funding from a range of funding organizations.

These have included:

- The European Commission
- The European Climate Foundation
- UK Government departments
- The UK Research Councils (EPSRC, ESRC, MRC, NERC)
- The Wellcome Trust

2 Methods

2.1 Searches

Literature searches were undertaken to identify studies primarily about excess winter deaths. The searches were also designed to identify studies about seasonal morbidity, fuel poverty, cold housing, energy efficient housing, winter related accidents and health forecasting. The search strategies were devised using a combination of indexed keyword terms and free text search terms appearing in the title and/or abstracts of database records. Search terms were identified through discussion between the research team, by scanning background literature and 'key articles' already known to the project team, and by browsing database thesauri.

The literature search involved searching a wide range of databases October 2013 and grey literature resources. Databases searched included: MEDLINE, Social Policy and Practice, Social Science Citation Index, HMIC, PsycINFO, Avery Index and ICONDA International. The searches were limited to the last twenty years (1993-2013) and to English language publications only.

The following databases and resources were searched:

- MEDLINE and MEDLINE In-Process
- EMBASE
- Social Policy & Practice
- Science Citation Index (SCI)
- Social Science Citation Index (SSCI)
- Conference Proceedings Citation Index- Science (CPCI-S)
- Conference Proceedings Citation Index- Social Science & Humanities (CPCI-SSH)
- Health Management Information Consortium (HMIC)
- PsycINFO
- Cochrane Database of Systematic Reviews (CDSR)
- Database of Abstracts of Reviews of Effects (DARE)
- Cochrane Central Register of Controlled Trials (CENTRAL)
- Health Technology Assessment (HTA) database
- NHS Economic Evaluation Database (NHS EED)
- EconLit
- CEA (Cost-Effectiveness Analysis) Registry
- RePEc: Research papers in Economics
- Campbell Library
- Trials Register of Promoting Health Interventions (TRoPHI)
- Database of Promoting Health Effectiveness Reviews (DoPHER)
- Scopus
- Avery Index
- ICONDA International
- PsycEXTRA
- NICE Evidence
- OpenGrey
- RIBA Catalogue (Royal Institute of British Architects)
- NYAM Grey Literature Report (New York Academy of Medicine)

Details of the MEDLINE and other database search strategies and their results are given in Appendix 2.

As a number of databases were searched, some degree of duplication resulted. The titles and abstracts of bibliographic records were downloaded and imported into EndNote bibliographic management software to allow removal of duplicate records and subsequent processing.

In addition, searches were made of selected relevant websites including:

- http://www.eagacharitabletrust.org/ (EAGA Charitable Trust)
- http://www.euro.who.int/en/health-topics/environment-and-health/Housing-and-health (The World Health Organization Regional Office for Europe)
- http://www.energysavingtrust.org.uk/ (The Energy Saving Trust)
- http://www.cse.org.uk/ (The Centre for Sustainable Energy)

Additional searches were made of websites of key research groups in the UK and elsewhere.

2.2 Inclusion/exclusion criteria for review

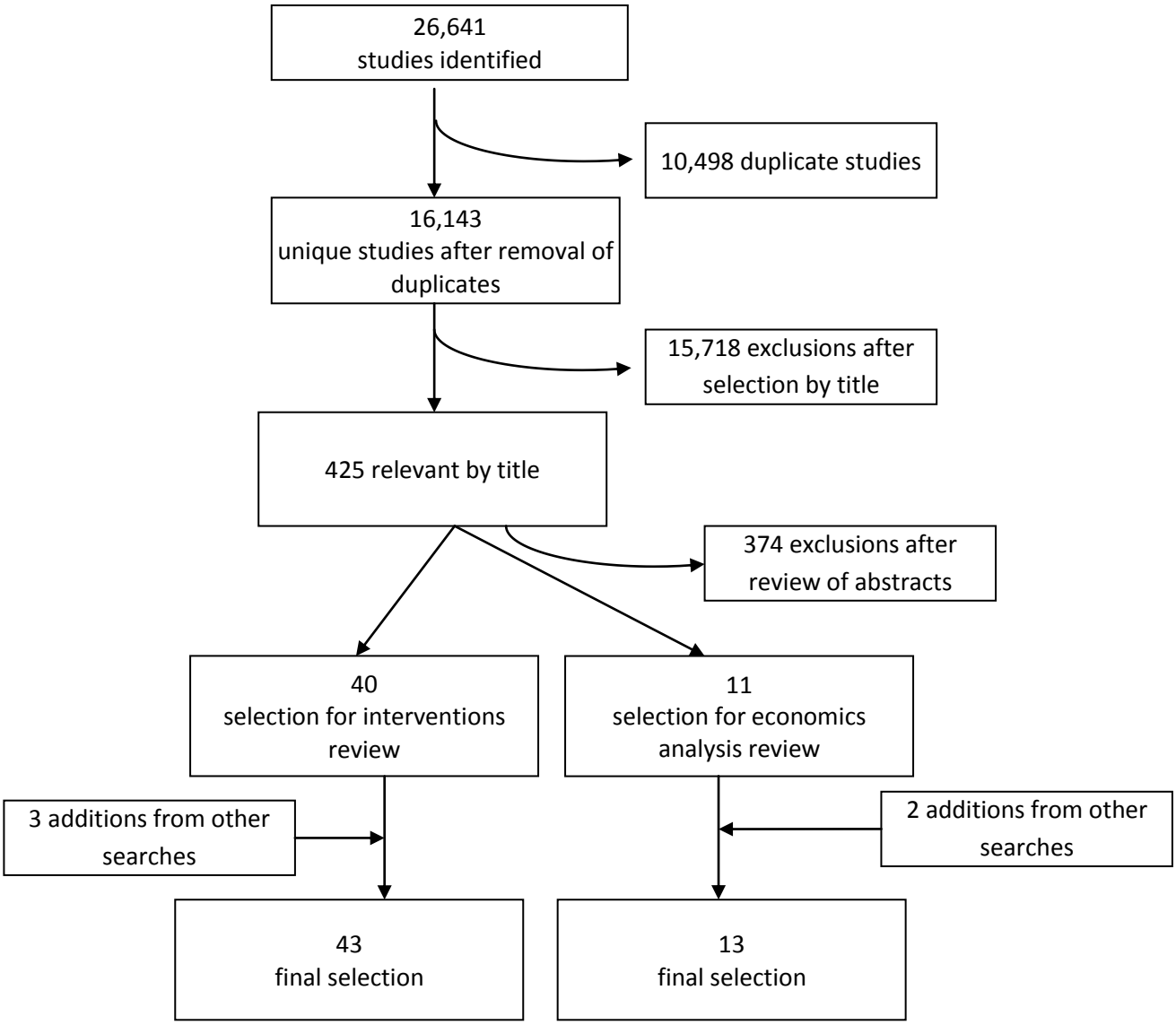
Inclusion

- Quantitative and qualitative primary research papers and reports presenting evidence on interventions aimed at reducing the risks of winter- and cold-related mortality/morbidity (including the effects of snow and ice)
- Studies of populations in countries which are members of the Organization of Economic Cooperation and Development (OECD)
- Publication year 1993 onwards
- English language

Exclusion

- Studies reporting only observational evidence on health or cold-related impacts without direct focus on interventions
- Reviews, commentaries and overview papers
- Publications as conference abstracts only or as simplified summaries without details of research design and methods

Flow chart of number of studies identified from different sources and numbers excluded at different stages of process and reasons for exclusion



Quality appraisal processes including consistency checking within and between appraisers, moderation at data extraction and analysis stages

Quality appraisal was made using the criteria and process for assessing intervention studies, qualitative studies and economic assessments as outlined in the *Methods for the development of NICE public health guidance (third edition) Sept 2012.* See Appendix 6.

All evidence summaries were extracted by one reviewer and agreed/supplemented by the second reviewer.

Various studies did not contain results that could be expressed as relative risks or equivalent, and published data in some cases did not allow the extraction of calculation of confidence intervals. Key statistics were reproduced in the most appropriate form to represent the original data.

2.3 Criteria for applicability

Studies were included if they contained data relevant to any form of intervention relevant to reduction of winter-/cold-related health burdens. There was no restriction in terms of health outcome or study design. Studies therefore included randomized controlled trials, other controlled interventions including before-after studies. We also included simulation studies of interventions where these were felt helpful to understanding the potential impacts of outcomes not usually quantifiable by direct observation because of long time lag (e.g. radon-related lung cancer risks) and mortality outcomes relating to disease induction as well as precipitation by cold temperature.

We selected papers from countries in the Organization of Economic Cooperation and Development.

2.4 Methods of synthesis and data presentation

For intervention studies, in addition to the summary tables of evidence (Appendix 5) we summarise findings in the following ways:

(1) By narrative description, highlighting main findings and strengths and weaknesses;

(2) For studies presenting quantitative associations of housing interventions with health, we graph measures of those associations as ratios (Figures 1-4) using forest plots. All symptoms are patient or parent reported unless indicated.

Associations which were represented as a difference (e.g. of symptom score or number of episodes) rather than ratio of odds or rates (intervention/control) were transformed to a ratio scale by dividing estimated differences by the mean of the variable in the intervention group, pre-intervention or the control group if there were no pre-intervention measures . All ratios are oriented so that a beneficial effect of the intervention is represented by a ratio below one.

In studies presenting several related outcomes (e.g. symptoms of wheeze) we selected the one we judged to have an association with the intervention representative of the group of outcomes. Where associations were published in more than one form (e.g. unadjusted and adjusted for confounders) or more than one publication we selected the result we judged the most robust. While judgement for selection is inevitably somewhat subjective, we sought selections that represent a balanced picture of what the studies found. Some studies, for example those reporting only p-values or "no significant" associations with intervention could not be included on the graph. No summary measures of effect are included as the studies, methods and measures of outcomes were generally heterogeneous.

(3) By use of a summary table to indicate the form and direction of effect for different outcomes reported in the different studies (Table 1). Papers and reports relating to the same specific study/intervention are grouped together. In this table, an up arrow ↑ is used to indicate *improvement* in indoor environmental conditions or health status etc (e.g. reduced symptoms), while a down arrow indicates a deterioration of conditions or health. These variables are shown with an asterisk (*) in the column headings. However, for outcomes that indicate frequencies (e.g. GP visits, frequency of hospital admission) the arrow indicates the change in frequency. Thus, for these variables, shown with † in the column heading, the down

arrow ↓ signifies *reduction* in number of events/GP visits/hospital admissions etc – an improvement in outcome. A double-headed horizontal arrow ↔ is used to indicate no clear evidence of increase or decrease. Where an up arrow or down arrow is contained in brackets it signifies a 'suggestive' trend of increase or decrease but not statistically significant. The judgement of when a pattern is suggestive of a trend is of course subjective and somewhat arbitrary.

For economic studies, because of their heterogeneity, we provide narrative description only in addition to the summary tables of evidence (Appendix 5).

Each description of evidence is concluded with a summarizing 'evidence statement' that attempts to sum up the number and strength of studies pointing to particular conclusions.

3 Findings - Effectiveness

3.1 Intervention studies overview table

Table 1 presents a summary of the findings on the effectiveness of interventions by intrervention category.

Table 1.

Ref no.		Study, reference and (in brackets) grading	Study design	Country (setting)	Target groups	Outcomes	Indoor environment*	Dampness*	Energy use (cost)*	Respiratory health*	Mental health*	General heath*	Other health	Days of work/school†	GP visits†	Hospital
		Housing & fuel poverty interventions														
1	Experiment of room heating	Saeki et al. *JECH* 2013; **67**(6): 484-90.[1] (++/+)	Assessor blinded, simple RCT	JPN	146 healthy participants	Ambulatory blood pressure measurements							↑			
2	CHARISMA study: asthma	Woodfine et al. *Br J Gen Pract* 2011; 61(592): e724-32.[2] (++/++)	Pragmatic RCT	Wales	Asthmatic children	PedsQL quality of life score (three dimensions); school absence				↑						↔
3	RCT of energy efficiency	Heyman B et al. *Housing Studies* 2011; 26(1): 117-32.[3] (+/+)	Pragmatic RCT	ENG	Families in fuel poverty	Respondent answers to survey	↑					↔				
4	NZ trial of healthy housing	Jackson et al. *J Epidemiol Community Health* 2011; **65**(7): 588-93.[4] (+/++)	Before-after (within-person, crossover design)	NZ	Healthy housing programme	Acute hospital admission (by age-group): all admissions and for outcomes 'sensitive to housing'										↓
5	Frankfurt housing study	Braubach M et al. World Health Organization, 2008.[5] ((-/+)/ +)	Controlled observation study	GER	Frankfurt housing agency	Indoor environment; mental well-being; health status & symptoms	↑			↔	↓	↔				
6 7 8 9	NZ study of seven low income communities	Howden-Chapman P *et al*. *BMJ* 2007; 334(7591): 460.[6] (++/++) Howden-Chapman *et al*. BMJ 2008; 337:a1411.[9] (++/++) (Heating intervention) Chapman R *et al*. *JECH* 2009; 63(4): 271-7.[7] (++/++) Howden-Chapman *et al*. *Int J Public Health* 2011; 56(6): 583-8.[8] (++/++) (NB This last paper summarizes data from two NZ studies)	Community based, cluster, single blinded randomized study (energy efficiency) RCT of heating intervention for childhood asthma	NZ	1,350 h'holds (4,407 people) in 7 low income communities (3 urban, 4 rural) with at least one occupant with chronic resp condition Heating intervention in 409 households with child aged 6-12 years with	Indoor temp, rel. humidity; energy consumption; Self-reported: wheezing, days off school and work, visits to general practitioners, hospital admission Self-reported health, comfort and wellbeing, primary care (GP) visits, days off school and work. Independent measures of temperature, relative humidity, mould, endotoxin, β-glucans, house dust mite allergens, GP and hospital visits.	↑		↓	↑	↑	↑		↓	↓	↔

					doctor-diagnosed asthma										
10 8	NZ study of households with asthmatic children	Free S *et al*. *JECH* 2010; 64(5): 379-86.[10] (++/++) Howden-Chapman *et al*. *Int J Public Health* 2011; 56(6): 583-8.[8] (++/++) (NB This paper summarizes data from two studies)	Single-blinded RCT	NZ	409 households with 6-12 year old child with asthma + main heating from plug-in electric heater or unflued gas heater.	Term-by-term school absence for 2006 and previous years (where available) Children kept daily diaries with twice-daily recordings of lung function (PEFR and FEV1), respiratory symptoms and medication. School attendance.	↑			↑		↑		↓	↓	
11	Housing intervention for COPD	Osman *et al*. *Eur Respir J* 2010; **35**(2): 303-9.[11]	RCT	SCO	178 patients with hospital adm for COPD	Respiratory and general health status; home energy efficiency; hospital admission.				↔						↔
12 13 14 15	Warm Front evaluation	Green G and Gilbertson J. CRESR, Sheffield Hallam University, 2008.[12] (+/+) <u>- which summarizes more detailed data from:</u> Warm Front Study Group. Summary of papers. London: DEFRA, 2006.[13] Critchley R. *Applied Energy* 2007; 84(2): 147-58.[14] (+/++) Gilbertson *et al*. *Energy Policy* 2012; **49**(1): 122-33.[15] (+/+)	Controlled before-after comparison: natural experiment	ENG (five urban areas)	Low income households: Warm Front recipients	• indoor temperatures, relative humidity, energy use • health status • quality of life (Short-Form 36, General Health Questionnaire, EuroQol 5D) • modelled cold- and winter-related changes in mortality • air infiltration & quality • in-depth interviews with a h'hold member in 49 dwellings	↑	↓	↔	↔	↑	↔				
16	Newham fuel poverty intervention	El Ansari W et al. *Chronic Illn* 2008; 4(4): 289-94.[16] (+/+)	Ecological observational study (controlled before-after comparison)	ENG	25,000 residents >=65 years, London borough Newham	Hospital admission for resp. disease, cardio-vascular disease, all causes. (Only resp. disease reported in relation to fuel poverty and winter/summer ratio)				↔						

17	Domestic heating programme	Walker J et al. *JECH* 2009; 63(1): 12-7.[17] (+/++)	Prospective controlled study	SCO	1,281 h'holds receiving new central heating; 1,084 comparison households	Self-reported diagnosis of asthma, bronchitis, eczema, nasal allergy, heart disease, circulatory problems or high blood pressure. Primary care and hospital contacts in the past year. SF-36 Health Survey scores	↑			↑		↑			↔	↔
18	Glasgow thermal quality study	Lloyd *et al*. *JECH* 2008; 62(9): 793-7.[18] (+/+)	Before and after study	SCO	Glasgow	Changes in blood pressure, general health and financial status.			↓			↑	↑			↓
19 20	Watcombe (Torbay) Housing Study	Barton *et al*. *JECH* 2007; 61(9): 771-7.[19] (++/++) Richardson *et al*. *Sci Total Environ* 2006; 361(1-3): 73-80.[20] (+/+)	Randomised to waiting list: before and after intervention study	ENG	119 houses in a Torbay socially rented housing estate	Indoor environment. Annual SF36 and GHQ12 (adults). Condition-specific questionnaires for residents reporting respiratory illness or arthritis, the former also completing peak flow and symptom diaries (children) or spirometry (adults). Health service use and time off school.	↑	↔		↑	↔	↔				
21	New Brunswick and Nova Scotia energy efficient new homes study	Leech *et al*. *Indoor Air* 2004; 14(3): 169-73.[21] ((+/-)/(+/-))	Controoled comparison of 52 energy efficient new homes & a control group of 53 other new homes	CAN	267 people in 105 homes (New Brunswick and Nova Scotia)	Propspective questionnaire of self-reported (graded) general and respiratory symptoms, asthma diagnosis, COPD or heart condition, medication use.				↑		↑	↑			
22	Cornwall home heating study	Somerville *et al*. *Public Health* 2000; 114(6): 434-9.[22] (+/+)	Before and after study.	ENG	72 children with asthma living in 59 damp homes (Cornwall)	Symptom-based questionnaire for asthma. Included frequency (in previous month, scored 0 to 4) of breathlessness. Number of days lost from school in the previous 3 months.				↑				↓		
23	Longitudinal study of housing and health	Hopton J and Hunt S. *Housing Studies* 1996; **11**(2):271-286.[23] (+/+)	Longitudinal (before and after) study.	SCO	997 households on an isolated housing estate.	Self-reported health status, including symptoms and reported health status of adults and any children present, use of health				↔		↔				

						services; chronic illness in the household									
Housing simulations															
24	Health impacts of GHG mitigation	Wilkinson *et al*. *Lancet* 2009; 374(9705):1917-29.[24] ((-/+)/++)	Simulation study of indoor environment with quantitative health impact modelling	UK	Simulation of the UK housing stock and population	Building-physics simulation of changes in indoor winter temperatures, $PM_{2.5}$, environmental tobacco smoke (ETS), carbon monoxide (CO), mould and radon. Associated health impacts	↑	↔	↓	↑			↑			
Non-housing interventions															
Health forecasting							**COPD exacerbation**		**Hosp adm**		**GP visits**		**Out-of-hours GP**		**Acceptability/ perceived utility**
25	COPD health forecasting	Bakerly *et al*. *Chron Resp Dis* 2011; 8(1): 5-9. [25] (+/+)	Before-after comparison	ENG	COPD patients (3 primary care practices)	Hospital admissions for acute exacerbations; HCU for these patients			↔		↓		↓		
26	COPD health forecasting	Halpin *et al*. *Prim Care Resp J* 2011; 20(3): 324-331.[26] (+/+)	Prospective randomised controlled trial	ENG	COPD patients (participants of Met Office alert system)	Smartphone patient-completed daily diary. Patients were contacted and assessed if signs of exacerbation.	(↓)								
27	COPD health forecasting	Maheswaran *et al*. *J Public Health* 2010; 32(1): 97-102.[27] (+/++)	Before-after comparison	ENG	COPD patients (Bradford and Airedale)	Practice level COPD admission counts during two winter periods.			↔						
28	COPD health forecasting	Marno *et al*. *J Health Serv Res Policy* 2010; 15(3): 150-5.[28] (-/+)	Cross-sectional questionnaire survey	UK	Service users from 189 general practices, end of 2007/08 winter	Acceptability and utility of service to users; GP consultation									↑

Influenza vaccine & winter mortality							**COPD seasonal mortality rate†**	**Overall seasonal mortality rate†**
29	Vaccination law	Kiyohara et al. *Eur J Public Health* 2013; 23(1): 133-9.[29] (+/+)	Before-after comparison	JPN	Population-level (nationwide) study, Jan 1995 to Dec 2009	Monthly COPD deaths by gender and age from the Monthly Vital Statistics Reports	↓ (elderly only, winter)	
30	Influenza vaccination and flu season mortality	de Diego *et al*. *Eur Heart J* 2009; 30: 209-16.[31] (+/+) Vila-Corcoles *et al*. *Int J Clin Pract* 2008; 62(1): 10-7[30] (+/+) Vila-Corcoles *et al*. *Vaccine* 2007; 25: 6699-707.[32] (++/+)	Prospective cohort study of 1298 community-dwelling elderly and elderly with heart or chronic pulm. disease	ESP	Elderly; those with heart disease or chronic pulmonary disease	All-cause death during influenza periods (January-April)		↓ (reduced flu season/winter mortality among the elderly and elderly with heart disease or COPD)
Anti-slip/fall devices								
33	Anti-slip devices	Berggard G and Johansson C. *Accid Anal Prevent* 2010; 42:1199-1204.[33] ((-/+)/(-/+))	Comparison of groups 'randomly allocated' to receive 1 of 3 anti-slip devices	SWE	Healthy adults employees at Luleå University of Technology	Falls; distanes walked	Users of anti-slip devices walked appreciably further per day than non-users at a very similar *daily* risk of falls but therefore lower risk of falls per kilometre walked	
34	Anti-slip trial	Parkin *et al*. *NZ Med J* 2009; 22(1298):31-8.[34] ((-/+)/-)	Randomized controlled trial	NZ	30 pedestrians travelling downhill direction on icy public footpath	Primary: difference in mean self-reported slipperiness (5-point scale). Secondary: falls, observer-rated slipperiness, observer-rated confidence, time to descend slope	Reduction in self-reported and observer-rated slipperiness	
35	Gait stabilizing devices	McKiernan FE. *J Am Geriat Soc* 2005; 53(6): 943-7.[35] (+/+)	Prospective, randomized, intervention trial	USA	Ambulatory, fall-prone people aged 65+ years	Number of indoor and outdoor slips, falls and injurious falls recorded in daily diary.	Lower risk of slips, falls and injurious falls	
Thermal clothing							**Days in hospital†**	**GP visits†**	**Self rated health***

36	Thermal clothing in heart failure	Barnett *et al*. *BMJ Open* 2013; 3: e002799.[36] (+/+)	Randomised controlled trial (pilot)	AUS	Heart failure patients 50+ yrs not in residential care	Primary: mean number of days in hospital. Secondary: number of GP visits; self-rated health (SF-36)	(↓)	(↓)	(↑)

* -- up arrow ↑signifies improvement in indoor environmental conditions, health status etc (e.g. reduced symptoms)
† -- down arrow ↓ signifies reduction in number of events/GP visits/hospital admissions etc
Where arrows are contained in brackets it indicates a non-statistically significant change

3.2 Intervention studies – Housing

3.2.1 Housing interventions - overview

Studies of housing and/or fuel poverty interventions account for the large part of the identified intervention studies. They include:

--randomized trials: a study of ventilation and heating for the management of children with asthma in Wrexham, Wales[2], a pragmatic randomized trial in NE England (quality rating +);[3] two community single-blinded randomized trials in New Zealand (both ++);[8] [10] [7] and a randomized trial of housing interventions for COPD patients in Scotland (+)[11]

-- before-after comparisons including of a housing intervention in Torquay (+),[19] [20] in Cornwall (+),[22] and controlled before-after comparisons of *Warm Front* energy efficiency interventions in five urban areas of England (+),[12] a controlled study of housing intervention in Scotland (+),[18] and a before-after evaluation of a housing intervention in New Zealand[4]

-- an area-level observational study of a natural experiment in London (+) [16]

-- a natural experiment of new housing in Canada.[21]

-- a Japanese experimental study of home heating control and its influence on blood pressure variation[1]

In addition we included one non-experimental simulation study of energy efficiency housing improvements in the UK (+)[24] because of its relevance to long-term outcomes not measureable in normal observational studies.

3.2.2 Housing interventions – Experimental studies: randomized trials and observational studies of natural experiments

A diverse range of housing studies has been published. Key outcomes from those with published quantitative effect estimates are summarized in Figure 1.

A recent Japanese study by Saeki et al,[1] is a somewhat unusual parallel group, assessor blinded, simple randomized controlled study of 146 healthy participants on the effect of heating control (rather than housing refurbishment) on ambulatory blood pressure (BP) measurements. Its aim was to determine whether intensive room heating in winter decreases ambulatory BP as compared with weak room heating (defined as a level of heating with 10°C lower target room temperature than the intensively heated room). Ambulatory BP was measured while the participants stayed in experimental rooms from 21:00 to 8:00. During the session, participants could adjust the amount of clothing and bedclothes as required. The key findings were that, in the intensive room heating group, systolic morning BP (mean BP 2 h after getting out of bed) was significantly lower by 5.8 mm Hg (95% CI 2.4 to 9.3) compared with those in the weak room heating group, and their sleep-trough morning BP surges substantially less than in the weak room heating group (14.3 vs 21.9 mm Hg;

p<0.01). This provides evidence for one possible mechanism of adverse cardiovascular effect of cold exposure.

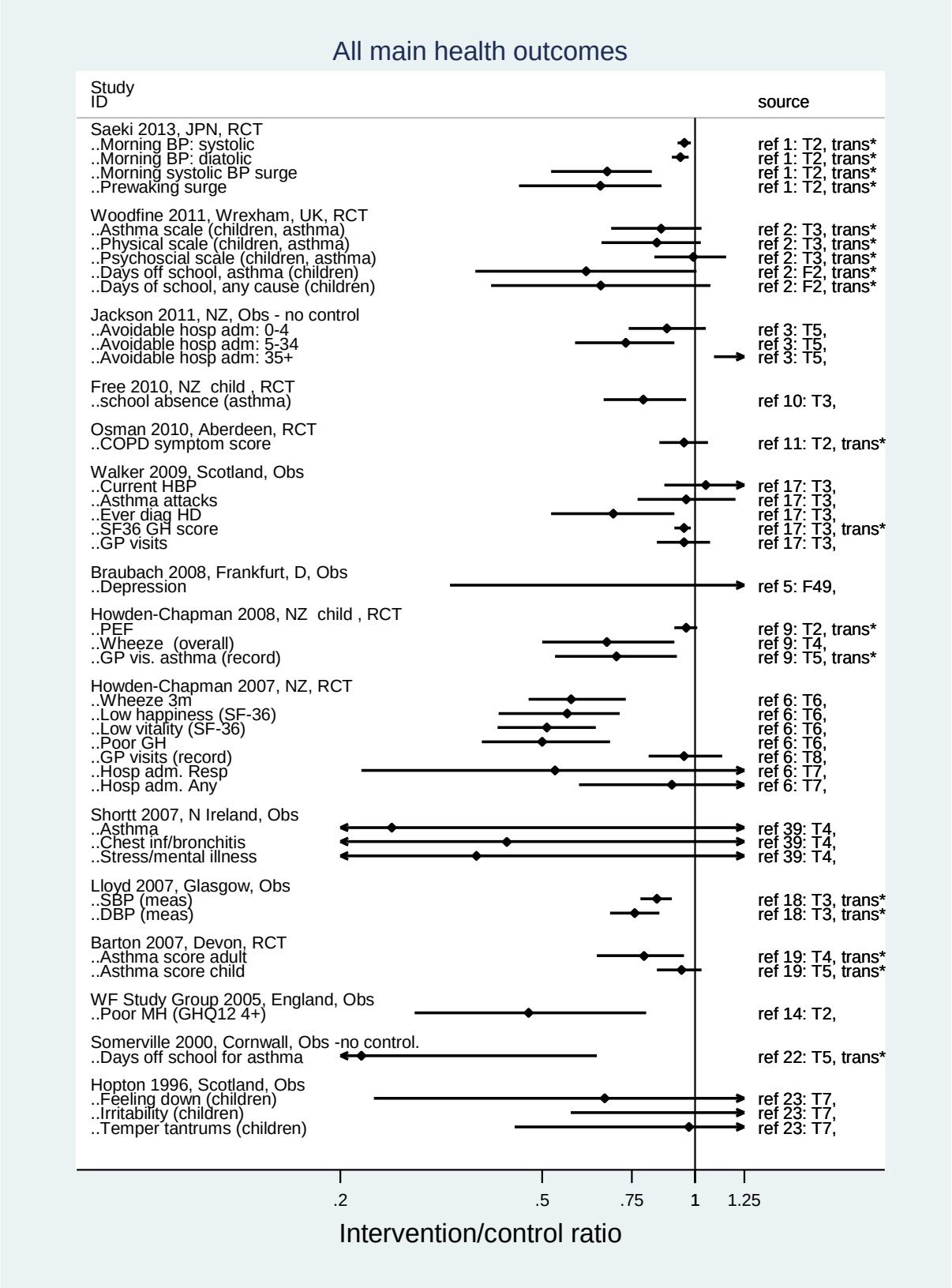


Figure 1. Forest plot of intervention/control ratios for selected outcomes for housing-related interventions. Note: trans* indicates that the intervention/control ratio is calculated from a difference measure.

A more conventional housing adaptation study was undertaken by Woodfine and colleagues[2] in Wrexham County Borough, Wales, to evaluate the effectiveness of installing ventilation systems and central heating where necessary, in the management of children with moderate or severe asthma: a pragmatic randomized controlled trial known as the CHARISMA study. It entailed a targeted package of housing adaptations primarily focused on mechanical ventilation to the bedroom, but with the addition of central heating in a subset. The results shown in Figures 1, 2 and 5 are for this subset with ventilation plus central heating installation (n=19 + 19). Key outcomes, assessed after 4 and 12 months, included (parent-reported) asthma-specific and generic quality of life, and days off school. At 12 months the PedsQL quality-of-life scores were appreciably better in the intervention group: with differences (adjusted for baseline) of 9.3 (–1.9, 20.6) on the overall asthma scale, 10.3 (–1.7, 22.4) on the physical scale and 0.6 (–10.1, 11.3) on the psychosocial scale. Parent-reported school attendance improved, but not significantly.

Other studies include a randomized controlled trial by Heyman and colleagues in north-east England of energy efficiency interventions for families living in fuel poverty.[3] 237 households in full or marginal fuel poverty were recruited, randomly allocated to the trial (n=129) or control group (n=108), and received the intervention. Households were observed over a four year period, with an energy efficiency intervention in year three in the 'trial group' and in year four in the control (comparison) group. The intervention improved energy efficiency as measured by the standard assessment procedure (SAP) rating (effective range 0-100) by 12 points, and room temperature of approximately one degree Celsius, though heating expenditure was not reduced. The intervention generated improvements in satisfaction with household warmth, but not in self-reported health though there were modest correlations between room temperatures and better social functioning, as measured by the SF36.

The Watcombe Housing Study entailed the randomization to early ('intervention' dwellings, n=50) or deferred (control dwellings, n=69) housing upgrades (including central heating, ventilation, rewiring, insulation, and re-roofing) to dwellings in the Watcombe Housing estate in Torbay, Devon, with data gathered on 480 residents of these properties.[19] [20] All residents completed an annual health questionnaire (SF36 and GHQ12), and residents reporting respiratory illness or arthritis were interviewed using condition-specific questionnaires. Those with respiratory symptoms also completing peak flow and symptom diaries (children) or spirometry (adults). Data on health service use and time lost from school were collected. The interventions were associated with improved winter indoor temperatures, unsustained reduction in wall dampness (reverted to pre-intervention levels within a year), and significant reductions in non-asthma-related chest problems ($p = 0.005$) and the combined asthma symptom score for adults ($p = 0.007$) but no difference between intervention and control houses for SF36 or GHQ12 scores. Thus small overall health benefits measured only over the short term.

In a randomised trial of home energy improvements in the homes of 178 elderly patients with Chronic Obstructive Pulmonary Disease (COPD) in Aberdeen, Scotland,[11] Osman and colleagues also

found mixed evidence. However, it should be noted that energy efficiency upgrading was carried out in only 42% of homes randomized to intervention, and independent energy efficiency action was taken by 15% participants in the control group (and in 18% of those in a 'monitoring only' group). The main outcome measures were respiratory and general health status, home energy efficiency and hospital admissions. On an intention-to-treat analysis, there was no difference in outcomes between intervention and control groups, although there were in the 45 patients who had energy efficiency action independent of original randomization: significant improvements in respiratory symptom scores (adjusted mean 9.0, 95% CI 2.5-15.5) not associated with an increase in indoor warmth, decreases in estimated annual fuel costs (-£65.3, 95% CI -£31.9 to -£98.7) and improved home energy efficiency rating (increment of 1.1, 95% CI 0-1.4 on a ten-point grading scale).

Two high quality (++) randomized controlled trials from New Zealand provide evidence in particular in relation to impact on respiratory health status. A cluster randomised study in the community by Howden-Chapman and colleagues[6] examined the impact of insulating homes on indoor temperatures and the occupants' health and wellbeing. Based on 1350 households containing 4407 participants in seven low income communities, measurements were made of indoor temperature, relative humidity, energy consumption, self reported health, wheezing, days off school and work, visits to general practitioners, and admissions to hospital. Insulation improved bedroom temperatures during the winter (0.5 degrees C) and decreased energy consumption by 19%. These changes were associated with reduced odds in the insulated homes of fair or poor self rated health (adjusted odds ratio 0.50, 95% confidence interval 0.38 to 0.68), self reports of wheezing in the past three months (0.57, 0.47 to 0.70), self reports of children taking a day off school (0.49, 0.31 to 0.80), and self reports of adults taking a day off work (0.62, 0.46 to 0.83), fewer general practitioner visits (0.73, 0.62 to 0.87), and (statistically insignificant) reduction in hospital admissions for respiratory conditions (0.53, 0.22 to 1.29). It should be noted that the households included in the study had at least one member with current respiratory symptoms, which may increase effect sizes, and contained a high proportion of Maori and Pacific people (who have relatively high morbidity and premature mortality).

A second New Zealand study, [8 10] the Housing, Heating and Health Study, investigated the impact of installing more effective heating in insulated houses for 409 households containing at least one child aged 6-12 years with doctor-diagnosed asthma. The intervention was associated with improved indoor temperatures, lower levels of NO_2 and children reported less poor health, lower levels of asthma symptoms and sleep disturbances by wheeze and dry cough. Children in households receiving the intervention experienced on average 21% (p=0.02) fewer days of absence from school after allowing for the effects of other factors.

Before-after comparisons include a study by Walker and colleagues (quality rating +) on the effects of a publicly funded heating programme in Scotland.[17] This was a prospective controlled study of 1281 households receiving new central heating compared with 1084 households not receiving new heating. The main outcome measures were self-reported diagnosis of asthma, bronchitis, eczema, nasal allergy, heart disease, circulatory problems or high blood pressure; number of primary care encounters and hospital contacts in the past year; and SF-36 Health Survey scores. Its results provide evidence that intervention was associated with various positive health effects, albeit modest in magnitude. Those receiving heating upgrades were more likely to report satisfaction with the heating (OR 4.96, 95%CI 3.87, 6.37). Among 30 specific measures of health outcome, recipients

were less likely to report a first diagnosis of heart disease (OR 0.69; 95% CI 0.52 to 0.91) or high blood pressure (OR 0.77; 95% CI 0.61 to 0.97), and better scores on the SF-36 Physical Functioning scale (difference 2.51; 95% CI 0.67 to 4.37) and General Health scale (difference 2.57; 95% CI 0.90 to 4.34). Groups did not however differ in contacts in primary care or with hospital services and, according to the authors, the interpretation of the self-reported results for first diagnosis with heart disease or high blood pressure remains uncertain given the limited time period and the failure to detect any difference in health service use.

Among other before-after comparison studies is the evaluation of the health impacts of the *Warm Front* scheme – a home energy efficiency programme for England targeted at low income households.[12 13 14] This study entailed observation of 3,099 dwellings undergoing *Warm Front* improvements over the winters of 2001-02 and 2002-03 in five urban areas of England: Birmingham, Liverpool, Manchester, Newcastle and Southampton. These dwellings underwent a property survey, and a subset of 1064 dwellings had detailed measurements of temperature and relative humidity. In 2,917 households, a computer assisted personal interview was undertaken with a household member. Measurements were made of changes in indoor environment conditions, general health status, thermal comfort and mental well-being. *Warm Front* housing improvements were associated with: increases in indoor temperatures (day-time living room temperatures 1.6°C higher than pre-intervention dwellings, and night-time bedroom temperatures were 2.8°C higher in dwellings with both insulation and a new heating system); reduction in relative humidity and risk of mould growth; little change in average air infiltration rate; satisfaction with the improved and more controllable warmth (including reported perceptions of improved physical health and comfort, especially of mental health and emotional well-being); evidence of improved mental health based on the results of the twelve question General Health Questionnaire (GHQ-12) score (adjusted odds ratio of 0.47 (0.28, 0.80) for the risk of having a GHQ-12 score of 4+ in those that recently benefited from insulation and heating improvements).The introduction of central heating, although theoretically associated with an improvement in heating efficiency, appeared to result in a rise in fuel consumption even after adjusting for increased internal temperatures.

Somerville and colleagues have reported an uncontrolled study of home heating installation (gas central heating in 28/59 (47%) houses, electric storage heaters in 22/59 (37%), solid fuel central heating in 7/59 (12%) and oil-fired central heating in 2/59 (4%)) on the health of children with asthma,[22] with the aim of evaluating the use of NHS money to improve health by improving housing conditions. The before-after comparisons were made of the symptom status of 72 children with previously diagnosed asthma living in 59 damp houses in Cornwall. The children's health was a symptom-based outcome measure for asthma and time lost from school. Interventions were associated with an improvement of 2.1 on the 10-category National Home Energy Rating scale (95% CI 1.68-2.47, P<0.001) in the 37/59 (62%) houses for which two readings were available. Respiratory symptoms were significantly reduced after intervention; the greatest reduction was seen in nocturnal cough from a median score of 3 (most nights) to 1 (on one or several nights) (P<0.001) in the previous month. School-age children lost significantly less time from school for asthma in the previous 3 months (9.3 days per 100 school days before intervention and 2.1 days afterwards, P<0.01) but not for other reasons (1.4 days per 100 school days before and 3.2 after, P>0.05). Caution is needed in the interpretation of results given the lack of a control group.

A controlled before-after study of thermal quality improvements in four blocks of flats in the Easthall area of Easterhouse in Glasgow measured changes in blood pressure, general health and financial status.[18] In the intervention subjects, there was markedly reduced expenditure on heating costs and other previous expenses. Their systolic and diastolic blood pressures fell ($p<0.000$) and there was an improvement in subjectively reported general health and as indicated by a reduction in the use of medication and in hospital admissions. There were no changes in the control subjects in any of these measures.

Another study examined the data at area level on excess winter mortality in people aged 65+ years following the implementation of the Warm Zone fuel poverty reduction scheme.[16] The before-after change in the London borough of Newham was compared to that for all London, employing data from before and throughout the duration of the Warm Zone project. No clear evidence was found to support the effect of the Warm Zone on EWM.

Outside of the UK, another New Zealand study by Jackson and colleagues [4] evaluated a healthy housing programme involving 9,736 residents of 3,410 homes in suburbs of Mangere, Manurewa or Otara in South Auckland, New Zealand from September 2001 to December 2007. All particpants lived in areas of relative deprivation and almost all self-identified as members of the Pacific ethnic group. The housing improvements entailed not only improvements to ventilation but also modifications to reduce overcrowding and improve ventilation, with the main outcome being acute hospitalisation rates before, during and after the intervention. Using a Cox proportional hazard model, hazard ratios for hospital admission in the intervention group compared with the control were as follows: 0-4 years: 0.89 (95% CI 0.79, 0.99); 5-34 years: 0.77 (95% CI 0.70, 0.85); 35 years+: 1.04 (95% CI 0.95, 1.15). When the causes of hospitalisation were restricted to those related to housing, HRs were: 0 to 4 years: 0.88 (95% CI 0.74, 1.05); 5-34 years: 0.73 (95% CI 0.58, 0.91): 35 years+: 1.31 (95% CI 1.09, 1.56). The authors conclude that the study provides evidence that addressing housing conditions is associated with a reduced acute hospitalisation rate for 0-34 year olds. It should be noted however that the package of housing improvements here were not confined to energy efficiency measures, and in particular reduction in overcrowding as well as ventilation improvements.

A Canadian pilot study (Leech et al, 2004 [21]) used telephone-administered questionnaires to compare the outcome of 128 occupants of 52 new homes built to energy efficient standards (R-2000 homes) and with heat recovery ventilators with that of a comparison group of 149 occupants of 53 other similar cost new homes built in the same year and location. Intervention occupants' summative symptom scores improved significantly over the year of occupancy (Wilcoxon rank sum test, $P < 0.006$). Analysis of variance of individuals' total symptom scores showed a significant effect of the house type: occupants of case homes reported more improvement than the control population in terms of throat irritation ($P < 0.004$), cough ($P < 0.002$), fatigue ($P < 0.009$) and irritability ($P < 0.002$) with the main change in symptom category being from 'sometimes' to 'never'.

An earlier, relatively small, controlled longitudinal study by Hopton and Hunt sought to evaluate the effects of an improved heating system (the "heat with rent" scheme) on the health of children living on a Scottish housing estate.[23] Comparisons of the 'heat with rent' (intervention) group (n=55) with the 'no heat with rent' group (n=77) provided mixed evidence. Over the course of the study, various health markers deteriorated. For child health, there was evidence of relative benefit for the

intervention group only in relation to one outcome (aches and pains, $p<0.05$) though the pattern appeared to suggest more deterioration in the comparison group.

Another relevant study has used simulation/modelling to examine the potential effect of home energy efficiency interventions on health, including through long term changes to the indoor environment with impact on indoor air quality (particle pollution, second hand tobacco smoke, carbon monoxide, radon, mould) and temperature.[24] Outcomes included potential (lagged) mortality outcomes, as well as estimates of adverse consequences on mental well-being. As a modelling study, the results do not provide direct empirical evidence, but do provide useful pointers to long term impacts of home energy efficiency interventions and their impacts on rare disease outcomes, including mortality and cancer risk not measureable in more short-term observational studies. Its results suggest overall net benefit from the sort of interventions needed to meet medium term housing energy efficiency upgrades (consonant with greenhouse gas mitigation objectives), but largely because assumed increased air tightness provides protection against the ingress of particle pollution from the outdoor air which has greater benefits to health than the dis-benefits due to the increase in pollutants of indoor origin (indoor particle sources, second hand tobacco smoke, radon, mould and others). Empirical data on the relationship between energy efficiency and indoor temperatures during the winter period suggest relatively modest changes in cold exposure with consequently modest reductions in cold-related adverse impacts on health.

3.2.3 Housing interventions – Qualitative studies

Semi-structured interviews were carried out in a purposive sample of 49 households who received home energy improvements as part of an evaluation of *Warm Front*, a scheme aimed at alleviating fuel poverty in England.[37] The *Warm Front* scheme involved home energy improvements such as installation, replacement or refurbishment of the heating system and in some cases loft and/or cavity insulation and draught proofing measures. All participants were satisfied with the home environment following the intervention and reported improved and more controllable warmth and hot water. Overall the work that was undertaken was of an acceptable standard and the disruption caused by the installers was tolerable. A minority of participants had noticed an appreciable reduction in fuel bills. Others reported that it was difficult to compare or that they were still getting used to the new technology. Nonetheless a quarter of participants said they would not have been able to afford a new boiler or heating system without the scheme. Most participants reported improvements in comfort following the intervention and some reported an easing of symptoms of chronic conditions such as arthritis and fewer minor illnesses. Other benefits included a reduction in anxiety (for example about the boiler breaking down) an improvement in mood and being able to use more rooms. The accumulated effect was a beneficial effect on participants' sense of wellbeing.

In another study interviews were undertaken with 30 individuals (ages ranged from 20 to >60 years) as part of research relating to the Warm Homes project.[38] The Warm Homes project aimed to alleviate fuel poverty by providing home improvements including loft insulation, cavity wall insulation, draught exclusion, heating controls and central heating. Subjects for the qualitative component of the study were recruited from a larger survey sample recruited from households in a

relatively poor area in the north east of England. The qualitative study explored respondent's understanding of fuel poverty and its health consequences, their ways of coping, and their response to fuel poverty interventions. There was a range of views and experiences reported in relation to these topics with little in the way of overriding themes with the exception that many felt it was important to provide a warm home to visitors. Many interviewees were unable to afford to invest in home improvements or were private tenants with unresponsive landlords. For those that had received home improvements prior to being interviewed these had increased the size of the living area during winter.

In-depth interviews and focus groups were also included as part of an evaluation of a fuel poverty intervention aimed at owner-occupiers in rural areas in Northern Ireland.[39] A questionnaire survey was administered before and after gas-fired central heating was installed to recipients of the intervention (n=54) and a control group who did not receive the intervention (n=46). The survey found that the intervention lead to improvements in health and wellbeing, increased comfort levels in the home and reduced use of health services (with associated potential cost savings for the NHS). The in-depth interviews and focus groups elaborated on the survey findings (the number of participants in the qualitative component were not given). Participants reported that the intervention had impacted positively on their overall health and wellbeing and that the new heating system was more economical. Interviewees reported satisfaction with the greater control afforded by oil-fired central heating (over solid fuel heating or electric fires). Specifically it enabled people to leave and return to a warm home. Householders also no longer restricted themselves to occupying one or two rooms. The authors conclude that the increased use of space in the home 'would have obvious impacts on quality of life, social functioning and familial relationships.'

One study aimed to develop a booklet that translated the findings from scientific studies into advice for older people on actions that can be taken to reduce health risk during episodes of cold weather.[40] The advice booklet was to be used with an 'early warning system' developed by the Met Office. The development of the booklet included discussion of the material with focus groups (one group of 12 people aged 64-76 years, one group of 10 people aged 71-87 years and one group of carers aged 19-89 years) and a field trial (37 participants aged 64-83 years). The focus groups and field trial revealed that while older people were aware of the risk of hypothermia during cold weather, few were aware of the cardiovascular risk of cold temperatures. In the field trial participants made behaviour changes in line with some of the advice provided in the booklet, such as wearing more layers and fitting draught excluders. However, participants resisted advice to keep household temperature at 21 c on the basis of the additional cost and advice to keep bedrooms windows shut at night based on a conviction that fresh air while sleeping was beneficial. One finding from both the focus groups and the field trial was a tendency for participants to suggest that the advice would be of benefit to 'other people' who were older, frailer and less knowledgeable than themselves. The authors suggest that an implication of this finding was that public awareness campaigns should include appropriate images to encourage those for whom the advice is intended to recognise it as relevant.

3.2.4 Housing interventions – evidence statements

Overall, there is reasonable evidence that housing interventions can improve respiratory outcomes for some children or adults with asthma and related conditions, with the strongest evidence coming from the larger scale randomised controlled trials in New Zealand and the UK; also evidence that housing interventions may improve various measures of mental well-being, at least in the short term, although evidence reporting in some studies has been selective; it is supported by qualitative evidence that has identified a number of pathways for psycho social well-being relating to energy efficiency improvement. Evidence about possible reductions in health service contact is mixed and much of it relates to (high-quality) studies in New Zealand which may have important differences from the UK. There is limited evidence that housing interventions may reduce absences in school for children with asthma.

ES2.1 EVIDENCE STATEMENT – Respiratory health

Fourteen papers provide mixed evidence on the impact of housing intervention on various aspects of respiratory health. Of these, 3 are RCTs from the UK (Woodfine *et al* 2011 and Barton *et al* 2007, both ++;[2 19] and Osman *et al* 2010, +)[11] while two are randomized controlled trials from New Zealand (Howden-Chapman *et al* 2007 and Howden-Chapman *et al* 2008, both ++).[6 9]

Of the remainder, six were UK before-after studies graded + (Green and Gilbertson 2008,[12] Walker *et al* 2009,[17] Richardson *et al* 2006,[20] Somerville *et al* 2000,[22] Hopton and Hunt 1996,[23] Shortt and Rugkasa 2007,[39] (the last of these being a before-after qualitative survey), one an analysis of national survey data (Critchley *et al* 2007),[13] and one a modelling study (Wilkinson *et al* 2009).[24] One study from Canada (Leech *et al* 2004)[21] was a prospective questionnaire of +/- quality.

Asthma

Six of these studies provide evidence about symptoms in children or adults relating to asthma: Woodfine *et al* 2011 (UK),[2] Howden-Chapman *et al* 2007 (NZ),[6] Howden-Chapman et al 2008 (NZ),[9] Walker et al 2009 (UK),[17] Barton *et al* 2007 (UK),[19] and Shortt and Rugkasa 2009 (UK).[39] Four studies show improvements in various measures relating to asthma symptoms, including PedsQL,[2] self reported wheeze in children,[6 9] and time off work or school.[6 9] One study, Barton et al 2007,[19] found no difference in self reported symptoms or severity of asthma but significant reductions in non-asthma-related chest problems (Mann–Whitney test, $p = 0.005$) and the combined asthma symptom score for adults (Mann–Whitney test, $z = 2.7$, $p = 0.007$). In a prospective controlled study of 1281 households in Scotland receiving new central heating under a publicly funded initiative, covariate-adjusted associations between ‘‘treatment group’’ membership (heating recipient vs comparison group household) also indicated no clear difference in ‘ever diagnosed with asthma’ OR 0.92 (0.63 to 1.34) or whether respondent has ever been diagnosed with bronchitis OR 1.29 (0.97 to 1.72).[17]

COPD

One UK study, Osman *et al* 2011 (+),[11] examined respiratory and general health in a group of patients living at home with COPD. Its intention-to-treat analysis did not find any improvement in health, but analysis looking at those who received the intervention found improvements in respiratory symptom scores. This was not associated with increases in indoor warmth.

Other measures, including general respiratory symptoms

Six papers, all graded +, included five from the UK (Green and Gilbertson 2008,[12] Critchley et al 2007,[14] Richardson *et al* 2006,[20] Somerville *et al* 2000,[22] Hopton and Hunt 1996,[23]) and one from

Canada (Leech *et al* 2004 [21]) examined the impact of housing interventions on general respiratory health. There was no clear evidence of impact on respiratory health from the *Warm Front* evaluation (Green and Gilbertson 2008,[12] Critchley et al 2007 [14]), or from an evaluation of housing improvements in socially rented housing in Torquay (Richardson et al 2006)[20] or from a longitudinal controlled study of a housing intervention in Scotland (Hopton and Hunt 1996).[23] A study of the installation of central heating in Cornwall, Somerville *et al* 2000,[22] reported evidence of reductions in all symptoms after the intervention, with the greatest reduction seen in nocturnal cough (median score of 3 (most nights) to 1 (one or several nights) in the previous month).

Less relevant to current UK housing interventions are the results of a Canadian study (Leech *et al* 2004)[21] which examined by questionnaire, the self-reported health of people occupying energy efficient new dwellings with mechanical ventilation compared to otherwise similar new dwellings, which provides some indication of positive impact on respiratory health.

Long term and mortality outcomes -- modelling study

The results of a simulation study of energy efficiency interventions in the home in the UK(Wilkinson et al 2009,+/-)[24] suggests there may also be potential benefits for longer term respiratory outcomes, but this depends on potentially important risk trade-offs for different exposures relating to reduced uncontrolled ventilation.

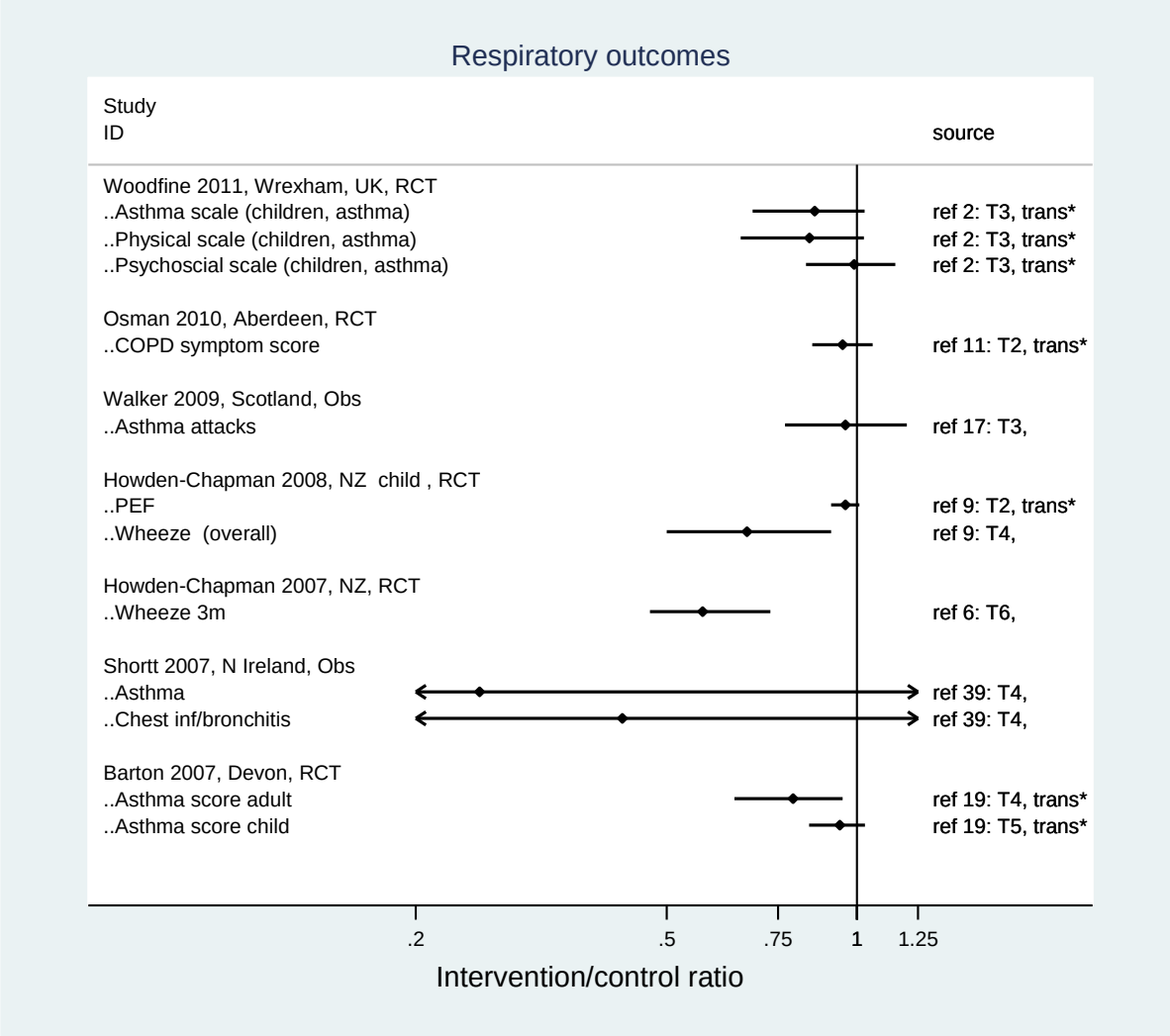


Figure 2. Forest plot of intervention/control ratios for respiratory outcomes: housing-related interventions. Note: trans* indicates that the intervention/control ratio is calculated from a difference measure.

ES2.2 EVIDENCE STATEMENT -- mental well-being

Nine studies address mental well-being, of which seven were quantitative studies (one RCT from New Zealand graded ++ (Howden-Chapman *et al* 2007),[6] four were before-after studies from the UK graded + (Green and Gilbertson 2008, Critchley *et al* 2007, Walker *et al* 2009, Hopton and Hunt 1996),[12 14 17 23] one a study of randomized housing upgrades among council properties in South Devon (The Watcombe Housing Study, Barton *et al* 2007, graded ++)[19] and one a German before-after study graded +/-.[5] Two qualitative studies were from the UK: Gilbertson et al 2006 graded ++,[37] and Shortt and Rugkasa 2007 graded +.[39]

Five of the seven studies with quantitative evidence had measures that could be summarized as intervention/control ratios in Figure 3. They include one of the New Zealand RCTs Howden-Chapman et al 2007, graded ++)[6] which reported better health outcomes in adults for three domains of the SF36; the Watcombe Housing Study (England),[19] which showed no clear difference in SF36 or

GHQ12 scores although full data were not tabulated; and the relatively small longitudinal study in Scotland by Hopton and Hunt (+)[23] with results for children, which showed no clear evidence of effect on mental-well being or most other measured outcomes. The controlled natural experiment examined in the *Warm Front* evaluation in five urban areas of England provided evidence that intervention had positive impact on the proportion of people with GHQ-12 scores of 4 or more but not other outcomes.[12 14]

Qualitative studies add to the evidence. During in-depth interviews undertaken as part of the *Warm Front* evaluation, most reported improved and more controllable warmth and hot water; many reported perceptions of improved physical health and comfort, especially of mental health and emotional well-being and, in several cases, the easing of symptoms of chronic illness. There were common reports of improved family relations, an expansion of the domestic space used during cold months, increased privacy within the home, improved social interaction, and an increase in comfort and atmosphere within the home.[37] A qualitative study of 54 homes in a rural community in the Armagh and Dungannon Health Action Zone (Shortt and Rugkasa 2007),[39] suggested improvements in well-being, increased comfort levels in the home (as well as reduction in the use of health services).

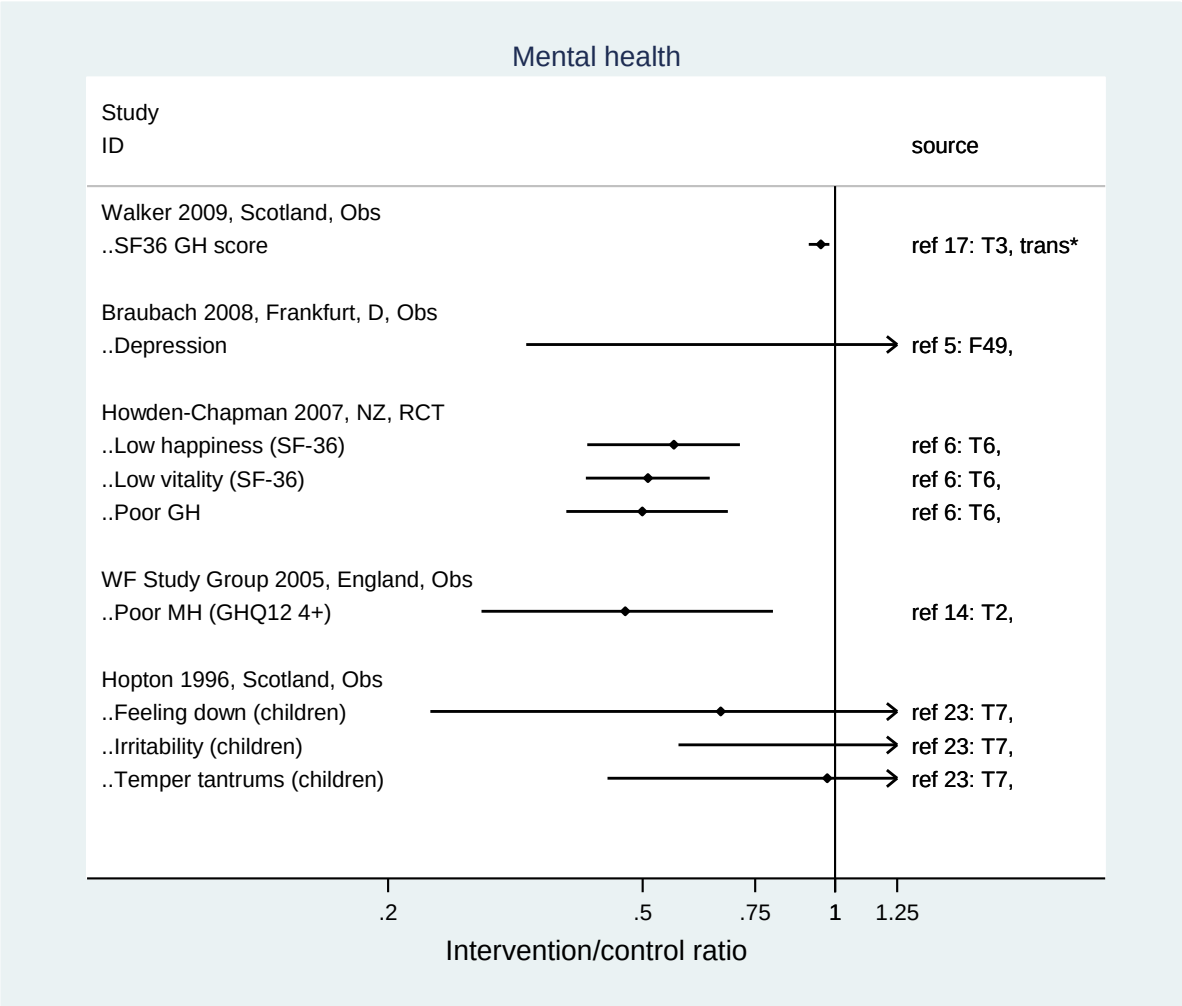


Figure 3. Forest plot of intervention/control ratios for mental health outcomes: housing-related interventions. Note: trans* indicates that the intervention/control ratio is calculated from a difference measure.

ES2.3 EVIDENCE STATEMENT – General health

Six studies consider various measures of general health and wellbeing, including two RCTs from New Zealand graded ++ (Howden-Chapman *et al* 2007, Howden-Chapman *et al* 2008),[6,8] one RCT from Japan graded ++ (Saeki et al 2001),[1] and three studies from the UK each graded + (Osman *et al* 2010, Green and Gilbertson 2008, Critchlet *et al* 2007).[11 12 14]

Various measures of general health and well-being have been reported including from two RCTs in New Zealand of adults and children(++),[6] and of children alone (++).[8] These studies targeted households where at least one member (adult or child) had some form of respiratory illness. Another comparatively small randomized trial (of COPD patients) in Scotland,[11] reported no clear difference in the Euroqol Visual Analogue Score. No clear differences following intervention were observed in the Warm Front evaluation(+).[12 14] A Japanese study provides evidence in relation to level of home heating and blood pressure variation.[1]

ES2.4 EVIDENCE STATEMENT – health care contacts

Four studies have provided quantitative evidence about changes in contact with the health service (either hospital admission or GP consultation). They include two papers reporting results of a randomized controlled trial (++),[6 9] and one observational study (+)[4] from New Zealand with somewhat mixed evidence, and the controlled study by Walker and colleagues on the effects on health of a publicly funded domestic heating programme(+),[17].These did not report evidence of any difference in health care contacts for primary care or hospital. The Osman study of housing intervention for COPD in Aberdeen also provided no clear evidence about impact on hospital admission, but its' comparatively small size and 'cross-contamination' are worth noting.[111] Evidence from two qualitative studies has opposing evidence: one suggesting no reduction in health care contacts [37] and another that such contacts *may* be reduced.[39]

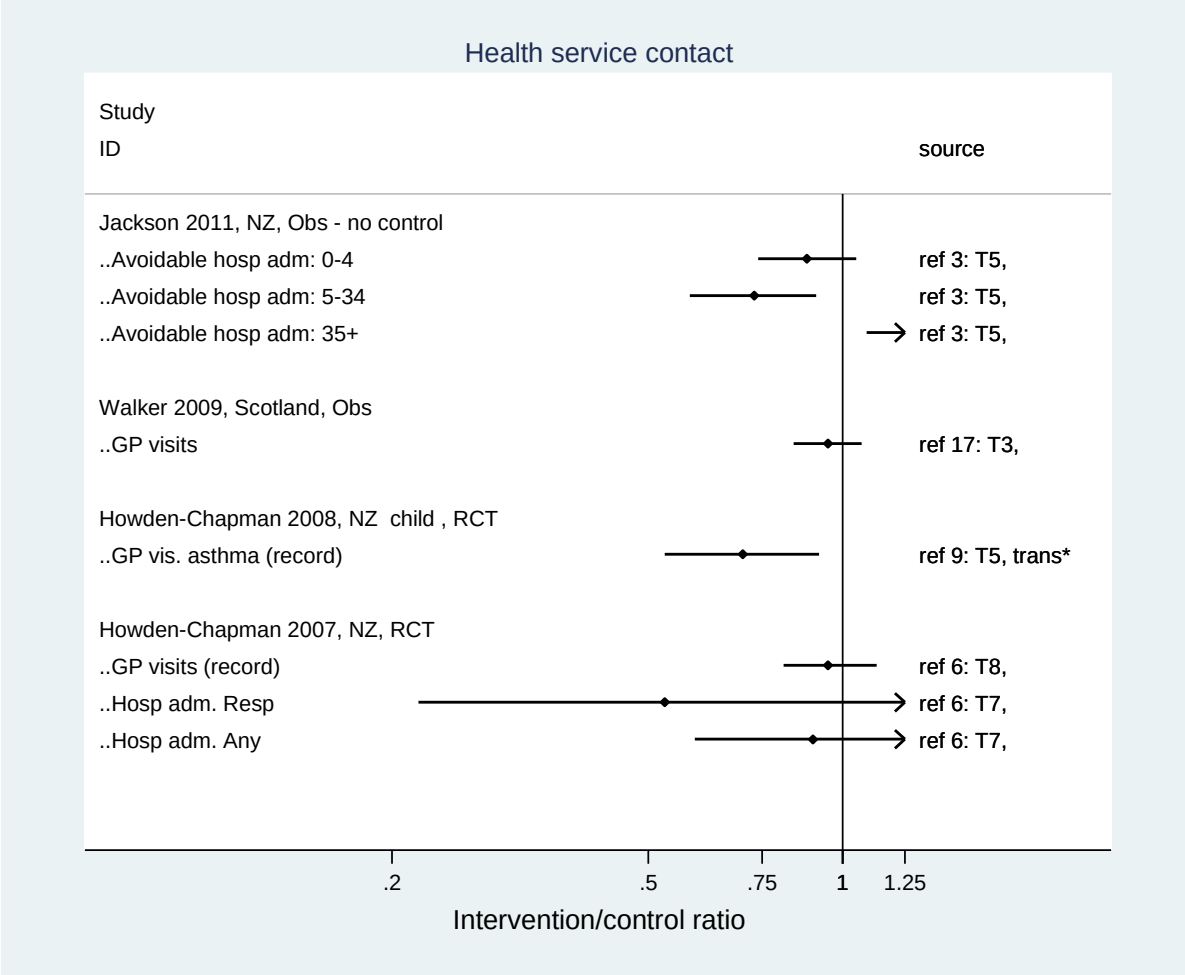


Figure 4. Forest plot of intervention/control ratios for heath service contacts: housing-related interventions. Note: trans* indicates that the intervention/control ratio is calculated from a difference measure.

ES2.5 EVIDENCE STATEMENT – absence from school

Randomized controlled trials from Wrexham, UK (++),[2] and New Zealand (++)[10] and an observational study in Cornwall (+),[22] all provide quantitative evidence about housing interventions and absence from school. The evidence suggests reductions in school absence in two of the studies and more equivocal evidence in the (small subset of the) Woodfine study.[2]

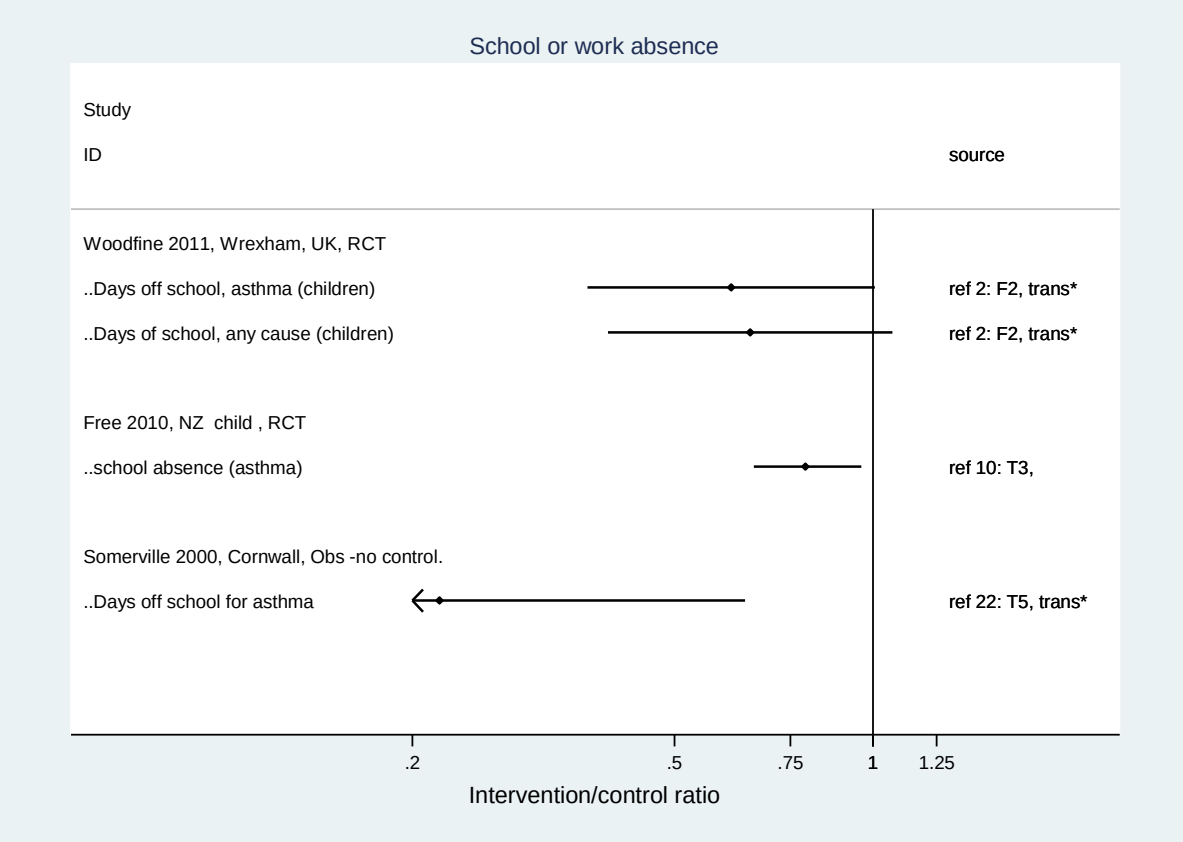


Figure 5. Forest plot of intervention/control ratios for school or work absence: housing-related interventions. Note: trans* indicates that the intervention/control ratio is calculated from a difference measure.

3.3 Intervention studies – health forecasting (in COPD)

Several UK studies have examined the effect of health forecasting systems in relation to the management of patients with chronic obstructive pulmonary diseasde (COPD). Such a health forecasting system had been run for a number of years by the UK Met Office, though since abandoned. Several published evaluations have been carried out[25 26 27 28] including by teams partly allied to the service provider.[26 27]

A study by Bakerly and colleagues of the effect of the COPD health forecasting on hospitalisation and health care utilisation in patients with mild-to-moderate COPD,[25] found that based on data for a total of 157 (34% of target COPD population) and five weather alerts there was a statistically non-significant increase in hospital admissions per patient (0.07-0.076; p = 0.83) and a fall in the number of general practice visits per patient from 4.9 to 3.8 (p = 0.001), with a drop in average number of visits to patients by out-of-hours services from 0.52-0.14 (p = 0.013). The average number of home consultations provided by general practice increased from 0.05 to 0.92 (p = 0.001).

A further study by Halpin and colleagues, was a 4-month randomized controlled trial of the effect of automated interactive calling combined with a health risk forecast on the frequency and severity of exacerbations of COPD.[26] Based on data from 79 patients and 40 received alert calls, the exacerbation frequency per patient per week was significantly greater during periods of predicted high risk. The exacerbation frequency (+/- standard error of the mean, SEM) in patients receiving alert calls was lower (0.95 +/- 0.27 v 1.17 +/- 0.29) but this was not statistically significant. Fewer patients receiving alert calls had one or more defined events compared to the controls (34% v 53%, p=0.11), their duration was shorter (8.2 +/- 2.0 v10.1 +/- 1.9 days, p=0.481) and they were less severe (65 +/- 21 v 115 +/- 22, p=0.118).

Some of the same authors reported on the experience of service users[28] and concluded that combining a rule-based model predicting risk based on environmental conditions with an anticipatory care intervention providing information on self-management and warnings via an interactive telephone call, the majority of respondents deemed the information pack (comprising a booklet and thermometers) useful while the automated calls were generally said to be convenient, easy to understand and reassuring. Most benefit was reported by those patients who were willing to be pro-active in the management of their condition

An evaluation which was independent of the service provider was conducted by Maheswaran and colleagues.[27] This examined the forecasting alert service available to general practices in Bradford and Airedale for the winter of 2007-08 on reduced COPD admissions. They compared admissions in 2007-08 with 2006-07 when the service was not available and found admission rate ratios for practices using the service were 0.98 [95% confidence interval (CI): 0.78-1.22] for December to March, and 0.82 (CI: 0.57-1.18) and 0.95 (CI: 0.72-1.26) for the 7- and 14-day post-alert periods, respectively. However, when account was taken of the proportion of patients entered on the alerts system and the duration for which practices participated in the service, admission rate ratios for practices fully using the service were 1.11 (CI: 0.80-1.52), 1.22 (CI: 0.73-2.04) and 1.21 (CI: 0.82-1.78) for the three corresponding periods.

The Cold Weather Plan (CWP) for England also entails a national alert system linked to weather forecasts for vulnerable groups. It has not yet been subject to a formal evaluation entailing empirical assessment of impact on health outcomes, though a recent evaluation provides qualitative evidence about the understanding of the alerts system and operational factors.[41] This found that those with the main responsibility for identifying at risk individuals, namely, health and social care managers, tended to think of 'vulnerability' in terms of socio-economic deprivation and existing clients (i.e. people who were in receipt of social care services such as home care) which may therefore miss some people who are vulnerable during cold weather (because they don't use services) and include some people who are not (e.g. because they live in a warm home). Many services, such as home care, are contracted out to independent providers. While the CWP and the cold weather alerts were a useful aid to prompt providers about actions that should be taken during cold weather, commissioning managers could not be sure that the actions set out in the CWP for front-line staff (such as checking room temperature) were being undertaken. Engagement with primary care was also found to be variable, and local leadership of implementation of the CWP tended to be with emergency planning staff rather than with public health staff, and emergency planners felt limited in what attention they could give to prevention.

Interviews with a sample of older people in this evaluation[41] indicated that while respondents thought cold weather may exacerbate existing conditions there was little knowledge of the risks to health associated with cold temperatures. Although all respondents were in regular contact with a health professional, none had received any advice or support related to cold weather. There was a universal preference for turning the heating off at night (for comfort), a universal fear of falling during icy conditions which was the greatest concern for participants. As a consequence respondents would stay inside when the risk of falling was thought to be high (i.e. during periods of ice and snow). Respondents would however go out as soon as it was thought safe to do so, to socialise or fulfil responsibilities (such as voluntary work) or simply to 'get out'. Nearly all respondents were reliant on public transport, with participants from the rural case study in particular facing arduous journeys to access facilities such as shops, exposing them to cold outdoor temperatures. The risk of poor health during cold weather was mediated by instrumental social support provided by family (predominantly) or neighbours. This took the form of car journeys, hot meals, shopping, repairs, help with heating technology, and monitoring health and wellbeing.

ES2.6 EVIDENCE STATEMENT -- health forecasting

Four UK studies (one randomized controlled trial, Halpin *et al* 2011, +),[26] two before-after intervention analyses (Barkerly *et al* 2011, and Maheswaran *et al* 2010, both +),[25 27] and one cross sectional questionnaire-based study (Marno *et al* 2010, -),[28] provide no clear evidence of the effect of the health forecast system for COPD on hospital admission and primary care contacts. Although at least one study suggests evidence for acceptability of the service, the pattern of findings across the four studies, does not allow robust conclusion on the impact of the forecast system in improving health outcomes or hospital admission for disease exacerbation.

Qualitative evidence from the national-level evaluation of the Cold Weather Plan for the England (+)[41] suggests that while the CWP and the cold weather alerts are a useful aid to prompt providers about actions that should be taken during cold weather, commissioning managers could not be sure that the actions were being undertaken, and that leadership is often with emergency planning staff (rather than say primary care teams) who feel they have limited capacity for health protection.

3.4 Intervention studies - Influenza vaccination in COPD

Other studies have examined the effect of influenza vaccination in COPD on (winter or flu season) mortality. Two studies were identified. The first was a nationwide analysis of data for Japan to examine the effect of a change in law, passed in November 2001 in which the Japanese government amended the Preventive Vaccination Law to specify elderly people aged >= 65 years as the target population for influenza vaccinations.[29] Analysis of monthly data for January 1995 to December 2009, analysed by Poisson regression, suggested a statistically significant reduction in the COPD mortality rates observed in January (RR 0.84; 95% CI 0.81-0.88), February (RR 0.85; 95% CI 0.81-0.89) and March (RR 0.92; 95% CI 0.88-0.96) among the population aged >= 65 years in contrast to the results for younger ages.

Two other, related studies in Spain[30 31] used a prospective cohort of 1298 Spanish community-dwelling individuals aged 65 years or older with COPD followed from 1 January 2002 to 30 April 2005. The primary outcome was all-cause death during influenza periods (January-April). Multivariable Cox proportional hazard models adjusted by age, sex and comorbidity were used to evaluate vaccine effectiveness. Multivariable analysis showed a statistically insignificant trend towards a reduced mortality in the vaccinated group considering overall influenza periods 2002-2005 (adjusted HR: 0.76; 95% CI: 0.52-1.06; p=0.098).

ES2.7 EVIDENCE STATEMENT – influenza vaccination in COPD

This review was not designed to gather evidence on the efficacy of influenza vaccination, or its effect in reducing mortality and morbidity. However four observational studies, one from Japan(Kiyohara *et al* 2013, [29]+) and three from Spain (Vila-Corcoles et al 2007, Vila-Corcoles et al 2008, de Diego et al 2009, all +)[32 30 31] provide suggestive evidence that influenza vaccination may protect against mortality risk during winter or the influenza season in the older population, especially those with chronic heart or lung disease. Measures that increase uptake of vaccination for such vulnerable groups are therefore likely to have beneficial effect on such mortality/morbidity.

3.5 Intervention studies – Anti-slip or gait stabilizing devices for preventing falls

We identified three studies that examined the potential effect of anti-slip or gait stabilizing devices.

A Swedish study by Berggard and Johansson,[33] was a small randomized controlled trial of anti-slip attachments to shoes among participants recruited from employees at Luleå University of Technology. The anti-slip devices included a heel device, a foot-blade device or a whole foot device. The trial included the use of a diary to record use of the device, distances walked, and falls/injuries. There was appreciable cross-contamination of groups (device wearers in the control group etc) and so the authors' main conclusions were based on comparison of users vs non-users, which is open to appreciable selection bias. Their principal observation was that users of anti-slip devices walked appreciably further per day than non-users at a very similar *daily* risk of falls but therefore lower risk of falls per kilometre walked. Only a limited statistical analysis was presented.

Another small study from New Zealand is a randomized trial of wearing socks over shoes to improve traction on icy footpaths.[34] The authors report that wearing socks over normal footwear was associated with a statistically significant improvement in traction as reflected in mean self-reported slipperiness scores between the control (n=15) and intervention (n=14) groups (which appeared to correspond well with observer ratings). The intervention group also appeared more confident on the slippery surface. However, this study had a number of weaknesses: the participants were simply intercepts of passers-by of the trial location, the sample size was small, there were appreciable baseline differences between intervention and control groups, neither participants nor observers were blinded to the intervention, and the test characteristics of the slipperiness rating are unclear. What this small study may signify, however, is that various forms of anti-slip device, including in this

case 'over-socks', may help reduce the risk of slips on slippery surfaces. But it does not provide any basis for quantifying the change in risk of a fall or injury.

A similar but higher quality US prospective randomised intervention trial by McKiernan[35] examined whether a nonmedical gait-stabilizing device, prevents outdoor falls and injurious falls in fall-prone older people during the winter. The study of ambulatory, community-dwelling, but fall-prone people aged 65 and older were randomized to wear the device or their usual winter footwear (UWF) outdoors during the winter of 2003/2004. The 109 participants completed 10,724 diary days. The relative risk (RR) of outdoor slip for the device was 0.50 (P<.04) for all diary days and 0.61 (P=.14) when only days walked on snow and ice was the exposure variable. The RR of outdoor fall for the device was 0.42 (P<.03) when only days walked on snow and ice was considered. The relative risk of injurious falls per day walked on snow and ice for the device was 0.13 (P<.02). The authors estimate that the number needed to treat with the the device to prevent one non-serious injurious fall in one winter was six.

ES2.8 EVIDENCE STATEMENT – anti-slip devices for preventing falls

Three studies of anti-slip devices/measures were from outside the UK: one each for Sweden (Berggård et al 2010, -/+),[33] New Zealand (Parkin et al 2009, -/+),[34] and the US (McKiernan FE 2005, +).[35] The first two were relatively weak studies with appreciable potential for bias, though the US study of a proprietary footware device (elastomere overshoe netting) was more robust. Even though their evidence is very limited, they suggest potential for reduction in fall and fall-related injury risk with similar devices worn during slippery/icy conditions.

3.6 Intervention studies – Thermal clothing in heart failure

Only one intervention study was identified of thermal clothing in this review, a small pilot randomized controlled trial. This study by Barnett and colleagues examined the benefits of thermal clothing during winter in 55 patients with heart failure over 50 years of age not in residential care in south-east Queensland. Participants randomized to the intervention received two thermal hats and tops and a digital thermometer. The primary outcome was the mean number of days in hospital, with secondary outcomes the number of general practitioner (GP) visits and self-rated health. The study did not have a sufficient sample size to determine key outcomes with precision, but it showed no clear evidence of benefit in the intervention arm in terms of the key primary or secondary outcomes: the mean number of days in hospital per 100 winter days was 2.5 in the intervention group and 1.8 in the usual care group, mean difference of 0.7 (95% CI −1.5 to 5.4); the intervention group had 0.2 fewer GP visits on average (95% CI −0.8 to 0.3), and slightly higher self-rated health, mean improvement –0.3 (95% CI −0.9 to 0.3). The thermal tops were generally well used, but even in cold temperatures the hats were only worn by 30% of the participants.

ES2.9 EVIDENCE STATEMENT – thermal clothing in heart failure

This single Australian study by Barnett et al 2013 (+),[36] though apparently well-conducted, was too small and its results too inconclusive to draw a clear interpretation, other than the need for further study of the potential utility of thermal clothing especially to vulnerable patient groups.

3.7 Intervention studies – Discussion

3.7.1 Intervention studies – Quality

As with much literature on excess winter mortality and morbidity the evidence on housing related interventions is very heterogeneous and mixed in quality. The randomized trials and controlled comparisons based on staged interventions represent fairly strong study designs. While there are good randomised controlled trials from New Zealand, Japan (in relation to BP measurements) and the UK, the CHARISMA study (Woodfine[2]) was primarily a specific ventilation intervention for asthma sufferers and only a small subset of the study population received heating intervention; and the Osman study[11] had appreciable cross contamination and its effective sample size was also small. It is also difficult to blind recipients (and sometimes researchers) to housing interventions, and many of the recorded outcomes were based on patient- or parent-reported symptoms. In such circumstances and with such outcomes it is difficult to assess the potential for bias where intervention recipients are likely to be pleased to have received an upgrade to their dwelling usually at no direct cost to themselves. This is especially so given relatively short-term follow-up. However, studies did include more 'objective' outcomes, including Peak Expiratory Flow Rate (PEFR) and blood pressure, doctor records of consultations and diagnoses, as well as measures of days off work or school, and instrument-based measures of mental well-being. With a few exceptions, individual studies were comparatively modest in size, which affects power and precision. The fact that usually multiple outcomes were measured adds to the complexities of interpretation, especially when similar outcome measures (or different dimensions of a measure) gave different patterns of results (e.g. the different dimensions of psychosocial well-being assessed in the *Warm Front* evaluation[15]). Longer term consequences of intervention were also generally not studied, nor impacts on 'hard' endpoints such as mortality, mainly for reasons of time lag and required sample size. The generally good qualitative studies add context and further understanding of pathways, and thereby help to provide a more complete picture of pathways and impacts.

The evidence in other areas is even more patchy, with no other single form of intervention having as large an evidence base as that of housing. Evidence is still needed and is awaited on the various measures of the Cold Weather Plan for England, including its health forecast and alert system, and studies published to date have not been large enough or sufficiently robust to provide clear evidence about the effectiveness of warning systems for particular vulnerable groups, notably those with COPD.

The evidence considered in this review for influenza vaccination and anti-slip devices as well as warmer clothing for vulnerable patient groups was limited.

3.7.3 Intervention studies – Implications of findings

That home energy efficiency improvements have the potential to improve health, especially for those with respiratory illness, and mental well-being, provides an additional rationale to pursue policies to upgrade the efficiency of the housing stock for particular target groups as well as the population in general. For some key target groups, such as children with asthma, housing intervention may be sufficiently justified in its own right as a means of helping to manage the clinical condition. However, the evidence base still remains limited, and there is potential for unintended adverse consequences of some forms of energy efficiency upgrade over the longer term, particular in relation to changes in ventilation characteristics of dwellings. This is an area in which there is particular lack of hard empirical evidence, and so more research is needed. How the costs of housing upgrades are shared remains an issue, as the costs and benefits do not necessarily fall on the same individual or institution, and more elaborate forms of intervention will be relatively costly. It is unclear how far such interventions need to be justified in health terms alone.

In other areas, this review again adds weight to ensuring high levels of uptake of influenza vaccination , especially among the elderly with chronic heart and lung disease; it suggests the need for further evaluation of health forecasting and alert systems for diminishing vulnerability during periods of severe cold and other adverse weather; and it suggests the need for further enquiry into the potential benefit of low-cost solutions for improving the traction of footwear during periods when pavements and roads may become slippery.

3.7.4 Intervention studies – Limitations of the evidence and gaps

The evidence on the different forms of ntervention that may help reduce the burden of winter and cold-related mortality and morbidity remains limited in general, so that there is a need for research in all areas. This is especially so given that the influence of housing quality on health may be very context specific so that extrapolation of results from one country to another should be done with caution. Specific research needs include:

-- studies of the effect of different forms of housing intervention, including studies that evaluate as wide a range of outcomes as possible, including mortality, hospital admissions and outcomes that may be affected over the longer term by changes in indoor air quality; studies need to be of sufficient scale and to employ methods of objective measurement;

-- studies of the effect of fuel prices and fuel poverty on health, whose assumed influence has not been adequately quantified through high-quality empirical research;

-- studies of the policy environment and operational factors to determine how policies may be justified and aligned to support health, environmental and other objectives simultaneously;

-- studies of the operational characteristics and effectiveness of targeted warning systems designed to help protect vulnerable population groups during periods of heightened risk;

-- studies that examine the potential effect of simple protective measures such as the use of improved clothing and footwear, and the uptake of vaccinations;

3.7.5 Intervention studies – Limitations of the review and impact on findings

Evident limitations of the review include the fact that it was limited to English language and OECD countries, though it is likely that many of the important factors are to a large degree specific to the local context -- local climate, housing, and other factors. The heterogeneity of studies, especially with the diversity of study designs and coming from multiple settings, makes it difficult to draw firm conclusions, and interpretation is also made more complex by changes over time that may appreciably alter the context in which interventions in housing and other sectors occur.

4 Findings – Economic analyses

4.1 Economic analyses – Summary of evidence

The review identified on 13 relevant economic analyses. However, these studies related only to interventions which improved household energy efficiency. Even this literature is not large, though it is certainly heterogeneous. The studies divide into two main groups, those undertaken at a national level and those at a local level.

4.1.1 National level studies

Jensen *et al*. [42] compared a number of policy simulations, including improved insulation and ventilation of the housing stock with a counterfactual in a general equilibrium model. Focussing on health-related net cost reductions they found that this investment would probably break even over a thirty year time horizon. They modelled the impact of improved household temperature and reduced particulate concentrations on cardiovascular disease, depression, cardiopulmonary disease and lung cancer. They also included health harms as a consequence of improved insulation. Health benefits were measured in terms of Years Lost due to Disability and Years of Life Lost. The model translated these into implications for GDP, that is, health improvements were not valued per se. They predicted a gross loss to the economy of £49.4 billion but this was halved when the energy efficiency gains (£24.4 billion) and health benefits (£450 million) were considered.

Cambridge Econometrics[43] made a macroeconomic assessment for the UK of investment in household energy efficiency in households at risk of fuel poverty and households with fuel poverty as compared to other ways of spending a similar amount of money. The multi-sectoral model identifies the benefits to the construction sector and then estimates the multiplier effect for the economy as a whole. The benefits of improved energy efficiency are assumed to arise from reductions in energy demand. The model recognises that some of the potential energy savings will not accrue as some fuel poor households will choose to heat their houses to a higher temperature. No health benefits are considered.

Sefton[44] assesses the cost-effectiveness of targeting grants for better ventilation and new heating systems in England. His measure of effectiveness is the change in the fuel poverty gap (the difference between what a household needs to spend annually to heat their house satisfactorily and ten per cent of their annual income). No benefits to health are included nor any carbon reduction benefit. He estimates the ratio of potential savings to the annualised cost of the energy efficiency measures.

Liddell[45] assesses the extent to which the costs of the Warm Homes programme in Northern Ireland were offset by health benefits. Health benefits were estimated in terms of QALYs (valued at £40,000 per QALY) and reduced NHS costs. The latter were found to be a small percentage of the former.

Levy *et al*.[46] consider how improved insulation in the US would result in lower energy use and reduced air pollution leading to fewer deaths, asthma attacks and restricted activity days. Although

it is an economy-wide assessment it is not a general equilibrium analysis. They estimate annual energy savings of $5.9 billion and morbidity and mortality benefits of $1.3 billion annually. They provide a fuller discussion than many others of the considerable uncertainties involved in making such estimates.

Grimes *et al*.[47] evaluate a national programme providing subsidies for insulation and clean heating in New Zealand. In addition to the costs of insulation and clean heating, they consider administrative costs and the deadweight cost associated with the taxation required to provide the subsidies. The benefits arise from energy savings, reductions in emissions and improved health outcomes (measured in terms of cost savings from reduced hospitalisation and pharmaceutical use, and reduced mortality). The greater part of the health benefits were in terms of reduced mortality (valuing life years at £75,000).

Clinch and Healy[48] modelled the costs and benefits anticipated to be associated with the retrofitting of 1.2 million houses in Ireland, using valuations from a range of sources. They estimate the mortality and morbidity benefits of reduced cardiovascular disease and respiratory disease. They also estimate the benefits of reduced energy consumption and reductions in emissions.

4.1.2 Local level studies

The studies undertaken at a local level generally involve more primary data collection than those at a national level and sometimes utilise randomised trial designs. Two such studies have been reported using data for New Zealand. Chapman *et al*. (2009)[7] undertook a cluster randomised trial of retrofitting insulation in households where at least one person had respiratory symptoms. Baseline data were collected for the three winter months in 2001 and follow-up in the three winter months of 2002. While they did collect SF36 data these were not used to estimate QALY gains.

Preval *et al*. (2010)[49] report the cost-effectiveness of improving heating in households (with satisfactory insulation) containing a child with asthma. The data were collected as part of a trial the Housing, Heating and Health Study. Monetary values were assigned to changes in visits to health professionals, medication use, time off school or work, and energy use. Positive benefit-cost ratios were only associated with targeted interventions.

Barton *et al*.[19] evaluated a randomised trial of housing improvement in Devon. No difference was found in hospitalisation, A & E attendances or pharmaceutical use, or in SF36 or GHQ12. The authors suggest that this might be because the short period of follow-up.

Edwards *et al*.[50] estimated the cost-effectiveness of the installation of ventilation and central heating in the homes of children with moderate to severe asthma. The data came from a randomised controlled trial in Wrexham. Cost effectiveness is measured in terms of the cost of achieving a unit change in the PedsQL and is thus difficult to interpret. However, since the time horizon is only one year, it is plausible that it was a cost-effective use of resources particularly in the case of households containing a child with severe asthma.

Liddell *et al*.[51] undertook a cost-benefit analysis of the Kirklees Warm Zone Project. Safety improvements produced a benefit of £1.30 million (largely due to a predicted reduction in

mortality). The benefits of improved insulation were estimated to be £2.28 million (wholly as a result of the reduction in common mental disorders). Installation of central heating generated a benefit of £1.27 million (assuming each pound spent produces health benefits of forty-two pence). Overall the project was estimated to have produced twenty pence of health benefit per pound spent.

In the BRE study of the improvement of 32 dwellings in Derby[52] the cost of mitigating particular hazards and the anticipated NHS cost savings were estimated. Thus improvements in health are only valued to the extent that they reduce healthcare expenditure. Savings to society were assumed to be 2.5 times the NHS cost savings.

ES2.10 EVIDENCE STATEMENT – economic analyses

This section discusses 13 studies which attempt an economic analysis.[19 53 43 52 44 45 46 47 48 50 51 49 7]

In summary there are many differences between studies which makes any attempt at synthesis challenging. Two UK studies undertaken for the economy as a whole (both +), take into account the effect of changes in one sector on the rest of the economy;[43 53] others do not.

Other 'national' level assessments include studies in England (Sefton 2002, +),[44] Northern Ireland (Liddell 2011, +),[45] Ireland (Clinch and Healy 2000, +)[48] New Zealand (Grimes *et al* 2011, +)[47] and one US study focussing only on air pollution-related impacts (Levy et al 2003, +/-)[46]

Some studies performed at a local level are trial-based, including an English study (Barton and colleagues 2007, +)[19], a Welsh study (Edwards and colleagues 2011, ++)[50], and two NewZealand studies (both +)[7 49] while others are more dependent on observational data (Liddell 2011, +)[51] and (BRE, +/-)[52]

The health benefits have been measured in various ways. Savings in health care costs have usually been included. Some studies estimate QALY gains (at least for changes in morbidity). Studies including a change in mortality have used the value of a statistical life. It is likely that the balance of (health-related) costs and benefits varies from setting to setting, with the precise form of intervention being considered, and from whose perspective the economic assessment is done.

4.2 Economic analyses – Commentary

4.2.1 Economic analyses – Quality of evidence

The available evidence is mixed. It is not clear how applicable cost-effectiveness information from other countries is to the UK (costs will differ, climate will differ, existing housing stock will differ, willingness to pay for particular benefits will differ). There is likely to be substantial variability in the reporting of the different studies and studies are variable in the extent to which they explore the uncertainty about their findings. Studies vary with respect to which health and non-health benefits

they include. A number of different approaches have been taken to the assessment of health benefit. All of this contributes to the complexity of interpreting economic assessments, and drawing general conclusions about costs and benefits.

4.2.2 Economic analyses - Implications

Taken together these studies support the view that there are health benefits to be obtained from improvements in household energy efficiency. However, if viewed solely as means of improving health these investments would (usually) not be justified; but once a wider range of benefits are considered they appear to be worthwhile investments.

The wide range of approaches that have been undertaken highlight the potential value on having an agreed Reference case for the economic assessment of public health interventions.

4.2.3 Economic analyses – Limitations of the evidence and gaps

Given the disparate outcomes which these investments can produce more research is required into means of making the different benefits commensurate. More needs to be known about the distribution of health and non-health benefits across different household types in order to design more cost-effective interventions. An important issue is the degree to which the balance of cost and benefits depends on the form of intervention, who the recipient is, and whose costs are counted and how (including over what time horizon). More elaborate forms of intervention are likely to have relatively lower returns for health in relation to each unit of expenditure.

4.2.4 Economic analyses – Limitations of the review and potential impact on findings

The principal limitations are its restriction to the English language and the fact that evidence from one setting may not be directly transferable to another setting. It is also a complexity that the evidence is so diverse that it is difficult to capture evidence relevant to all the important forms of intervention, and the factors that bear on the costs and benefits.

5 Conclusions

(1) Evidence on interventions that may help reduce the multiple factors contributing to excess winter- and cold-related mortality/morbidity remains limited and very heterogeneous.

(2) There is a limited body of evidence that suggests that energy efficiency interventions in housing may improve the health of some population groups, notably those with

respiratory (asthma, COPD) and other chronic diseases, especially in the elderly and young children. Positive effects on health may include improvements in respiratory symptoms and the symptoms of other chronic illnesses, improved mental well-being, reduced contacts with the health service and fewer days of absence from school or work.

(3) However in many areas the evidence is fragmentary, and no single study has captured a comprehensive range of potential health impacts, including those that relate to mortality and the long-term effects of exposures, especially those relating to changes in the ventilation characteristics of dwellings. Without improved understanding of the full spectrum of positive and negative health effects of energy efficiency upgrades, it will not be possible to ensure that interventions are appropriately tailored to maximize the positive benefits and minimize unintended adverse consequences.

(4) For some target groups, specific forms of housing intervention may be justified on the basis of their benefits to health alone. This may be the case for children with asthma, for example. However, for lower risk target groups and with increasingly elaborate forms of intervention, the health effects may add to the case for actions to improve energy efficiency, but such actions are more readily justified if the health effects are considered alongside other social, environmental and economic consequences.

(5) We were unable to identify robust empirical literature that enables the link between fuel price, fuel poverty and health to be quantified.

(6) Although this review was not aimed at capturing evidence on the efficacy of influenza vaccination, there is evidence to suggest potential benefit for the elderly population and those with chronic disease of the increased uptake of flu vaccination. Although these are among target groups for flu vaccination, there is likely to be benefit from improving vaccine uptake.

(7) Evidence relating to the effect of health forecasting and alert systems for cold weather remains limited. Local evaluations of alert systems for COPD patients have yet to demonstrate clear evidence of positive effect in reducing disease exacerbations or hospital admission or mortality, though this remains possible.

(8) The evidence of this review was insufficient to draw firm conclusions about the usefulness and most effective forms of anti-slip devices and the thermal characteristics of clothing for reducing risks of slips, falls or cold exposure among target groups. However, these are likely to be simple low-cost measures that carry a small probability of any adverse effect, and may have the potential to help reduce risks for certain population groups.

(9) Evidence on the cost-effectiveness of interventions to reduce winter-and cold-related mortality/morbidity is comparatively small and very heterogeneous. It is difficult therefore to draw general conclusions about the balance of costs and benefits which are likely to depend on target groups, local context and the form of intervention. More needs to be known about the distribution of health and non-health benefits across different household types in order to design more cost-effective interventions.

(10) Available studies support the view that there are health benefits to be obtained from improvements in household energy efficiency but, from an economic view, if viewed solely as means of improving health these investments would (usually) not be justified. Once a wider range of benefits are included they appear to be worthwhile investments.

(11) The evidence relating to other forms of intervention to reduce winter-or cold-related mortality/morbidity provides an insufficient basis for economic assessment.

(12) Many forms of economic assessment are hampered by the limited availability of quantitative evidence on the links between upstream determinants and eventual health outcomes. This includes housing factors where there remain many uncertainties about the performance of a dwelling and how its impact on health is modified by interventions.

Appendix 1: Review team

The review team and their expertise are summarized in the table below.

Person (institution)	*Experience and expertise*
LSHTM	
Paul Wilkinson (Professor of Environmental Epidemiology)	Researcher in environmental epidemiology with long-standing interest in excess winter deaths, with multiple contributions in this area particularly for the UK. Expertise: topic expertise (excess winter death), study design and methods for quantifying the effect of seasonal/cold-related risks and modification by social, environmental and other factors.
Ben Armstrong (Professor in Epidemiological Statistics)	Epidemiological statistician with thirty years' experience in environmental and occupational health research, including multiple publications on weather, climate and health, several of which are methodological contributions. Previously member of the Committee on the Medical Effects of Air Pollution (2000-2010). Expertise: statistical aspects, especially with regard to the methods and interpretation of time-series studies and methods used to quantify and attribute health effects to cold and seasonal influences, and their modification by social, environmental and other factors.
John Cairns (Professor of Health Economics)	Economist with more than 35 years research experience, more than 25 years specialising in health economics. Previously led a team of health economists undertaking economic modelling for cancer guidelines. Expertise: economic assessment: cost-benefit analysis
Zaid Chalabi (Senior Lecturer in Health Impact Analysis and Modelling)	Mathematical modeller with wide expertise in environmental health risk assessment, health impact analysis, cost-effectiveness analysis, value of information and uncertainty analyses, and decision analysis. Expertise: evidence regarding cost-effectiveness (CE) of methods to identify at risk populations; CE of interventions to prevent excess mortality & morbidity; CE of systems for delivery and implementation of approaches to prevent excess mortality & morbidity
Shakoor Hajat (Senior Lecturer in Epidemiology and Medical Statistics)	Medical statistician with long-standing interest in temperature (heat- and cold-) related impacts on health. Expertise in time series and related analyses in this field and has undertaken reviews of published evidence for European research projects. Currently involved in an evaluation of the Department of Health Cold Weather Plan for England. Expertise: epidemiological evidence review, especially with regard to studies of temperature and seasonal variations in risk and the effect of interventions
Lorelei Jones (Research fellow)	A health services researcher with long-standing interests in UK health policy and health services, especially the sociology of health service organisation. Previously a research fellow on the NICE clinical guideline for diabetes in pregnancy she has extensive experience of systematic reviews and guideline development. Currently has a core role in the on-going *Evaluation of the National Cold Weather Plan for England.* Expertise: literature review especially with regard to behavioural responses and

	interventions
James Milner (Research Fellow)	Researcher with interests involving modelling the interactions between the urban environment and health, including the effects on health of air pollutants, and indoor air quality and housing. Has also developed techniques to assess the health impacts of changes in environmental exposures due to climate change mitigation policies in different sectors of society, including the housing sector. Expertise: modelling of health impacts, especially with regard to housing related health risks
Mark Petticrew (Professor of Public Health Evaluation)	Researcher with long-standing interests in evidence-based policymaking, systematic reviews, and the evaluation of the health effects of social policies. He is an editor of the new Cochrane Public Health Review Group, and is closely involved in the Cochrane/Campbell Health Equity Field. He has co-authored Petticrew M, Roberts H (2006) *Systematic Reviews in the Social Sciences: A practical guide.* Oxford: Blackwell Publishing) Expertise: methods for systematic review and assessment of evidence for policy.
Noaf Scovronick (doctoral student)	Reseaercher in environment and health, with special interest in methods of health impact estimation/modelling, particularly relating to air pollution and other environmental exposures.
University of York	
Steve Duffy (Information Analyst)	Information analyst with extensive experience of the development and implementation of search methods for literature review. Expertise: database searches/literature review

Appendix 2: Search strategies

Literature searches were undertaken to identify studies primarily about excess winter deaths. The searches were also designed to identify studies about seasonal morbidity, fuel poverty, cold housing, energy efficient housing, winter related accidents, and health forecasting.

The search strategies were devised using a combination of indexed subject heading terms and free text search terms appearing in the title and/or abstracts of database records. Search terms were identified through discussion between the research team, by scanning background literature and 'key articles' already known to the project team, and by browsing database thesauri.

The searches were limited by date range to the last 20 years (1993 to the present), and to English language publications only. The final MEDLINE search strategy was peer reviewed for accuracy by another Information Specialist based at CRD (Melissa Harden).

The literature searches involved searching a wide range of databases covering health, social care, mental health, economics, environmental issues, and architecture. The following databases and resources were searched:

- MEDLINE and MEDLINE In-Process
- EMBASE
- Social Policy & Practice
- Science Citation Index (SCI)
- Social Sciences Citation Index (SSCI)
- Conference Proceedings Citation Index-Science (CPCI-S)
- Conference Proceedings Citation Index-Social Science & Humanities (CPCI-SSH)
- Health Management Information Consortium (HMIC)
- PsycINFO
- Cochrane Database of Systematic Reviews (CDSR)
- Database of Abstracts of Reviews of Effects (DARE)
- Cochrane Central Register of Controlled Trials (CENTRAL)
- Health Technology Assessment (HTA) database
- NHS Economic Evaluation Database (NHS EED)
- EconLit
- CEA (Cost-Effectiveness Analysis) Registry
- RePEc: Research Papers in Economics
- Campbell Library
- Trials Register of Promoting Health Interventions (TRoPHI)
- Database of Promoting Health Effectiveness Reviews (DoPHER)
- Scopus
- Avery Index to Architectural Periodicals
- ICONDA International
- PsycEXTRA

- NICE Evidence
- OpenGrey
- RIBA Catalogue (Royal Institute of British Architects)
- NYAM Grey Literature Report (New York Academy of Medicine)

As a number of databases were searched, some degree of duplication resulted. In order to manage this issue, the titles and abstracts of bibliographic records were downloaded and imported into EndNote bibliographic management software and duplicate records removed.

Databases and resources searched

Resource	Interface/url	Date range	Search date	Results
MEDLINE and MEDLINE In-Process	OvidSP	1946-2013/Sep week 2	23 Sep 2013	8451
EMBASE	OvidSP	1974-2013/week 38	24 Sep 2013	5445
Social Policy & Practice	OvidSP	1890s-201307	30 Sep 2013	1357
Science Citation Index (SCI)	Web of Science	1900–2013/09/27	2 Oct 2013	4433
Social Sciences Citation Index (SSCI)	Web of Science	1956–2013/09/27	2 Oct 2013	1291
Conference Proceedings Citation Index-Science (CPCI-S)	Web of Science	1990–2013/09/27	2 Oct 2013	238
Conference Proceedings Citation Index-Social Science & Humanities (CPCI-SSH)	Web of Science	1990–2013/09/27	2 Oct 2013	112
Health Management Information Consortium (HMIC)	OvidSP	1979-2013/Mar	30 Sep 2013	352
PsycINFO	OvidSP	1806-2013/Sep week 4	30 Sep 2013	829
Cochrane Database of Systematic Reviews (CDSR)	Wiley Online Library; The Cochrane Library	2013: Issue 9/12	1 Oct 2013	22
Database of Abstracts of Reviews of Effects (DARE)	Wiley Online Library; The Cochrane Library	2013: Issue 3/4	1 Oct 2013	7
Cochrane Central Register of Controlled Trials (CENTRAL)	Wiley Online Library; The Cochrane Library	2013: Issue 9/12	1 Oct 2013	554
Health Technology Assessment (HTA) database	Wiley Online Library; The Cochrane Library	2013: Issue 3/4	1 Oct 2013	1
NHS Economic Evaluation Database (NHS EED)	Wiley Online Library; The Cochrane Library	2013: Issue 3/4	1 Oct 2013	8
EconLit	OvidSP	1961-2013/Aug	30 Sep 2013	745
CEA Registry	www.cearegistry.org	3 Oct 2013	3 Oct 2013	0
RePEc	http://repec.org/	3 Oct 2013	3 Oct 2013	119
Campbell Library	http://www.campbellcollabo	3 Oct 2013	3 Oct	1

	ration.org/library.php		2013	
TRoPHI	EPPI-Centre	3 Oct 2013	3 Oct 2013	8
DoPHER	EPPI-Centre	3 Oct 2013	3 Oct 2013	5
OpenGrey	http://www.opengrey.eu/	3 Oct 2013	3 Oct 2013	45
NHS Evidence	https://www.evidence.nhs.uk/	18 Oct 2013	18 Oct 2013	67
RIBA Catalogue	http://riba.sirsidynix.net.uk/uhtbin/webcat	18 Oct 2013	18 Oct 2013	26
NYAM Grey Literature Report	http://www.greylit.org/	18 Oct 2013	18 Oct 2013	0
Scopus	Elsevier	1823-2013/Oct	21 Oct 2013	1696
Avery Index	ProQuest	1934-2013/Oct	24 Oct 2013	244
ICONDA International	Ovid	1976-2013/Oct	25 Oct 2013	492
PsycEXTRA	Ovid	1908-2013/Oct	25 Oct 2013	93
TOTAL				**26,641**
TOTAL after deduplication				**16,143**

Search strategies

MEDLINE and MEDLINE In-Process (OvidSP). 1946-2013/Sep week 2. Searched 23 September 2013.

1 exp Cold Temperature/ (60709)
2 Snow/ or Ice/ (4363)
3 1 or 2 (64253)
4 exp Death/ (114941)
5 exp Mortality/ or mo.fs. (576727)
6 exp Morbidity/ (373172)
7 Risk Factors/ (567327)
8 or/4-7 (1396264)
9 3 and 8 (1725)
10 (winter adj4 (death$ or fatalit$ or mortalit$ or morbidit$ or illness$ or disease$)).ti,ab. (788)
11 (weather adj3 (death$ or fatalit$ or mortalit$ or morbidit$ or illness$ or disease$)).ti,ab. (239)
12 (temperature$ adj3 (death$ or fatalit$ or mortalit$ or morbidit$ or illness$ or disease$)).ti,ab. (1273)
13 ((cold or colder) adj4 (spell$ or season$ or month$ or period$ or condition$ or event$1 or related or excess or excessive or severe or severity or extreme)).ti,ab. (6057)
14 (death$ or fatalit$ or mortalit$ or morbidit$ or illness$ or disease$).ti,ab. (3171249)
15 13 and 14 (1243)
16 ((excess or excessive or severe or severity or exposure) adj3 winter).ti,ab. (472)
17 (winter adj4 (vulnerab$ or risk$1 or suceptib$)).ti,ab. (177)
18 (temperature$ adj3 (vulnerab$ or risk$1 or suceptib$)).ti,ab. (343)
19 (weather adj3 (vulnerab$ or risk$1 or suceptib$)).ti,ab. (75)
20 ((cold or colder) adj3 (vulnerab$ or risk$1 or suceptib$)).ti,ab. (194)
21 Seasons/ and (Death/ or Mortality/ or Morbidity/ or Risk Factors/) (5119)
22 (season$ adj3 (death$ or fatalit$ or mortalit$ or morbidit$ or risk$1 or vulnerabl$ or suceptib$)).ti,ab. (1222)
23 or/9-12,15-22 (11237)
24 ((fuel or energy or gas or electricity) adj3 (poverty or poor or afford or affordable or affordability or tariff$)).ti,ab. (455)
25 (winter adj3 fuel).ti,ab. (14)
26 (winter adj3 (payment$ or allowance$ or benefit$ or grant$ or voucher$)).ti,ab. (19)
27 ((cold or weather) adj3 (payment$ or allowance$ or benefit$ or grant$ or voucher$)).ti,ab. (44)
28 ((heat$ or gas or electricity) adj3 (payment$ or allowance$ or benefit$ or grant$ or voucher$)).ti,ab. (177)
29 or/24-28 (705)
30 exp Housing/ (25422)
31 exp Cold Temperature/ (60709)
32 Heating/ (4100)
33 30 and (31 or 32) (433)
34 ((cold or freez$ or frozen) adj3 (home or homes or house or houses or household$ or housing)).ti,ab. (129)

35 ((warm$ or heat$ or underheat$ or temperature$) adj3 (home or homes or house or houses or household$ or housing)).ti,ab. (682)
36 ((damp$ or humid$ or mold or moldy or mould or mouldy or condensation$) adj3 (home or homes or house or houses or household$ or housing)).ti,ab. (505)
37 ((cold or freez$ or frozen) adj3 (accommodation$ or rent or rents or rented or tenancy or tenancies or dwelling$)).ti,ab. (17)
38 ((warm$ or heat$ or underheat$ or temperature$) adj3 (accommodation$ or rent or rents or rented or tenancy or tenancies or dwelling$)).ti,ab. (39)
39 ((damp or humid or mold or moldy or mould or mouldy) adj3 (accommodation$ or rent or rents or rented or tenancy or tenancies or dwelling$)).ti,ab. (48)
40 ((energy adj3 efficien$) and (home or homes or house or houses or household$ or housing)).ti,ab. (117)
41 ((energy adj3 efficien$) and (accommodation$ or rent or rents or rented or tenancy or tenancies or dwelling$ or domestic$)).ti,ab. (53)
42 (home energy adj3 (program$ or assist$)).ti,ab. (3)
43 (insulat$ adj4 (home or homes or house or houses or household$ or housing)).ti,ab. (86)
44 (insulat$ adj4 (accommodation$ or rent or rents or rented or tenancy or tenancies or dwelling$)).ti,ab. (8)
45 (Warm Front or Warm Deal or Green Deal or Warm Zone or Energy Company Obligation).ti,ab. (21)
46 thermal comfort.ti,ab. (558)
47 or/33-46 (2481)
48 exp Accidents/ (138538)
49 exp *"Wounds and Injuries"/ (547370)
50 Snow/ or Ice/ (4363)
51 *Seasons/ (14654)
52 (48 or 49) and (50 or 51) (607)
53 ((fall or falls or falling or slip or slips or slipping) adj3 (winter or snow or ice or weather or season$)).ti,ab. (1558)
54 ((accident$ or injury or injuries or injured or fracture$ or trauma$) adj3 (winter or snow or ice or weather or season$)).ti,ab. (881)
55 ((grit or gritted or gritting or gritter$) adj3 (road$ or pavement$ or sidewalk$ or driveway$ or pathway$ or path$1)).ti,ab. (5)
56 or/52-55 (2913)
57 Forecasting/ and Weather/ (174)
58 ((forecast$ or alert$ or warning$ or alarm$) adj3 (cold or colder or weather or winter or met office or meteorological office)).ti,ab. (224)
59 health forecast$.ti,ab. (18)
60 or/57-59 (392)
61 23 or 29 or 47 or 56 or 60 (17234)
62 exp Animals/ not Humans/ (4031668)
63 (exp Plants/ or exp Plant Structures/ or exp Plant Physiological Phenomena/) not humans/ (447136)
64 (comment or editorial or letter).pt. (1234425)
65 61 not (62 or 63 or 64) (13264)

66 limit 65 to (english language and yr="1993 -Current") (9279)

NB. After removal of duplicate records the final results total was 8451

Key:

/	subject heading (MeSH)
exp	explode subject heading (MeSH)
.ti,ab.	searches are restricted to the title and abstract fields
adj	searches for adjacent terms
adj3	searches for terms within three words of each other
$	truncation symbol
$1	truncation restricted to one character
or/1-4	combine sets 1 to 4 using OR

Embase (OvidSP). 1974-2013/week 38. Searched 24 September 2013.

1 *winter/ (4511)
2 *cold/ (9790)
3 *snow/ or *ice/ (2997)
4 or/1-3 (17247)
5 exp *death/ (100114)
6 exp *mortality/ (81918)
7 exp *morbidity/ (17192)
8 *risk factor/ (25240)
9 or/5-8 (211937)
10 4 and 9 (236)
11 (winter adj4 (death$ or fatalit$ or mortalit$ or morbidit$ or illness$ or disease$)).ti,ab. (926)
12 (weather adj3 (death$ or fatalit$ or mortalit$ or morbidit$ or illness$ or disease$)).ti,ab. (291)
13 (temperature$ adj3 (death$ or fatalit$ or mortalit$ or morbidit$ or illness$ or disease$)).ti,ab. (1478)
14 ((cold or colder) adj3 (spell$ or season$ or month$ or period$ or condition$ or event$1 or related or excess or excessive or severe or severity or extreme)).ti,ab. (6539)
15 (death$ or fatalit$ or mortalit$ or morbidit$ or illness$ or disease$).ti,ab. (4143060)
16 14 and 15 (1398)
17 ((excess or excessive or severe or severity or exposure) adj3 winter).ti,ab. (556)
18 (winter adj4 (vulnerab$ or risk$1 or suceptib$)).ti,ab. (217)
19 (temperature$ adj3 (vulnerab$ or risk$1 or suceptib$)).ti,ab. (397)
20 (weather adj3 (vulnerab$ or risk$1 or suceptib$)).ti,ab. (93)
21 ((cold or colder) adj3 (vulnerab$ or risk$1 or suceptib$)).ti,ab. (232)
22 *season/ and (exp *death/ or exp *mortality/ or exp *morbidity/ or *risk factor/) (487)
23 (season$ adj2 (death$ or fatalit$ or mortalit$ or morbidit$ or risk$1 or vulnerabl$ or suceptib$)).ti,ab. (759)
24 or/10-13,16-23 (6277)
25 ((fuel or energy or gas or electricity) adj3 (poverty or poor or afford or affordable or affordability or tariff$)).ti,ab. (632)

26 (winter adj3 fuel).ti,ab. (20)
27 (winter adj3 (payment$ or allowance$ or benefit$ or grant$ or voucher$)).ti,ab. (22)
28 ((cold or weather) adj3 (payment$ or allowance$ or benefit$ or grant$ or voucher$)).ti,ab. (64)
29 ((heat$ or gas or electricity) adj3 (payment$ or allowance$ or benefit$ or grant$ or voucher$)).ti,ab. (246)
30 or/25-29 (979)
31 *housing/ (7070)
32 *cold/ (9790)
33 *heating/ (3074)
34 31 and (32 or 33) (117)
35 ((cold or freez$ or frozen) adj3 (home or homes or house or houses or household$ or housing)).ti,ab. (155)
36 ((warm$ or heat$ or underheat$ or temperature$) adj3 (home or homes or house or houses or household$ or housing)).ti,ab. (887)
37 ((damp$ or humid$ or mold or moldy or mould or mouldy or condensation$) adj3 (home or homes or house or houses or household$ or housing)).ti,ab. (604)
38 ((cold or freez$ or frozen) adj3 (accommodation$ or rent or rents or rented or tenancy or tenancies or dwelling$)).ti,ab. (20)
39 ((warm$ or heat$ or underheat$ or temperature$) adj3 (accommodation$ or rent or rents or rented or tenancy or tenancies or dwelling$)).ti,ab. (63)
40 ((damp or humid or mold or moldy or mould or mouldy) adj3 (accommodation$ or rent or rents or rented or tenancy or tenancies or dwelling$)).ti,ab. (70)
41 ((energy adj3 efficien$) and (home or homes or house or houses or household$ or housing)).ti,ab. (163)
42 ((energy adj3 efficien$) and (accommodation$ or rent or rents or rented or tenancy or tenancies or dwelling$ or domestic$)).ti,ab. (85)
43 (home energy adj3 (program$ or assist$)).ti,ab. (3)
44 (insulat$ adj3 (home or homes or house or houses or household$ or housing)).ti,ab. (94)
45 (insulat$ adj3 (accommodation$ or rent or rents or rented or tenancy or tenancies or dwelling$)).ti,ab. (16)
46 (Warm Front or Warm Deal or Green Deal or Warm Zone or Energy Company Obligation).ti,ab. (31)
47 thermal comfort.ti,ab. (694)
48 or/34-47 (2838)
49 exp *accident/ (74718)
50 exp *injury/ or exp *fracture/ (841006)
51 *snow/ or *ice/ (2997)
52 *season/ (10421)
53 (49 or 50) and (51 or 52) (481)
54 ((fall or falls or falling or slip or slips or slipping) adj2 (winter or snow or ice or weather or season$)).ti,ab. (1748)
55 ((accident$ or injury or injuries or injured or fracture$ or trauma$) adj2 (winter or snow or ice or weather or season$)).ti,ab. (702)
56 ((grit or gritted or gritting or gritter$) adj3 (road$ or pavement$ or sidewalk$ or driveway$ or pathway$ or path$1)).ti,ab. (9)

57 or/53-56 (2878)
58 *forecasting/ and *weather/ (52)
59 ((forecast$ or alert$ or warning$ or alarm$) adj3 (cold or colder or weather or winter or met office or meteorological office)).ti,ab. (396)
60 health forecast$.ti,ab. (22)
61 or/58-60 (442)
62 24 or 30 or 48 or 57 or 61 (13179)
63 (editorial or letter or note).pt. (1872994)
64 62 not 63 (12925)
65 limit 64 to human (7380)
66 limit 65 to (english language and yr="1993 -Current") (5445)

Key:

/	subject heading (EMTREE)
exp	explode subject heading (EMTREE)
*	focus subject heading (EMTREE)
.ti,ab.	searches are restricted to the title and abstract fields
adj	searches for adjacent terms
adj3	searches for terms within three words of each other
$	truncation symbol
$1	truncation restricted to one character
or/1-4	combine sets 1 to 4 using OR

Social Policy & Practice (OvidSP). 1890s-201307. Searched 30 September 2013.

1 (winter adj4 (death$ or fatalit$ or mortalit$ or morbidit$ or illness$ or disease$)).ti,ab,de. (64)
2 (weather adj3 (death$ or fatalit$ or mortalit$ or morbidit$ or illness$ or disease$)).ti,ab,de. (12)
3 (temperature$ adj3 (death$ or fatalit$ or mortalit$ or morbidit$ or illness$ or disease$)).ti,ab,de. (28)
4 ((cold or colder) adj4 (spell$ or season$ or month$ or period$ or condition$ or event$1 or related or excess or excessive or severe or severity or extreme)).ti,ab,de. (46)
5 ((excess or excessive or severe or severity or exposure) adj3 winter).ti,ab,de. (48)
6 (winter adj4 (vulnerab$ or risk$1 or suceptib$)).ti,ab,de. (13)
7 (temperature$ adj3 (vulnerab$ or risk$1 or suceptib$)).ti,ab,de. (5)
8 (weather adj3 (vulnerab$ or risk$1 or suceptib$)).ti,ab,de. (14)
9 ((cold or colder) adj3 (vulnerab$ or risk$1 or suceptib$)).ti,ab,de. (9)
10 (season$ adj3 (death$ or fatalit$ or mortalit$ or morbidit$ or risk$1 or vulnerabl$ or suceptib$)).ti,ab,de. (23)
11 or/1-10 (160)
12 (fuel adj3 (poverty or poor or afford or affordable or affordability or tariff$)).ti,ab,de. (469)
13 (winter adj3 fuel).ti,ab,de. (42)
14 (winter adj3 (payment$ or allowance$ or benefit$ or grant$ or voucher$)).ti,ab,de. (43)
15 ((cold or weather) adj3 (payment$ or allowance$ or benefit$ or grant$ or voucher$)).ti,ab,de. (26)

16 ((heat$ or gas or electricity) adj3 (payment$ or allowance$ or benefit$ or grant$ or voucher$)).ti,ab,de. (57)
17 or/12-16 (556)
18 ((cold or freez$ or frozen) adj3 (home or homes or house or houses or household$ or housing)).ti,ab,de. (64)
19 ((warm$ or heat$ or underheat$ or temperature$) adj3 (home or homes or house or houses or household$ or housing)).ti,ab,de. (528)
20 ((damp$ or humid$ or mold or moldy or mould or mouldy or condensation$) adj3 (home or homes or house or houses or households or housing)).ti,ab,de. (162)
21 ((cold or freez$ or frozen) adj3 (accommodation$ or rent or rents or rented or tenancy or tenancies or dwelling$)).ti,ab,de. (3)
22 ((warm$ or heat$ or underheat$ or temperature$) adj3 (accommodation$ or rent or rents or rented or tenancy or tenancies or dwelling$)).ti,ab,de. (24)
23 ((damp or humid or mold or moldy or mould or mouldy) adj3 (accommodation$ or rent or rents or rented or tenancy or tenancies or dwelling$)).ti,ab,de. (4)
24 (energy efficienc$ adj3 (home or homes or house or houses or household$ or housing)).ti,ab,de. (343)
25 (energy efficienc$ adj3 (accommodation$ or rent or rents or rented or tenancy or tenancies or dwelling$ or domestic$)).ti,ab,de. (75)
26 (home energy adj3 (program$ or assist$)).ti,ab,de. (6)
27 (insulat$ adj3 (home or homes or house or houses or household$ or housing)).ti,ab,de. (265)
28 (insulat$ adj3 (accommodation$ or rent or rents or rented or tenancy or tenancies or dwelling$)).ti,ab,de. (16)
29 (Warm Front or Warm Deal or Green Deal or Warm Zone or Energy Company Obligation).ti,ab,de. (122)
30 thermal comfort.ti,ab,de. (32)
31 or/18-30 (1146)
32 ((fall or falls or falling or slip or slips or slipping) adj3 (winter or snow or ice or weather or season$)).ti,ab,de. (2)
33 ((accident$ or injury or injuries or injured or fracture$ or trauma$) adj3 (winter or snow or ice or weather or season$)).ti,ab,de. (6)
34 ((grit or gritted or gritting or gritter$) adj3 (road$ or pavement$ or sidewalk$ or driveway$ or pathway$ or path$1)).ti,ab,de. (2)
35 or/32-34 (10)
36 ((forecast$ or alert$ or warning$ or alarm$) adj3 (cold or colder or weather or winter or met office or meteorological office)).ti,ab,de. (13)
37 health forecast$.ti,ab,de. (1)
38 36 or 37 (14)
39 11 or 17 or 31 or 35 or 38 (1590)
40 limit 39 to yr="1993 -Current" (1357)

Key:

.ti,ab,de.	searches are restricted to the title, abstract and descriptor fields
adj	searches for adjacent terms
adj3	searches for terms within three words of each other

$	truncation symbol
$1	truncation restricted to one character
or/1-4	combine sets 1 to 4 using OR

Science Citation Index (SCI) (Web of Science). 1900 – 2013-09-27. Searched 2 October 2013.

# 34	4,433	(#33) AND Document Types=(Article OR Book OR Book Chapter OR Meeting Abstract OR Proceedings Paper OR Review) Databases=SCI-EXPANDED Timespan=1993-2013
# 33	4,743	#27 NOT #32 Databases=SCI-EXPANDED Timespan=1993-2013
# 32	14,445,591	#28 or #29 or #30 or #31 Databases=SCI-EXPANDED Timespan=1993-2013
# 31	7,053,047	SU=(Agriculture or "Astronomy & Astrophysics" or "Biochemistry & Molecular Biology" or "Biodiversity & Conservation" or Chemistry or Crystallography or Electrochemistry or "Energy & Fuels" or Entomology or "Evolutionary Biology" or Fisheries or "Food Science & Technology" or Forestry or "Geochemistry & Geophysics" or Geology or "Marine & Freshwater Biology" or "Medical Laboratory Technology" or Oceanography or Parasitology or"Plant Sciences" or Spectroscopy or "Veterinary Sciences" or Zoology) Databases=SCI-EXPANDED Timespan=1993-2013
# 30	11,740,697	WC=(Agricultural or Agriculture or Agronomy or Astronomy or Astrophysics or Biochemistry or "Biodiversity Conservation" or "Molecular Biology" or Chemistry or "Computer Science" or Ecology or "Energy & Fuels" or Engineering or Entomology or "Evolutionary Biology" or Fisheries or "Food Science & Technology" or Forestry or Genetics or Heredity or Geology or Geosciences or Horticulture or "Marine & Freshwater Biology" or "Materials Science" or "Meteorology & Atmospheric Sciences" or Mineralogy or "Mining & Mineral Processing" or Oceanography or Parasitology or Physics or "Plant Sciences" or "Soil Science" or Spectroscopy or "Veterinary Sciences" or "Water Resources" or Zoology) Databases=SCI-EXPANDED Timespan=1993-2013
# 29	1,751,630	TS=(tree or trees or woodland or forest or forests or plant or plants or leaf or leaves or soil or agriculture or agricultural or agronomy or crop or crops or grass or grasses) Databases=SCI-EXPANDED Timespan=1993-2013
# 28	3,144,056	TS=(rat or rats or mouse or mice or murine or hamster or hamsters or animal or animals or dogs or dog or canine or pig or pigs or cats or bovine or cow or cattle or sheep or ovine or porcine or monkey or monkeys or hen or hens or chicken or chickens or poultry or rabbit or rabbits or fish or fishes or salmon or bird or birds or insect or insects) Databases=SCI-EXPANDED Timespan=1993-2013

# 27	18,313	#8 or #12 or #20 or #26 Databases=SCI-EXPANDED Timespan=1993-2013
# 26	3,464	#21 or #22 or #23 or #24 or #25 Databases=SCI-EXPANDED Timespan=1993-2013
# 25	24	TS=("health forecast*") Databases=SCI-EXPANDED Timespan=1993-2013
# 24	1,788	TS=(("forecast" or "alert" or "alerts" or "warning" or "warnings" or "alarm" or "alarms") NEAR/3 ("cold" or "colder" or "weather" or "winter" or "met office" or "meteorological office")) Databases=SCI-EXPANDED Timespan=1993-2013
# 23	15	TS=((grit or gritted or gritting or gritter*) NEAR/3 (road* or pavement* or sidewalk* or driveway* or pathway* or path*1)) Databases=SCI-EXPANDED Timespan=1993-2013
# 22	1,217	TS=(("accident" or "accidents" or "injury" or "injuries" or "injured" or fracture*) NEAR/3 ("winter" or "snow" or "ice" or "weather")) Databases=SCI-EXPANDED Timespan=1993-2013
# 21	443	TS=(("falls" or "falling" or "slip" or "slips" or "slipping") NEAR/3 ("winter" or "snow" or "ice" or "weather")) Databases=SCI-EXPANDED Timespan=1993-2013
# 20	2,873	#13 or #14 or #15 or #16 or #17 or #18 or #19 Databases=SCI-EXPANDED Timespan=1993-2013
# 19	193	TS=("Warm Front" or "Warm Deal" or "Green Deal" or "Warm Zone" or "Energy Company Obligation") Databases=SCI-EXPANDED Timespan=1993-2013
# 18	272	TS=(insulat* NEAR/3 (home or homes or house or houses or household* or housing or accommodation* or rent or rents or rented or tenancy or tenancies or dwelling*)) Databases=SCI-EXPANDED Timespan=1993-2013
# 17	13	TS=("home energy " NEAR/3 (program* or assist*)) Databases=SCI-EXPANDED Timespan=1993-2013
# 16	332	TS=("energy efficien*" NEAR/3 (home or homes or house or houses or household* or housing or accommodation* or rent or rents or rented or tenancy or tenancies or dwelling* or domestic*)) Databases=SCI-EXPANDED Timespan=1993-2013
# 15	119	TS=(damp NEAR/3 (home or homes or house or houses or household* or housing or accommodation* or rent or rents or rented or tenancy or tenancies or dwelling*)) Databases=SCI-EXPANDED Timespan=1993-2013
# 14	1,758	TS=((warm* or heat* or underheat* or temperature*) NEAR/2 (home or homes or house or houses or household* or housing or accommodation* or rent or rents or rented or tenancy or tenancies or dwelling*)) Databases=SCI-EXPANDED Timespan=1993-2013
# 13	365	TS=((cold or freez* or frozen) NEAR/3 (home or homes or house or

		houses or household* or housing or accommodation* or rent or rents or rented or tenancy or tenancies or dwelling*)) Databases=SCI-EXPANDED Timespan=1993-2013
# 12	1,073	#9 or #10 or #11 Databases=SCI-EXPANDED Timespan=1993-2013
# 11	500	TS=(("heating" or gas or electricity) NEAR/2 (payment* or allowance* or benefit* or grant* or voucher*)) Databases=SCI-EXPANDED Timespan=1993-2013
# 10	246	TS=((winter or cold or weaher) NEAR/3 (payment* or allowance* or benefit* or grant* or voucher*)) Databases=SCI-EXPANDED Timespan=1993-2013
# 9	334	TS=("fuel" NEAR/3 (winter or poverty or poor or afford or affordable or affordability or tariff*)) Databases=SCI-EXPANDED Timespan=1993-2013
# 8	11,193	#1 or #4 or #5 or #6 or #7 Databases=SCI-EXPANDED Timespan=1993-2013
# 7	1,678	TS=(season* NEAR/2 (death* or fatalit* or mortalit* or morbidit* or "risk" or "risks" or vulnerabl* or suceptib*)) Databases=SCI-EXPANDED Timespan=1993-2013
# 6	1,552	TS=((winter or weather or temperature* or cold or colder) NEAR/2 (vulnerab* or "risk" or "risks" or suceptib*)) Databases=SCI-EXPANDED Timespan=1993-2013
# 5	1,719	TS=((excess or excessive or severe or severity or exposure) NEAR/3 winter) Databases=SCI-EXPANDED Timespan=1993-2013
# 4	1,365	#2 and #3 Databases=SCI-EXPANDED Timespan=1993-2013
# 3	2,799,726	TS=(death* or fatalit* or mortalit* or morbidit* or illness* or disease*) Databases=SCI-EXPANDED Timespan=1993-2013
# 2	13,498	TS=((cold or colder) NEAR/2 (spell* or season* or month* or period* or condition* or event or related or excess or excessive or severe or severity or extreme)) Databases=SCI-EXPANDED Timespan=1993-2013
# 1	5,890	TS=((winter or weather or temperature*) NEAR/3 (death* or fatalit* or mortalit* or morbidit* or illness* or disease*)) Databases=SCI-EXPANDED Timespan=1993-2013

Key:

TS Topic (searches terms in Title, Abstract, Author Keywords and Keywords Plus fields)

SU Research Area (specific fields of study)

WC Web of Science Category (specific fields of study)

NEAR searches for adjacent terms

NEAR/3 searches for terms within three words of each other
* truncation symbol
" " phrase search

Social Sciences Citation Index (SSCI) (Web of Science). 1956 – 2013-09-27. Searched 2 October 2013.

# 34	1,291	(#33) AND Document Types=(Article OR Book OR Book Chapter OR Meeting Abstract OR Proceedings Paper OR Review) Databases=SSCI Timespan=1993-2013
# 33	1,399	#27 NOT #32 Databases=SSCI Timespan=1993-2013
# 32	364,512	#28 or #29 or #30 or #31 Databases=SSCI Timespan=1993-2013
# 31	80,352	SU=(Agriculture or "Astronomy & Astrophysics" or "Biochemistry & Molecular Biology" or "Biodiversity & Conservation" or Chemistry or Crystallography or Electrochemistry or "Energy & Fuels" or Entomology or "Evolutionary Biology" or Fisheries or "Food Science & Technology" or Forestry or "Geochemistry & Geophysics" or Geology or "Marine & Freshwater Biology" or "Medical Laboratory Technology" or Oceanography or Parasitology or"Plant Sciences" or Spectroscopy or "Veterinary Sciences" or Zoology) Databases=SSCI Timespan=1993-2013
# 30	212,424	WC=(Agricultural or Agriculture or Agronomy or Astronomy or Astrophysics or Biochemistry or "Biodiversity Conservation" or "Molecular Biology" or Chemistry or "Computer Science" or Ecology or "Energy & Fuels" or Engineering or Entomology or "Evolutionary Biology" or Fisheries or "Food Science & Technology" or Forestry or Genetics or Heredity or Geology or Geosciences or Horticulture or "Marine & Freshwater Biology" or "Materials Science" or "Meteorology & Atmospheric Sciences" or Mineralogy or "Mining & Mineral Processing" or Oceanography or Parasitology or Physics or "Plant Sciences" or "Soil Science" or Spectroscopy or "Veterinary Sciences" or "Water Resources" or Zoology) Databases=SSCI Timespan=1993-2013
# 29	115,582	TS=(tree or trees or woodland or forest or forests or plant or plants or leaf or leaves or soil or agriculture or agricultural or agronomy or crop or crops or grass or grasses) Databases=SSCI Timespan=1993-2013
# 28	83,105	TS=(rat or rats or mouse or mice or murine or hamster or hamsters or animal or animals or dogs or dog or canine or pig or pigs or cats or bovine or cow or cattle or sheep or ovine or porcine or monkey or monkeys or hen or hens or chicken or chickens or poultry or rabbit or rabbits or fish or fishes or salmon or bird or birds or insect or insects)

		Databases=SSCI Timespan=1993-2013
# 27	2,123	#8 or #12 or #20 or #26 Databases=SSCI Timespan=1993-2013
# 26	259	#21 or #22 or #23 or #24 or #25 Databases=SSCI Timespan=1993-2013
# 25	16	TS=("health forecast*") Databases=SSCI Timespan=1993-2013
# 24	92	TS=(("forecast" or "alert" or "alerts" or "warning" or "warnings" or "alarm" or "alarms") NEAR/3 ("cold" or "colder" or "weather" or "winter" or "met office" or "meteorological office")) Databases=SSCI Timespan=1993-2013
# 23	4	TS=((grit or gritted or gritting or gritter*) NEAR/3 (road* or pavement* or sidewalk* or driveway* or pathway* or path*1)) Databases=SSCI Timespan=1993-2013
# 22	127	TS=(("accident" or "accidents" or "injury" or "injuries" or "injured" or fracture*) NEAR/3 ("winter" or "snow" or "ice" or "weather")) Databases=SSCI Timespan=1993-2013
# 21	29	TS=(("falls" or "falling" or "slip" or "slips" or "slipping") NEAR/3 ("winter" or "snow" or "ice" or "weather")) Databases=SSCI Timespan=1993-2013
# 20	557	#13 or #14 or #15 or #16 or #17 or #18 or #19 Databases=SSCI Timespan=1993-2013
# 19	11	TS=("Warm Front" or "Warm Deal" or "Green Deal" or "Warm Zone" or "Energy Company Obligation") Databases=SSCI Timespan=1993-2013
# 18	44	TS=(insulat* NEAR/3 (home or homes or house or houses or household* or housing or accommodation* or rent or rents or rented or tenancy or tenancies or dwelling*)) Databases=SSCI Timespan=1993-2013
# 17	8	TS=("home energy " NEAR/3 (program* or assist*)) Databases=SSCI Timespan=1993-2013
# 16	210	TS=("energy efficien*" NEAR/3 (home or homes or house or houses or household* or housing or accommodation* or rent or rents or rented or tenancy or tenancies or dwelling* or domestic*)) Databases=SSCI Timespan=1993-2013
# 15	17	TS=(damp NEAR/3 (home or homes or house or houses or household* or housing or accommodation* or rent or rents or rented or tenancy or tenancies or dwelling*)) Databases=SSCI Timespan=1993-2013
# 14	239	TS=((warm* or heat* or underheat* or temperature*) NEAR/2 (home or homes or house or houses or household* or housing or accommodation* or rent or rents or rented or tenancy or tenancies or dwelling*)) Databases=SSCI Timespan=1993-2013
# 13	92	TS=((cold or freez* or frozen) NEAR/3 (home or homes or house or

		houses or household* or housing or accommodation* or rent or rents or rented or tenancy or tenancies or dwelling*)) Databases=SSCI Timespan=1993-2013
# 12	287	#9 or #10 or #11 Databases=SSCI Timespan=1993-2013
# 11	150	TS=(("heating" or gas or electricity) NEAR/2 (payment* or allowance* or benefit* or grant* or voucher*)) Databases=SSCI Timespan=1993-2013
# 10	19	TS=((winter or cold or weaher) NEAR/3 (payment* or allowance* or benefit* or grant* or voucher*)) Databases=SSCI Timespan=1993-2013
# 9	122	TS=("fuel" NEAR/3 (winter or poverty or poor or afford or affordable or affordability or tariff*)) Databases=SSCI Timespan=1993-2013
# 8	1,150	#1 or #4 or #5 or #6 or #7 Databases=SSCI Timespan=1993-2013
# 7	277	TS=(season* NEAR/2 (death* or fatalit* or mortalit* or morbidit* or "risk" or "risks" or vulnerabl* or suceptib*)) Databases=SSCI Timespan=1993-2013
# 6	319	TS=((winter or weather or temperature* or cold or colder) NEAR/2 (vulnerab* or "risk" or "risks" or suceptib*)) Databases=SSCI Timespan=1993-2013
# 5	166	TS=((excess or excessive or severe or severity or exposure) NEAR/3 winter) Databases=SSCI Timespan=1993-2013
# 4	135	#2 and #3 Databases=SSCI Timespan=1993-2013
# 3	284,868	TS=(death* or fatalit* or mortalit* or morbidit* or illness* or disease*) Databases=SSCI Timespan=1993-2013
# 2	693	TS=((cold or colder) NEAR/2 (spell* or season* or month* or period* or condition* or event or related or excess or excessive or severe or severity or extreme)) Databases=SSCI Timespan=1993-2013
# 1	439	TS=((winter or weather or temperature*) NEAR/3 (death* or fatalit* or mortalit* or morbidit* or illness* or disease*)) Databases=SSCI Timespan=1993-2013

Key:

TS Topic (searches terms in Title, Abstract, Author Keywords and Keywords Plus fields)

SU Research Area (specific fields of study)

WC Web of Science Category (specific fields of study)

NEAR searches for adjacent terms

NEAR/3 searches for terms within three words of each other

* truncation symbol

" " phrase search

Conference Proceedings Citation Index-Science (CPCI-S) (Web of Science). 1990 – 2013-09-27. Searched 2 October 2013.

# 33	238	#27 NOT #32 Databases=CPCI-S Timespan=1993-2013
# 32	4,622,783	#28 or #29 or #30 or #31 Databases=CPCI-S Timespan=1993-2013
# 31	1,199,928	SU=(Agriculture or "Astronomy & Astrophysics" or "Biochemistry & Molecular Biology" or "Biodiversity & Conservation" or Chemistry or Crystallography or Electrochemistry or "Energy & Fuels" or Entomology or "Evolutionary Biology" or Fisheries or "Food Science & Technology" or Forestry or "Geochemistry & Geophysics" or Geology or "Marine & Freshwater Biology" or "Medical Laboratory Technology" or Oceanography or Parasitology or"Plant Sciences" or Spectroscopy or "Veterinary Sciences" or Zoology) Databases=CPCI-S Timespan=1993-2013
# 30	4,304,050	WC=(Agricultural or Agriculture or Agronomy or Astronomy or Astrophysics or Biochemistry or "Biodiversity Conservation" or "Molecular Biology" or Chemistry or "Computer Science" or Ecology or "Energy & Fuels" or Engineering or Entomology or "Evolutionary Biology" or Fisheries or "Food Science & Technology" or Forestry or Genetics or Heredity or Geology or Geosciences or Horticulture or "Marine & Freshwater Biology" or "Materials Science" or "Meteorology & Atmospheric Sciences" or Mineralogy or "Mining & Mineral Processing" or Oceanography or Parasitology or Physics or "Plant Sciences" or "Soil Science" or Spectroscopy or "Veterinary Sciences" or "Water Resources" or Zoology) Databases=CPCI-S Timespan=1993-2013
# 29	350,620	TS=(tree or trees or woodland or forest or forests or plant or plants or leaf or leaves or soil or agriculture or agricultural or agronomy or crop or crops or grass or grasses) Databases=CPCI-S Timespan=1993-2013
# 28	353,128	TS=(rat or rats or mouse or mice or murine or hamster or hamsters or animal or animals or dogs or dog or canine or pig or pigs or cats or bovine or cow or cattle or sheep or ovine or porcine or monkey or monkeys or hen or hens or chicken or chickens or poultry or rabbit or rabbits or fish or fishes or salmon or bird or birds or insect or insects) Databases=CPCI-S Timespan=1993-2013
# 27	723	#8 or #12 or #20 or #26 Databases=CPCI-S Timespan=1993-2013
# 26	219	#21 or #22 or #23 or #24 or #25 Databases=CPCI-S Timespan=1993-2013

# 25	4	TI=("health forecast*") Databases=CPCI-S Timespan=1993-2013
# 24	133	TI=(("forecast" or "alert" or "alerts" or "warning" or "warnings" or "alarm" or "alarms") NEAR/3 ("cold" or "colder" or "weather" or "winter" or "met office" or "meteorological office")) Databases=CPCI-S Timespan=1993-2013
# 23	0	TI=((grit or gritted or gritting or gritter*) NEAR/3 (road* or pavement* or sidewalk* or driveway* or pathway* or path or paths)) Databases=CPCI-S Timespan=1993-2013
# 22	61	TI=(("accident" or "accidents" or "injury" or "injuries" or "injured" or fracture*) NEAR/3 ("winter" or "snow" or "ice" or "weather")) Databases=CPCI-S Timespan=1993-2013
# 21	22	TI=(("falls" or "falling" or "slip" or "slips" or "slipping") NEAR/3 ("winter" or "snow" or "ice" or "weather")) Databases=CPCI-S Timespan=1993-2013
# 20	198	#13 or #14 or #15 or #16 or #17 or #18 or #19 Databases=CPCI-S Timespan=1993-2013
# 19	3	TI=("Warm Front" or "Warm Deal" or "Green Deal" or "Warm Zone" or "Energy Company Obligation") Databases=CPCI-S Timespan=1993-2013
# 18	34	TI=(insulat* NEAR/3 (home or homes or house or houses or household* or housing or accommodation* or rent or rents or rented or tenancy or tenancies or dwelling*)) Databases=CPCI-S Timespan=1993-2013
# 17	1	TI=("home energy " NEAR/3 (program* or assist*)) Databases=CPCI-S Timespan=1993-2013
# 16	41	TI=("energy efficien*" NEAR/3 (home or homes or house or houses or household* or housing or accommodation* or rent or rents or rented or tenancy or tenancies or dwelling* or domestic*)) Databases=CPCI-S Timespan=1993-2013
# 15	6	TI=(damp NEAR/3 (home or homes or house or houses or household* or housing or accommodation* or rent or rents or rented or tenancy or tenancies or dwelling*)) Databases=CPCI-S Timespan=1993-2013
# 14	89	TI=((warm* or heat* or underheat* or temperature*) NEAR/2 (home or homes or house or houses or household* or housing or accommodation* or rent or rents or rented or tenancy or tenancies or dwelling*)) Databases=CPCI-S Timespan=1993-2013
# 13	27	TI=((cold or freez* or frozen) NEAR/3 (home or homes or house or houses or household* or housing or accommodation* or rent or rents or rented or tenancy or tenancies or dwelling*)) Databases=CPCI-S Timespan=1993-2013
# 12	31	#9 or #10 or #11

		Databases=CPCI-S Timespan=1993-2013
# 11	23	TI=(("heating" or gas or electricity) NEAR/2 (payment* or allowance* or benefit* or grant* or voucher*)) Databases=CPCI-S Timespan=1993-2013
# 10	5	TI=((winter or cold or weaher) NEAR/3 (payment* or allowance* or benefit* or grant* or voucher*)) Databases=CPCI-S Timespan=1993-2013
# 9	3	TI=(fuel NEAR/3 (winter or poverty or poor or afford or affordable or affordability or tariff*)) Databases=CPCI-S Timespan=1993-2013
# 8	278	#1 or #4 or #5 or #6 or #7 Databases=CPCI-S Timespan=1993-2013
# 7	42	TI=(season* NEAR/3 (death* or fatalit* or mortalit* or morbidit* or "risk" or "risks" or vulnerabl* or suceptib*)) Databases=CPCI-S Timespan=1993-2013
# 6	70	TI=((winter or weather or temperature* or cold or colder) NEAR/3 (vulnerab* or "risk" or "risks" or suceptib*)) Databases=CPCI-S Timespan=1993-2013
# 5	20	TI=((excess or excessive or severe or severity or exposure) NEAR/3 winter) Databases=CPCI-S Timespan=1993-2013
# 4	10	#2 and #3 Databases=CPCI-S Timespan=1993-2013
# 3	197	TI=((cold or colder) NEAR/2 (spell* or season* or month* or period* or condition* or event or related or excess or excessive or severe or severity or extreme)) Databases=CPCI-S Timespan=1993-2013
# 2	134,816	TI=(death* or fatalit* or mortalit* or morbidit* or illness* or disease*) Databases=CPCI-S Timespan=1993-2013
# 1	147	TI=((winter or weather or temperature*) NEAR/3 (death* or fatalit* or mortalit* or morbidit* or illness* or disease*)) Databases=CPCI-S Timespan=1993-2013

Key:

TS Topic (searches terms in Title, Abstract, Author Keywords and Keywords Plus fields)
SU Research Area (specific fields of study)
WC Web of Science Category (specific fields of study)
NEAR searches for adjacent terms
NEAR/3 searches for terms within three words of each other
* truncation symbol
" " phrase search

Conference Proceedings Citation Index-Social Science & Humanities (CPCI-SSH) (Web of Science). 1990 – 2013-09-27. Searched 2 October 2013.

# 33	112	#27 NOT #32 Databases=CPCI-SSH Timespan=1993-2013
# 32	120,196	#28 or #29 or #30 or #31 Databases=CPCI-SSH Timespan=1993-2013
# 31	11,270	SU=(Agriculture or "Astronomy & Astrophysics" or "Biochemistry & Molecular Biology" or "Biodiversity & Conservation" or Chemistry or Crystallography or Electrochemistry or "Energy & Fuels" or Entomology or "Evolutionary Biology" or Fisheries or "Food Science & Technology" or Forestry or "Geochemistry & Geophysics" or Geology or "Marine & Freshwater Biology" or "Medical Laboratory Technology" or Oceanography or Parasitology or"Plant Sciences" or Spectroscopy or "Veterinary Sciences" or Zoology) Databases=CPCI-SSH Timespan=1993-2013
# 30	105,727	WC=(Agricultural or Agriculture or Agronomy or Astronomy or Astrophysics or Biochemistry or "Biodiversity Conservation" or "Molecular Biology" or Chemistry or "Computer Science" or Ecology or "Energy & Fuels" or Engineering or Entomology or "Evolutionary Biology" or Fisheries or "Food Science & Technology" or Forestry or Genetics or Heredity or Geology or Geosciences or Horticulture or "Marine & Freshwater Biology" or "Materials Science" or "Meteorology & Atmospheric Sciences" or Mineralogy or "Mining & Mineral Processing" or Oceanography or Parasitology or Physics or "Plant Sciences" or "Soil Science" or Spectroscopy or "Veterinary Sciences" or "Water Resources" or Zoology) Databases=CPCI-SSH Timespan=1993-2013
# 29	17,347	TS=(tree or trees or woodland or forest or forests or plant or plants or leaf or leaves or soil or agriculture or agricultural or agronomy or crop or crops or grass or grasses) Databases=CPCI-SSH Timespan=1993-2013
# 28	6,472	TS=(rat or rats or mouse or mice or murine or hamster or hamsters or animal or animals or dogs or dog or canine or pig or pigs or cats or bovine or cow or cattle or sheep or ovine or porcine or monkey or monkeys or hen or hens or chicken or chickens or poultry or rabbit or rabbits or fish or fishes or salmon or bird or birds or insect or insects) Databases=CPCI-SSH Timespan=1993-2013
# 27	226	#8 or #12 or #20 or #26 Databases=CPCI-SSH Timespan=1993-2013
# 26	39	#21 or #22 or #23 or #24 or #25 Databases=CPCI-SSH Timespan=1993-2013
# 25	1	TS=("health forecast*") Databases=CPCI-SSH Timespan=1993-2013
# 24	22	TS=(("forecast" or "alert" or "alerts" or "warning" or "warnings" or "alarm" or "alarms") NEAR/3 ("cold" or "colder" or "weather" or "winter"

		or "met office" or "meteorological office")) Databases=CPCI-SSH Timespan=1993-2013
# 23	1	TS=((grit or gritted or gritting or gritter*) NEAR/3 (road* or pavement* or sidewalk* or driveway* or pathway* or path*1)) Databases=CPCI-SSH Timespan=1993-2013
# 22	11	TS=(("accident" or "accidents" or "injury" or "injuries" or "injured" or fracture*) NEAR/3 ("winter" or "snow" or "ice" or "weather")) Databases=CPCI-SSH Timespan=1993-2013
# 21	5	TS=(("falls" or "falling" or "slip" or "slips" or "slipping") NEAR/3 ("winter" or "snow" or "ice" or "weather")) Databases=CPCI-SSH Timespan=1993-2013
# 20	78	#13 or #14 or #15 or #16 or #17 or #18 or #19 Databases=CPCI-SSH Timespan=1993-2013
# 19	0	TS=("Warm Front" or "Warm Deal" or "Green Deal" or "Warm Zone" or "Energy Company Obligation") Databases=CPCI-SSH Timespan=1993-2013
# 18	12	TS=(insulat* NEAR/3 (home or homes or house or houses or household* or housing or accommodation* or rent or rents or rented or tenancy or tenancies or dwelling*)) Databases=CPCI-SSH Timespan=1993-2013
# 17	2	TS=("home energy " NEAR/3 (program* or assist*)) Databases=CPCI-SSH Timespan=1993-2013
# 16	31	TS=("energy efficien*" NEAR/3 (home or homes or house or houses or household* or housing or accommodation* or rent or rents or rented or tenancy or tenancies or dwelling* or domestic*)) Databases=CPCI-SSH Timespan=1993-2013
# 15	0	TS=(damp NEAR/3 (home or homes or house or houses or household* or housing or accommodation* or rent or rents or rented or tenancy or tenancies or dwelling*)) Databases=CPCI-SSH Timespan=1993-2013
# 14	26	TS=((warm* or heat* or underheat* or temperature*) NEAR/2 (home or homes or house or houses or household* or housing or accommodation* or rent or rents or rented or tenancy or tenancies or dwelling*)) Databases=CPCI-SSH Timespan=1993-2013
# 13	13	TS=((cold or freez* or frozen) NEAR/3 (home or homes or house or houses or household* or housing or accommodation* or rent or rents or rented or tenancy or tenancies or dwelling*)) Databases=CPCI-SSH Timespan=1993-2013
# 12	27	#9 or #10 or #11 Databases=CPCI-SSH Timespan=1993-2013
# 11	17	TS=(("heating" or gas or electricity) NEAR/2 (payment* or allowance* or benefit* or grant* or voucher*)) Databases=CPCI-SSH Timespan=1993-2013
# 10	1	TS=((winter or cold or weaher) NEAR/3 (payment* or allowance* or

		benefit* or grant* or voucher*)) Databases=CPCI-SSH Timespan=1993-2013
# 9	9	TS=("fuel" NEAR/3 (winter or poverty or poor or afford or affordable or affordability or tariff*)) Databases=CPCI-SSH Timespan=1993-2013
# 8	87	#1 or #4 or #5 or #6 or #7 Databases=CPCI-SSH Timespan=1993-2013
# 7	12	TS=(season* NEAR/2 (death* or fatalit* or mortalit* or morbidit* or "risk" or "risks" or vulnerabl* or suceptib*)) Databases=CPCI-SSH Timespan=1993-2013
# 6	34	TS=((winter or weather or temperature* or cold or colder) NEAR/2 (vulnerab* or "risk" or "risks" or suceptib*)) Databases=CPCI-SSH Timespan=1993-2013
# 5	20	TS=((excess or excessive or severe or severity or exposure) NEAR/3 winter) Databases=CPCI-SSH Timespan=1993-2013
# 4	7	#2 and #3 Databases=CPCI-SSH Timespan=1993-2013
# 3	12,795	TS=(death* or fatalit* or mortalit* or morbidit* or illness* or disease*) Databases=CPCI-SSH Timespan=1993-2013
# 2	88	TS=((cold or colder) NEAR/2 (spell* or season* or month* or period* or condition* or event or related or excess or excessive or severe or severity or extreme)) Databases=CPCI-SSH Timespan=1993-2013
# 1	17	TS=((winter or weather or temperature*) NEAR/3 (death* or fatalit* or mortalit* or morbidit* or illness* or disease*)) Databases=CPCI-SSH Timespan=1993-2013

Key:

TS Topic (searches terms in Title, Abstract, Author Keywords and Keywords Plus fields)
SU Research Area (specific fields of study)
WC Web of Science Category (specific fields of study)
NEAR searches for adjacent terms
NEAR/3 searches for terms within three words of each other
* truncation symbol
" " phrase search

HMIC (OvidSP). 1979-2013/March. Searched 30 September 2013.

1 exp Winter/ (180)
2 Snow/ or Ice/ (4)
3 1 or 2 (183)
4 exp Death/ (2782)
5 exp Mortality/ (5160)

6 exp Morbidity/ (3077)
7 exp Risk factors/ (3899)
8 or/4-7 (12869)
9 3 and 8 (30)
10 exp "Cold as cause of disease"/ (48)
11 (winter adj4 (death$ or fatalit$ or mortalit$ or morbidit$ or illness$ or disease$)).ti,ab. (58)
12 (weather adj3 (death$ or fatalit$ or mortalit$ or morbidit$ or illness$ or disease$)).ti,ab. (6)
13 (temperature$ adj3 (death$ or fatalit$ or mortalit$ or morbidit$ or illness$ or disease$)).ti,ab. (20)
14 ((cold or colder) adj4 (spell$ or season$ or month$ or period$ or condition$ or event$1 or related or excess or excessive or severe or severity or extreme)).ti,ab. (52)
15 ((excess or excessive or severe or severity or exposure) adj3 winter).ti,ab. (49)
16 (winter adj4 (vulnerab$ or risk$1 or suceptib$)).ti,ab. (11)
17 (temperature$ adj3 (vulnerab$ or risk$1 or suceptib$)).ti,ab. (17)
18 (weather adj3 (vulnerab$ or risk$1 or suceptib$)).ti,ab. (2)
19 ((cold or colder) adj3 (vulnerab$ or risk$1 or suceptib$)).ti,ab. (6)
20 exp Seasonal factors/ and (Death/ or Mortality/ or Morbidity/ or Risk Factors/) (20)
21 (season$ adj3 (death$ or fatalit$ or mortalit$ or morbidit$ or risk$1 or vulnerabl$ or suceptib$)).ti,ab. (39)
22 or/9-21 (224)
23 exp Fuel poverty/ (40)
24 ((fuel or energy or gas or electricity) adj3 (poverty or poor or afford or affordable or affordability or tariff$)).ti,ab. (79)
25 (winter adj3 fuel).ti,ab. (6)
26 (winter adj3 (payment$ or allowance$ or benefit$ or grant$ or voucher$)).ti,ab. (3)
27 ((cold or weather) adj3 (payment$ or allowance$ or benefit$ or grant$ or voucher$)).ti,ab. (10)
28 ((heat$ or gas or electricity) adj3 (payment$ or allowance$ or benefit$ or grant$ or voucher$)).ti,ab. (12)
29 or/23-28 (118)
30 exp Housing/ (3183)
31 exp Winter/ or exp Seasonal Factors/ (286)
32 exp building climatic services/ (390)
33 warmth/ (36)
34 30 and (31 or 32 or 33) (17)
35 ((cold or freez$ or frozen) adj3 (home or homes or house or houses or household$ or housing)).ti,ab. (26)
36 ((warm$ or heat$ or underheat$ or temperature$) adj3 (home or homes or house or houses or household$ or housing)).ti,ab. (64)
37 ((damp$ or humid$ or mold or moldy or mould or mouldy or condensation$) adj3 (home or homes or house or houses or household$ or housing)).ti,ab. (24)
38 ((cold or freez$ or frozen) adj3 (accommodation$ or rent or rents or rented or tenancy or tenancies or dwelling$)).ti,ab. (2)
39 ((warm$ or heat$ or underheat$ or temperature$) adj3 (accommodation$ or rent or rents or rented or tenancy or tenancies or dwelling$)).ti,ab. (0)

40 ((damp or humid or mold or moldy or mould or mouldy) adj3 (accommodation$ or rent or rents or rented or tenancy or tenancies or dwelling$)).ti,ab. (0)
41 ((energy adj3 efficien$) and (home or homes or house or houses or household$ or housing)).ti,ab. (38)
42 ((energy adj3 efficien$) and (accommodation$ or rent or rents or rented or tenancy or tenancies or dwelling$ or domestic$)).ti,ab. (12)
43 (home energy adj3 (program$ or assist$)).ti,ab. (1)
44 (insulat$ adj4 (home or homes or house or houses or household$ or housing)).ti,ab. (9)
45 (insulat$ adj4 (accommodation$ or rent or rents or rented or tenancy or tenancies or dwelling$)).ti,ab. (0)
46 (Warm Front or Warm Deal or Green Deal or Warm Zone or Energy Company Obligation).ti,ab. (4)
47 thermal comfort.ti,ab. (10)
48 or/34-47 (150)
49 exp Accidents/ (2703)
50 exp wounds & injuries/ (2186)
51 Winter/ or Snow/ or Ice/ (183)
52 exp seasonal factors/ (131)
53 (49 or 50) and (51 or 52) (0)
54 exp Weather hazards/ (51)
55 ((fall or falls or falling or slip or slips or slipping) adj3 (winter or snow or ice or weather or season$)).ti,ab. (9)
56 ((accident$ or injury or injuries or injured or fracture$ or trauma$) adj3 (winter or snow or ice or weather or season$)).ti,ab. (5)
57 ((grit or gritted or gritting or gritter$) adj3 (road$ or pavement$ or sidewalk$ or driveway$ or pathway$ or path$1)).ti,ab. (0)
58 or/53-57 (65)
59 exp Weather/ and exp Forecasting/ (4)
60 ((forecast$ or alert$ or warning$ or alarm$) adj3 (cold or colder or weather or winter or met office or meteorological office)).ti,ab. (18)
61 health forecast$.ti,ab. (9)
62 or/59-61 (26)
63 22 or 29 or 48 or 58 or 62 (482)
64 limit 63 to yr="1993 -Current" (352)

Key:

/	subject heading
exp	explode subject heading
.ti,ab.	searches are restricted to the title and abstract fields
adj	searches for adjacent terms
adj3	searches for terms within three words of each other
$	truncation symbol
$1	truncation restricted to one character
or/1-4	combine sets 1 to 4 using OR

PsycINFO (OvidSP). 1806-2013/Sep week 4. Searched 30 September 2013.

1 temperature effects/ or cold effects/ (3080)
2 "death and dying"/ (21318)
3 exp Morbidity/ (2616)
4 risk factors/ (41469)
5 1 and (2 or 3 or 4) (21)
6 (winter adj4 (death$ or fatalit$ or mortalit$ or morbidit$ or illness$ or disease$)).ti,ab. (37)
7 (weather adj3 (death$ or fatalit$ or mortalit$ or morbidit$ or illness$ or disease$)).ti,ab. (17)
8 (temperature$ adj3 (death$ or fatalit$ or mortalit$ or morbidit$ or illness$ or disease$)).ti,ab. (57)
9 ((cold or colder) adj4 (spell$ or season$ or month$ or period$ or condition$ or event$1 or related or excess or excessive or severe or severity or extreme)).ti,ab. (531)
10 (death$ or fatalit$ or mortalit$ or morbidit$ or illness$ or disease$).ti,ab. (314094)
11 9 and 10 (55)
12 ((excess or excessive or severe or severity or exposure) adj3 winter).ti,ab. (86)
13 (winter adj4 (vulnerab$ or risk$1 or suceptib$)).ti,ab. (32)
14 (temperature$ adj3 (vulnerab$ or risk$1 or suceptib$)).ti,ab. (20)
15 (weather adj3 (vulnerab$ or risk$1 or suceptib$)).ti,ab. (25)
16 ((cold or colder) adj3 (vulnerab$ or risk$1 or suceptib$)).ti,ab. (13)
17 seasonal variations/ and ("death and dying"/ or exp Morbidity/ or risk factors/) (78)
18 (season$ adj3 (death$ or fatalit$ or mortalit$ or morbidit$ or risk$1 or vulnerabl$ or suceptib$)).ti,ab. (110)
19 or/5-8,11-18 (490)
20 ((fuel or energy or gas or electricity) adj3 (poverty or poor or afford or affordable or affordability or tariff$)).ti,ab. (85)
21 (winter adj3 fuel).ti,ab. (0)
22 (winter adj3 (payment$ or allowance$ or benefit$ or grant$ or voucher$)).ti,ab. (9)
23 ((cold or weather) adj3 (payment$ or allowance$ or benefit$ or grant$ or voucher$)).ti,ab. (2)
24 ((heat$ or gas or electricity) adj3 (payment$ or allowance$ or benefit$ or grant$ or voucher$)).ti,ab. (20)
25 or/20-24 (115)
26 housing/ and (Temperature effects/ or cold effects/) (4)
27 ((cold or freez$ or frozen) adj3 (home or homes or house or houses or household$ or housing)).ti,ab. (17)
28 ((warm$ or heat$ or underheat$ or temperature$) adj3 (home or homes or house or houses or household$ or housing)).ti,ab. (93)
29 ((damp$ or humid$ or mold or moldy or mould or mouldy or condensation$) adj3 (home or homes or house or houses or household$ or housing)).ti,ab. (17)
30 ((cold or freez$ or frozen) adj3 (accommodation$ or rent or rents or rented or tenancy or tenancies or dwelling$)).ti,ab. (2)
31 ((warm$ or heat$ or underheat$ or temperature$) adj3 (accommodation$ or rent or rents or rented or tenancy or tenancies or dwelling$)).ti,ab. (4)
32 ((damp or humid or mold or moldy or mould or mouldy) adj3 (accommodation$ or rent or rents or rented or tenancy or tenancies or dwelling$)).ti,ab. (1)

33 ((energy adj3 efficien$) and (home or homes or house or houses or household$ or housing)).ti,ab. (37)
34 ((energy adj3 efficien$) and (accommodation$ or rent or rents or rented or tenancy or tenancies or dwelling$ or domestic$)).ti,ab. (9)
35 (home energy adj3 (program$ or assist$)).ti,ab. (7)
36 (insulat$ adj4 (home or homes or house or houses or household$ or housing)).ti,ab. (12)
37 (insulat$ adj4 (accommodation$ or rent or rents or rented or tenancy or tenancies or dwelling$)).ti,ab. (0)
38 (Warm Front or Warm Deal or Green Deal or Warm Zone or Energy Company Obligation).ti,ab. (2)
39 or/26-38 (185)
40 (exp accidents/ or exp Injuries/) and exp Seasonal Variations/ (22)
41 ((fall or falls or falling or slip or slips or slipping) adj3 (winter or snow or ice or weather or season$)).ti,ab. (372)
42 ((accident$ or injury or injuries or injured or fracture$ or trauma$) adj3 (winter or snow or ice or weather or season$)).ti,ab. (78)
43 ((grit or gritted or gritting or gritter$) adj3 (road$ or pavement$ or sidewalk$ or driveway$ or pathway$ or path$1)).ti,ab. (0)
44 or/40-43 (463)
45 ((forecast$ or alert$ or warning$ or alarm$) adj3 (cold or colder or weather or winter or met office or meteorological office)).ti,ab. (87)
46 health forecast$.ti,ab. (1)
47 45 or 46 (88)
48 19 or 25 or 39 or 44 or 47 (1312)
49 limit 48 to (human and english language and yr="1993 -Current") (829)

Key:

/	subject heading
.ti,ab.	searches are restricted to the title and abstract fields
adj	searches for adjacent terms
adj3	searches for terms within three words of each other
$	truncation symbol
$1	truncation restricted to one character
or/1-4	combine sets 1 to 4 using OR

Cochrane Library: CDSR, DARE, CENTRAL, NHS EED and HTA (Wiley). 2013:Issue 9/12 and 3/4. Searched 1 October 2013.

#1 MeSH descriptor: [Cold Temperature] explode all trees 1110
#2 MeSH descriptor: [Snow] this term only 5
#3 MeSH descriptor: [Ice] this term only 83
#4 #1 or #2 or #3 1181
#5 MeSH descriptor: [Death] explode all trees 1500
#6 MeSH descriptor: [Mortality] explode all trees 10049
#7 [mh /MO] 20804

#8 MeSH descriptor: [Morbidity] explode all trees 10513
#9 MeSH descriptor: [Risk Factors] this term only 17598
#10 #5 or #6 or #7 or #8 or #9 46439
#11 #4 and #10 35
#12 (winter near/4 (death* or fatalit* or mortalit* or morbidit* or illness* or disease*)):ti,ab,kw 26
#13 (weather near/3 (death* or fatalit* or mortalit* or morbidit* or illness* or disease*)):ti,ab,kw 5
#14 (temperature* near/3 (death* or fatalit* or mortalit* or morbidit* or illness* or disease*)):ti,ab,kw 131
#15 ((cold or colder) near/4 (spell* or season* or month* or period* or condition* or event or events or related or excess or excessive or severe or severity or extreme)):ti,ab,kw 280
#16 (death* or fatalit* or mortalit* or morbidit* or illness* or disease*):ti,ab,kw 173933
#17 #15 and #16 92
#18 ((excess or excessive or severe or severity or exposure) near/3 winter):ti,ab,kw 18
#19 (winter near/4 (vulnerab* or risk or risks or suceptib*)):ti,ab,kw 5
#20 (temperature* near/3 (vulnerab* or risk or risks or suceptib*)):ti,ab,kw 26
#21 (weather near/3 (vulnerab* or risk or risks or suceptib*)):ti,ab,kw 3
#22 ((cold or colder) near/3 (vulnerab* or risk or risks or suceptib*)):ti,ab,kw 17
#23 MeSH descriptor: [Seasons] this term only 707
#24 MeSH descriptor: [Death] this term only 64
#25 MeSH descriptor: [Mortality] this term only 390
#26 MeSH descriptor: [Morbidity] this term only 664
#27 MeSH descriptor: [Risk Factors] this term only 17598
#28 #24 or #25 or #26 or #27 18533
#29 #23 and #28 43
#30 (season* near/3 (death* or fatalit* or mortalit* or morbidit* or risk or risks or vulnerabl* or suceptib*)):ti,ab,kw 68
#31 #11 or #12 or #13 or #14 or #17 or #18 or #19 or #20 or #21 or #22 or #29 or #30 411
#32 ((fuel or energy or gas or electricity) near/3 (poverty or poor or afford or affordable or affordability or tariff*)):ti,ab,kw 18
#33 (winter near/3 fuel):ti,ab,kw 0
#34 (winter near/3 (payment* or allowance* or benefit* or grant* or voucher*)):ti,ab,kw 3
#35 ((cold or weather) near/3 (payment* or allowance* or benefit* or grant* or voucher*)):ti,ab,kw 10
#36 ((heat* or gas or electricity) near/3 (payment* or allowance* or benefit* or grant* or voucher*)):ti,ab,kw 21
#37 #32 or #33 or #34 or #35 or #36 51
#38 MeSH descriptor: [Housing] explode all trees 252
#39 MeSH descriptor: [Cold Temperature] explode all trees 1110
#40 MeSH descriptor: [Heating] this term only 120
#41 #38 and (#39 or #40) 12
#42 ((cold or freez* or frozen) near/3 (home or homes or house or houses or household* or housing)):ti,ab,kw 3

#43 ((warm* or heat* or underheat* or temperature*) near/3 (home or homes or house or houses or household* or housing)):ti,ab,kw 48
#44 ((damp* or humid* or mold or moldy or mould or mouldy or condensation*) near/3 (home or homes or house or houses or household* or housing)):ti,ab,kw 25
#45 ((cold or freez* or frozen) near/3 (accommodation* or rent or rents or rented or tenancy or tenancies or dwelling*)):ti,ab,kw 0
#46 ((warm* or heat* or underheat* or temperature*) near/3 (accommodation* or rent or rents or rented or tenancy or tenancies or dwelling*)):ti,ab,kw 2
#47 ((damp or humid or mold or moldy or mould or mouldy) near/3 (accommodation* or rent or rents or rented or tenancy or tenancies or dwelling*)):ti,ab,kw 0
#48 ((energy near/3 efficien*) and (home or homes or house or houses or household* or housing)):ti,ab,kw 6
#49 ((energy near/3 efficien*) and (accommodation* or rent or rents or rented or tenancy or tenancies or dwelling* or domestic*)):ti,ab,kw 0
#50 ("home energy" near/3 (program* or assist*)):ti,ab,kw 0
#51 (insulat* near/4 (home or homes or house or houses or household* or housing)):ti,ab,kw 8
#52 (insulat* near/4 (accommodation* or rent or rents or rented or tenancy or tenancies or dwelling*)):ti,ab,kw 0
#53 ("Warm Front" or "Warm Deal" or "Green Deal" or "Warm Zone" or "Energy Company Obligation"):ti,ab,kw 0
#54 "thermal comfort":ti,ab,kw 60
#55 #41 or #42 or #43 or #44 or #45 or #46 or #47 or #48 or #49 or #50 or #51 or #52 or #53 or #54 137
#56 MeSH descriptor: [Accidents] explode all trees 4421
#57 MeSH descriptor: [Wounds and Injuries] explode all trees 14069
#58 MeSH descriptor: [Snow] this term only 5
#59 MeSH descriptor: [Ice] this term only 83
#60 MeSH descriptor: [Seasons] this term only 707
#61 (#56 or #57) and (#58 or #59 or #60) 55
#62 ((fall or falls or falling or slip or slips or slipping) near/3 (winter or snow or ice or weather or season*)):ti,ab,kw 67
#63 ((accident* or injury or injuries or injured or fracture* or trauma*) near/3 (winter or snow or ice or weather or season*)):ti,ab,kw 17
#64 ((grit or gritted or gritting or gritter*) near/3 (road* or pavement* or sidewalk* or driveway* or pathway* or path or paths)):ti,ab,kw 0
#65 #61 or #62 or #63 or #64 137
#66 MeSH descriptor: [Forecasting] this term only 455
#67 MeSH descriptor: [Weather] this term only 25
#68 #66 and #67 1
#69 ((forecast* or alert* or warning* or alarm*) near/3 (cold or colder or weather or winter or "met office" or "meteorological office")):ti,ab,kw 7
#70 health next forecast*:ti,ab,kw 3
#71 #68 or #69 or #70 10
#72 #31 or #37 or #55 or #65 or #71 722

#73 #31 or #37 or #55 or #65 or #71 from 1993 598

Key:

MeSH descriptor	subject heading (MeSH)
explode all trees	explode subject heading (MeSH)
:ti,ab,kw	searches are restricted to the title, abstract and keyword fields
near	searches for adjacent terms
near/3	searches for terms within three words of each other
*	truncation symbol

EconLit (OvidSP). 1961-2013/Aug. Searched 30 September 2013.

1 (winter adj4 (death$ or fatalit$ or mortalit$ or morbidit$ or illness$ or disease$)).ti,ab,kw. (12)
2 (weather adj3 (death$ or fatalit$ or mortalit$ or morbidit$ or illness$ or disease$)).ti,ab,kw. (18)
3 (temperature$ adj3 (death$ or fatalit$ or mortalit$ or morbidit$ or illness$ or disease$)).ti,ab,kw. (13)
4 ((cold or colder) adj4 (spell$ or season$ or month$ or period$ or condition$ or event$1 or related or excess or excessive or severe or severity or extreme)).ti,ab,kw. (115)
5 (death$ or fatalit$ or mortalit$ or morbidit$ or illness$ or disease$).ti,ab,kw. (13550)
6 4 and 5 (12)
7 ((excess or excessive or severe or severity or exposure) adj3 winter).ti,ab,kw. (7)
8 (winter adj4 (vulnerab$ or risk$1 or suceptib$)).ti,ab,kw. (3)
9 (temperature$ adj3 (vulnerab$ or risk$1 or suceptib$)).ti,ab,kw. (20)
10 (weather adj3 (vulnerab$ or risk$1 or suceptib$)).ti,ab,kw. (139)
11 ((cold or colder) adj3 (vulnerab$ or risk$1 or suceptib$)).ti,ab,kw. (4)
12 (season$ adj3 (death$ or fatalit$ or mortalit$ or morbidit$ or risk$1 or vulnerabl$ or suceptib$)).ti,ab,kw. (44)
13 or/1-3,6-12 (253)
14 (fuel adj3 (poverty or poor or afford or affordable or affordability or tariff$)).ti,ab,kw. (87)
15 (winter adj3 (payment$ or allowance$ or benefit$ or grant$ or voucher$)).ti,ab,kw. (3)
16 ((cold or weather) adj3 (payment$ or allowance$ or benefit$ or grant$ or voucher$)).ti,ab,kw. (6)
17 ((heat$ or gas or electricity) adj3 (payment$ or allowance$ or benefit$ or grant$ or voucher$)).ti,ab,kw. (132)
18 or/14-17 (227)
19 ((cold or freez$ or frozen) adj3 (home or homes or house or houses or household$ or housing)).ti,ab,kw. (15)
20 ((warm$ or heat$ or underheat$ or temperature$) adj3 (home or homes or house or houses or household$ or housing)).ti,ab,kw. (80)
21 ((damp$ or humid$ or mold or moldy or mould or mouldy or condensation$) adj3 (home or homes or house or houses or households or housing)).ti,ab,kw. (13)
22 ((cold or freez$ or frozen) adj3 (accommodation$ or rent or rents or rented or tenancy or tenancies or dwelling$)).ti,ab,kw. (1)
23 ((warm$ or heat$ or underheat$ or temperature$) adj3 (accommodation$ or rent or rents or rented or tenancy or tenancies or dwelling$)).ti,ab,kw. (6)

24 ((damp or humid or mold or moldy or mould or mouldy) adj3 (accommodation$ or rent or rents or rented or tenancy or tenancies or dwelling$)).ti,ab,kw. (1)
25 (energy efficienc$ adj3 (home or homes or house or houses or household$ or housing)).ti,ab,kw. (88)
26 (energy efficienc$ adj3 (accommodation$ or rent or rents or rented or tenancy or tenancies or dwelling$ or domestic$)).ti,ab,kw. (18)
27 (home energy adj3 (program$ or assist$)).ti,ab,kw. (2)
28 (insulat$ adj3 (home or homes or house or houses or household$ or housing)).ti,ab,kw. (20)
29 (insulat$ adj3 (accommodation$ or rent or rents or rented or tenancy or tenancies or dwelling$)).ti,ab,kw. (0)
30 (Warm Front or Warm Deal or Green Deal or Warm Zone or Energy Company Obligation).ti,ab,kw. (8)
31 thermal comfort.ti,ab,kw. (21)
32 or/19-31 (245)
33 ((fall or falls or falling or slip or slips or slipping) adj3 (winter or snow or ice or weather or season$)).ti,ab,kw. (33)
34 ((accident$ or injury or injuries or injured or fracture$ or trauma$) adj3 (winter or snow or ice or weather or season$)).ti,ab,kw. (4)
35 ((grit or gritted or gritting or gritter$) adj3 (road$ or pavement$ or sidewalk$ or driveway$ or pathway$ or path$1)).ti,ab,kw. (0)
36 or/33-35 (37)
37 ((forecast$ or alert$ or warning$ or alarm$) adj3 (cold or colder or weather or winter or met office or meteorological office)).ti,ab,kw. (66)
38 health forecast$.ti,ab,kw. (1)
39 37 or 38 (67)
40 13 or 18 or 32 or 36 or 39 (793)
41 limit 40 to yr="1993 -Current" (745)

Key:

.ti,ab,kw.	searches are restricted to the title, abstract and keyword fields
adj	searches for adjacent terms
adj3	searches for terms within three words of each other
$	truncation symbol
$1	truncation restricted to one character
or/1-4	combine sets 1 to 4 using OR

CEA Registry (www.cearegistry.org). Searched 3 October 2013.

The Basic search option only allows one word/phrase at a time: searched each line separately and then browsed for potentially useful records.

winter	1 (0 potentially relevant)
snow	2 (0 potentially relevant)
weather	1 (0 potentially relevant)
season	33 (0 potentially relevant: mostly about influenza vaccination)

seasonal 16 (0 potentially relevant: mostly about influenza vaccination)
fuel 1 (0 potentially relevant)
housing 3 (0 potentially relevant)
energy 15 (0 potentially relevant)
falls 37 (0 potentially relevant: general falls prevention, not winter specific)
forecast 19 (0 potentially relevant)

RePEc (http://repec.org/). Searched 3 October 2013.

IDEAS search interface

(winter | weather | temperature) + (death | deaths | fatality | fatalities | mortality)
In: Title
Publication Date Range: 1993 to 2013
20 records retrieved

(winter | weather | temperature) + (death | deaths | fatality | fatalities | mortality)
In: Abstract
Publication Date Range: 1993 to 2013
127 records retrieved

(season | seasonal) + (death | deaths | fatality | fatalities | mortality)
In: Title
Publication Date Range: 1993 to 2013
4 records retrieved

(season | seasonal) + (death | deaths | fatality | fatalities | mortality)
In: Abstract
Publication Date Range: 1993 to 2013
75 records retrieved

("fuel poverty" | "winter fuel" | "winter payment" | "cold payment" | "weather payment" | "winter payments" | "cold payments" | "weather payments")
In: Title
Publication Date Range: 1993 to 2013
32 records retrieved

("fuel poverty" | "winter fuel" | "winter payment" | "cold payment" | "weather payment" | "winter payments" | "cold payments" | "weather payments")
In: Abstract
Publication Date Range: 1993 to 2013
65 records retrieved

"cold home" | "cold homes" | "cold house" | "cold houses" | "cold household*" | "cold housing"
In: Title

Publication Date Range: 1993 to 2013
8 records retrieved

"cold home" | "cold homes" | "cold house" | "cold houses" | "cold household*" | "cold housing"
In: Abstract
Publication Date Range: 1993 to 2013
3 records retrieved

"warm home" | "warm homes" | "warm house" | "warm houses" | "warm households" | "warm housing" | "warmer home" | "warmer homes" | "warmer house" | "warmer houses" | "warmer households" | "warmer housing"
In: Title
Publication Date Range: 1993 to 2013
2 records retrieved

"warm home" | "warm homes" | "warm house" | "warm houses" | "warm households" | "warm housing" | "warmer home" | "warmer homes" | "warmer house" | "warmer houses" | "warmer households" | "warmer housing"
In: Abstract
Publication Date Range: 1993 to 2013
0 records retrieved

"heating home" | "heating homes" | "heating house" | "heating houses" | "heating households" | "heating housing" | "Warm Front" | "Warm Deal" | "Green Deal" | "Warm Zone" | "Energy Company Obligation"
In: Title
Publication Date Range: 1993 to 2013
9 records retrieved

"heating home" | "heating homes" | "heating house" | "heating houses" | "heating households" | "heating housing" | "Warm Front" | "Warm Deal" | "Green Deal" | "Warm Zone" | "Energy Company Obligation"
In: Abstract
Publication Date Range: 1993 to 2013
12 records retrieved

"damp home" | "damp homes" | "damp house" | "damp houses" | "damp household*" | "damp housing"
In: Title
Publication Date Range: 1993 to 2013
0 records retrieved

"damp home" | "damp homes" | "damp house" | "damp houses" | "damp household*" | "damp housing"
In: Abstract

Publication Date Range: 1993 to 2013
1 record retrieved

"energy efficient home" | "energy efficiency home" | "energy efficient homes" | "energy efficiency homes" | "energy efficient house" | "energy efficiency house" | "energy efficient houses" | "energy efficiency houses" | "energy efficient households" | "energy efficiency households" | "energy efficient housing" | "energy efficiency housing"
In: Title
Publication Date Range: 1993 to 2013
6 records retrieved

"energy efficient home" | "energy efficiency home" | "energy efficient homes" | "energy efficiency homes" | "energy efficient house" | "energy efficiency house" | "energy efficient houses" | "energy efficiency houses" | "energy efficient households" | "energy efficiency households" | "energy efficient housing" | "energy efficiency housing"
In: Abstract
Publication Date Range: 1993 to 2013
15 records retrieved

("energy efficient" | "energy efficiency") + cost
In: Title
Publication Date Range: 1993 to 2013
34 records retrieved
[NB almost 600 records when searched in Abstract]

"winter falls" | "winter accidents" | "winter injuries" | "seasonal falls" | " seasonal accidents" | " seasonal injuries"
In: Title
Publication Date Range: 1993 to 2013
0 records retrieved

"winter falls" | "winter accidents" | "winter injuries" | "seasonal falls" | " seasonal accidents" | " seasonal injuries"
In: Abstract
Publication Date Range: 1993 to 2013
0 records retrieved

"health forecast" | "health forecasts" | "health forecasting"
In: Title
Publication Date Range: 1993 to 2013
1 record retrieved

"health forecast" | "health forecasts" | "health forecasting"
In: Abstract
Publication Date Range: 1993 to 2013

1 record retrieved

Key:
| OR
+ AND
" " phrase search

Campbel Library (http://www.campbellcollaboration.org/library.php). Searched 3 October 2013.

0	title is winter OR weather OR season* OR temperature OR cold OR colder	0
1	keywords is winter OR weather OR season* OR temperature OR cold OR colder	0
2	title is fuel	0
3	keywords is fuel	0
4	title is house OR houses OR housing	2
5	keywords is house OR houses OR housing	1
6	title is damp* OR mold* OR mould*	0
7	keywords is damp* OR mold* OR mould*	0
8	title is "energy efficient" OR "energy efficiency"	0
9	keywords is "energy efficient" OR "energy efficiency"	0
10	title is falls OR falling OR slip OR slips OR slipping	0
11	keywords is falls OR falling OR slip OR slips OR slipping	0
12	title is accident* OR injury OR injuries OR injured OR fracture*	3
13	keywords is accident* OR injury OR injuries OR injured OR fracture*	2
14	title is forecast*	0
15	keywords is forecast*	0
16	title is winter OR weather OR season* OR temperature OR cold OR colder or keywords is winter OR weather OR season* OR temperature OR cold OR colder or title is fuel or keywords is fuel or title is house OR houses OR housing or keywords is house OR houses OR housing or title is damp* OR mold* OR mould* or keywords is damp* OR mold* OR mould* or title is "energy efficient" OR "energy efficiency" or keywords is "energy efficient" OR "energy efficiency" or title is falls OR falling OR slip OR slips OR slipping or keywords is falls OR falling OR slip OR slips OR slipping or title is accident* OR injury OR injuries OR injured OR fracture* or keywords is accident* OR injury OR injuries OR injured OR fracture* or title is forecast* or keywords is forecast*	6

NB. Only 1 record was retrieved; the other 5 records were irrelevant

Key:
title searches are restricted to the title field
keywords searches are restricted to the keywords field
* truncation symbol
" " phrase search

Trials Register of Promoting Health Interventions (TRoPHI) (EPPI-Centre database interface). Searched 3 October 2013.

Freetext: "winter death*" OR "winter fatalit*" OR "winter mortalit*" OR "winter morbidit*" OR "winter illness*" OR "winter disease*" 0
Freetext: "weather death*" OR "weather fatalit*" OR "weather mortalit*" OR "weather morbidit*" OR "weather illness*" OR "weather disease*" 0
Freetext: "temperature* death*" OR "temperature* fatalit*" OR "temperature* mortalit*" OR "temperature* morbidit*" OR "temperature* illness*" OR "temperature* disease*" 0
Freetext: "cold* death*" OR "cold* fatalit*" OR "cold* mortalit*" OR "cold* morbidit*" OR "cold* illness*" OR "cold* disease*" 0
Freetext: (excess OR excessive OR severe OR severity OR exposure) AND (winter OR weather OR "temperature*" OR cold OR colder) 9
Freetext: ("vulnerab*" or risk OR risks OR "suceptib*") AND (winter OR weather OR "temperature*" OR cold OR colder) 8
Freetext: "season*" AND ("death*" OR "fatalit*" OR "mortalit*" OR "morbidit*" OR "risk*" OR "vulnerabl*" OR "suceptib*") 17
Freetext: "fuel poverty" OR "winter fuel" OR "winter payment*" OR "cold payment*" OR "weather payment*" 0
Freetext: (cold OR "freez*" OR frozen) AND (home OR homes OR house OR houses OR "household*" OR housing) 1
Freetext: ("warm*" OR "heat*" OR "underheat*" OR "temperature*" OR "insulat*") AND (home OR homes OR house OR houses OR "household*" OR housing) 8
Freetext: ("damp*" OR "mold*" OR "mould*") AND (home OR homes OR house OR houses OR "household*" OR housing) 2
Freetext: "energy efficien*" OR "home energy" OR "Warm Front" OR "Warm Deal" OR "Green Deal" OR "Warm Zone" OR "Energy Company Obligation" OR "thermal comfort" 0
Freetext: (falls OR falling OR slip OR slips OR slipping) AND (winter OR snow OR ice OR weather OR "season*") 2
Freetext: ("accident*" OR injury OR injuries OR injured OR "fracture*" OR "trauma*") AND (winter OR snow OR ice OR weather OR "season*") 9
Freetext: ("forecast*" OR "alert*" OR "warning*" OR "alarm*") AND (cold OR colder OR weather OR winter OR "met office" OR "meteorological office") 1
Freetext: "health forecast*" 0
1 OR 2 OR 3 OR 4 OR 5 OR 6 OR 7 OR 8 OR 9 OR 10 OR 11 OR 12 OR 13 OR 14 OR 15 OR 16 44

NB. Only 8 records were retrieved; the other 36 records were irrelevant

Key:

Freetext	searches are restricted to the text fields (title, author and abstract)
*	truncation symbol
" "	phrase search
" *"	ensures truncation search works

Database of Promoting Health Effectiveness Reviews (DoPHER) (EPPI-Centre database interface). Searched 3 October 2013.

Freetext: "winter death*" OR "winter fatalit*" OR "winter mortalit*" OR "winter morbidit*" OR "winter illness*" OR "winter disease*" 0
Freetext: "weather death*" OR "weather fatalit*" OR "weather mortalit*" OR "weather morbidit*" OR "weather illness*" OR "weather disease*" 0
Freetext: "temperature* death*" OR "temperature* fatalit*" OR "temperature* mortalit*" OR "temperature* morbidit*" OR "temperature* illness*" OR "temperature* disease*" 0
Freetext: "cold* death*" OR "cold* fatalit*" OR "cold* mortalit*" OR "cold* morbidit*" OR "cold* illness*" OR "cold* disease*" 0
Freetext: (excess OR excessive OR severe OR severity OR exposure) AND (winter OR weather OR "temperature*" OR cold OR colder) 2
Freetext: ("vulnerab*" or risk OR risks OR "suceptib*") AND (winter OR weather OR "temperature*" OR cold OR colder) 5
Freetext: "season*" AND ("death*" OR "fatalit*" OR "mortalit*" OR "morbidit*" OR "risk*" OR "vulnerabl*" OR "suceptib*") 3
Freetext: "fuel poverty" OR "winter fuel" OR "winter payment*" OR "cold payment*" OR "weather payment*" 0
Freetext: (cold OR "freez*" OR frozen) AND (home OR homes OR house OR houses OR "household*" OR housing) 1
Freetext: ("warm*" OR "heat*" OR "underheat*" OR "temperature*" OR "insulat*") AND (home OR homes OR house OR houses OR "household*" OR housing) 6
Freetext: ("damp*" OR "mold*" OR "mould*") AND (home OR homes OR house OR houses OR "household*" OR housing) 2
Freetext: "energy efficien*" OR "home energy" OR "Warm Front" OR "Warm Deal" OR "Green Deal" OR "Warm Zone" OR "Energy Company Obligation" OR "thermal comfort" 3
Freetext: (falls OR falling OR slip OR slips OR slipping) AND (winter OR snow OR ice OR weather OR "season*") 0
Freetext: ("accident*" OR injury OR injuries OR injured OR "fracture*" OR "trauma*") AND (winter OR snow OR ice OR weather OR "season*") 2
Freetext: ("forecast*" OR "alert*" OR "warning*" OR "alarm*") AND (cold OR colder OR weather OR winter OR "met office" OR "meteorological office") 0
Freetext: "health forecast*" 0
1 OR 2 OR 3 OR 4 OR 5 OR 6 OR 7 OR 8 OR 9 OR 10 OR 11 OR 12 OR 13 OR 14 OR 15 OR 16 14

NB. Only 5 records were retrieved; the other 9 records were irrelevant

Key:

Freetext	searches are restricted to the text fields (title, author and abstract)
*	truncation symbol
" "	phrase search
" *"	ensures truncation search works

OpenGrey (http://www.opengrey.eu/). Searched 3 October 2013.

("winter death*" OR "winter fatalit*" OR "winter mortalit*" OR "winter morbidit*" OR "winter illness*" OR "winter disease*" OR "fuel poverty" OR "winter fuel" OR "winter payment*" OR "cold payment*" OR "weather payment*" OR "cold home" OR "cold homes" OR "cold house" OR "cold houses" OR "cold household*" OR "cold housing" OR "warm* home" OR "warm* homes" OR "warm* house" OR "warm* houses" OR "warm* household*" OR "warm* housing" OR "heat* home" OR "heat* homes" OR "heat* house" OR "heat* houses" OR "heat* household*" OR "heat* housing" OR "Warm Zone" OR "Energy Company Obligation")

Key:
* truncation symbol
" " phrase search

NHS Evidence (https://www.evidence.nhs.uk/). Searched 18 October 2013.

Limited by 'Types of information': Drug/Medicines Management; Drug Costs; Commissioning Guides; Evidence Summaries; Grey literature; Guidelines; Health Technology Assessments; Policy and Service Development; Population Needs Assessment; Primary Research; Systematic Reviews - *Not* Population Intelligence; Patient Information

"winter deaths" OR "winter death"
"winter mortality" OR "winter morbidity"
"fuel poverty"
"weather payments" OR "weather payment"
"cold homes" OR "cold house" OR "cold houses" OR "cold housing"
"energy efficient homes" OR "energy efficient house" OR "energy efficient houses" OR "energy efficient housing"
"home energy" OR "home insulation"
"Warm Front" OR "Warm Deal" OR "Green Deal" OR "Warm Zone" OR "Energy Company Obligation"
"winter fall" OR "winter falls" OR "winter accident" OR "winter accidents"
"weather forecast" OR "weather forecasts" OR "weather forecasting" OR "weather alert" OR "weather alerts"
"health forecast" OR "health forecasts" OR "health forecasting"

Key:
" " phrase search

RIBA Catalogue (http://riba.sirsidynix.net.uk/uhtbin/webcat). Searched 15 October 2013.

Advanced Search
Keyword(s)

winter ADJ death$
(winter OR temperature$ OR cold OR colder) AND mortalit$
(winter OR temperature$ OR cold OR colder) AND morbidit$

(winter OR weather OR temperature$ OR cold OR colder) AND (vulnerab$ OR risk OR risks OR suceptib$)
fuel ADJ poverty
(cold OR freez$ OR frozen) ADJ (home OR homes OR house OR houses OR household$ OR housing)
(warm$ OR heat$ OR underheat$ OR temperature$) (home OR homes OR house OR houses OR household$ OR housing)
(damp$ OR humid$ OR mold$ OR mould$) ADJ (home OR homes OR house OR houses OR household$ OR housing)
(energy ADJ efficien$) AND (home OR homes OR house OR houses OR household$ OR housing)
(energy ADJ efficien$) AND (home OR homes OR house OR houses OR household$ OR housing)
(home ADJ energy) AND (program$ OR assist$)

1993 - 2013

Key:
ADJ adjacent terms
$ truncation symbol

NYAM Grey Literature Report (http://www.greylit.org/). Searched 18 October 2013.

Each line was searched separately

winter death
winter mortality
winter morbidity
fuel poverty
weather payments
weather payment
cold homes
cold house
cold housing
energy efficient home
energy efficient house
home energy
home insulation
winter falls
winter accident
weather forecast
weather alert

Scopus (Elsevier). 1823-2013/Oct. Searched 18 October 2013.

Advanced search

((TITLE-ABS-KEY("Warm Front" OR "Warm Deal" OR "Green Deal" OR "Warm Zone" OR "Energy Company Obligation")) OR (TITLE-ABS-KEY("winter falls" OR "winter accident*" OR "winter injur*")) OR (TITLE-ABS-KEY("health forecast*")) OR ((TITLE-ABS-KEY("winter death" OR "winter fatalit*" OR "winter mortalit*" OR "winter morbidit*")) OR (TITLE-ABS-KEY(weather W/2 (death* OR fatalit* OR mortalit* OR morbidit*))) OR (TITLE-ABS-KEY("season* death" OR "season* fatalit*" OR "season* mortalit*" OR "season* morbidit*")) OR (TITLE-ABS-KEY((winter OR weather OR cold OR colder) W/2 (vulnerab* OR risk OR risks OR suceptib*))) OR (TITLE-ABS-KEY("fuel poverty" OR "winter fuel" OR "winter payment*" OR "winter allowance*" OR "weather payment*" OR "weather allowance*")) OR (TITLE-ABS-KEY((cold OR freez* OR frozen) W/2 (home OR homes OR house OR houses OR household* OR housing))) OR (TITLE-ABS-KEY("energy efficien*" W/2 (home OR homes OR house OR houses OR household* OR housing))) OR (TITLE-ABS-KEY("home energy" W/2 (program* OR assist*))))) AND NOT ((ALL((rat OR rats OR mouse OR mice OR murine OR hamster OR hamsters OR animal OR animals OR dogs OR dog OR canine OR pig OR pigs OR cats OR bovine OR cow OR cattle OR sheep OR ovine OR porcine))) OR (ALL((monkey OR monkeys OR hen OR hens OR chicken OR chickens OR poultry OR rabbit OR rabbits OR fish OR fishes OR salmon OR bird OR birds OR insect OR insects))) OR (ALL((tree OR trees OR woodland OR forest OR forests OR plant OR plants OR leaf OR leaves OR soil OR agriculture OR agricultural OR agronomy OR crop OR crops OR grass OR grasses)))) AND (LIMIT-TO(PUBYEAR, 2014) OR LIMIT-TO(PUBYEAR, 2013) OR LIMIT-TO(PUBYEAR, 2012) OR LIMIT-TO(PUBYEAR, 2011) OR LIMIT-TO(PUBYEAR, 2010) OR LIMIT-TO(PUBYEAR, 2009) OR LIMIT-TO(PUBYEAR, 2008) OR LIMIT-TO(PUBYEAR, 2007) OR LIMIT-TO(PUBYEAR, 2006) OR LIMIT-TO(PUBYEAR, 2005) OR LIMIT-TO(PUBYEAR, 2004) OR LIMIT-TO(PUBYEAR, 2003) OR LIMIT-TO(PUBYEAR, 2002) OR LIMIT-TO(PUBYEAR, 2001) OR LIMIT-TO(PUBYEAR, 2000) OR LIMIT-TO(PUBYEAR, 1999) OR LIMIT-TO(PUBYEAR, 1998) OR LIMIT-TO(PUBYEAR, 1997) OR LIMIT-TO(PUBYEAR, 1996) OR LIMIT-TO(PUBYEAR, 1995) OR LIMIT-TO(PUBYEAR, 1994) OR LIMIT-TO(PUBYEAR, 1993)) AND (LIMIT-TO(LANGUAGE, "English")) AND (LIMIT-TO(SUBJAREA, "DECI") OR LIMIT-TO(SUBJAREA, "MEDI") OR LIMIT-TO(SUBJAREA, "ENVI") OR LIMIT-TO(SUBJAREA, "SOCI") OR LIMIT-TO(SUBJAREA, "BUSI") OR LIMIT-TO(SUBJAREA, "NURS") OR LIMIT-TO(SUBJAREA, "ECON") OR LIMIT-TO(SUBJAREA, "PSYC") OR LIMIT-TO(SUBJAREA, "HEAL") OR LIMIT-TO(SUBJAREA, "PHAR") OR LIMIT-TO(SUBJAREA, "DECI") OR LIMIT-TO(SUBJAREA, "MULT"))

Key:

SUBJAREA	Subject Areas
TITLE-ABS-KEY	searches are restricted to the title, abstract and keyword fields
W	searches for adjacent terms
W/3	searches for terms within three words of each other
*	truncation symbol
" "	phrase search

Avery Index to Architectural Periodicals (ProQuest). 1934-2013/Oct. Searched 24 October 2013.

TI,AB(winter NEAR/4 (death* OR fatality* OR mortality* OR morbidity* OR illness* OR disease*)) OR (TI,AB(winter NEAR/4 (death* OR fatality* OR mortality* OR morbidity* OR illness* OR disease*)) OR (TI,AB(weather NEAR/3 (death* OR fatality* OR mortality* OR morbidity* OR illness* OR disease*)) OR TI,AB(temperature* NEAR/3 (death* OR fatality* OR mortality* OR morbidity* OR illness* OR disease*)))) OR TI,AB((cold OR colder) NEAR/4 (spell* OR season* OR month* OR period* OR

condition* OR event*1 OR related OR excess OR excessive OR severe OR severity OR extreme)) OR TI,AB((excess OR excessive OR severe OR severity OR exposure) NEAR/3 winter) OR TI,AB(winter NEAR/4 (vulnerable* OR risk*1 OR suceptib*)) OR TI,AB(temperature* NEAR/3 (vulnerable* OR risk*1 OR suceptib*)) OR TI,AB(weather NEAR/3 (vulnerable* OR risk*1 OR suceptib*)) OR TI,AB((cold OR colder) NEAR/3 (vulnerable* OR risk*1 OR suceptib*)) OR TI,AB(season* NEAR/3 (death* OR fatality* OR mortality* OR morbidity* OR risk*1 OR vulnerable* OR suceptib*)) OR TI,AB(fuel NEAR/3 (poverty OR poor OR afford OR affordable OR affordability OR tariff)) OR TI,AB(winter NEAR/3 fuel) OR TI,AB(winter NEAR/3 (payment* OR allowance* OR benefit* OR grant* OR voucher*)) OR TI,AB((cold OR weather) NEAR/3 (payment* OR allowance* OR benefit* OR grant* OR voucher*)) OR TI,AB((cold OR free* OR frozen) NEAR/3 (home OR homes OR house OR houses OR household* OR housing)) OR TI,AB((warm* OR heat* OR underseat* OR temperature*) NEAR/3 (home OR homes OR house OR houses OR household* OR housing)) OR TI,AB((damp* OR humid* OR mold OR moldy OR mould OR mouldy OR condensation*) NEAR/3 (home OR homes OR house OR houses OR household* OR housing)) OR TI,AB((cold OR free* OR frozen) NEAR/3 (accommodation* OR rent OR rents OR rented OR tenancy OR tenancies OR dwelling*)) OR TI,AB((warm* OR heat* OR underseat* OR temperature*) NEAR/3 (accommodation* OR rent OR rents OR rented OR tenancy OR tenancies OR dwelling*)) OR TI,AB((damp* OR humid* OR mold OR moldy OR mould OR mouldy OR condensation*) NEAR/3 (accommodation* OR rent OR rents OR rented OR tenancy OR tenancies OR dwelling*)) OR TI,AB("energy efficien* home" OR "energy efficien* homes" OR "energy efficien* house" OR "energy efficien* houses" OR "energy efficien* household*" OR "energy efficien* housing") OR TI,AB("energy efficien* accommodation*" OR "energy efficien* rent" OR "energy efficien* rents" OR "energy efficien* rented" OR "energy efficien* tenancy*" OR "energy efficien* tenancies" OR "energy efficien* dwelling*" OR "energy efficien* domestic*") OR TI,AB("home energy program*" OR "home energy assist*") OR TI,AB("Warm Front" OR "Warm Deal" OR "Green Deal" OR "Warm Zone" OR "Energy Company Obligation") OR TI,AB("thermal comfort") OR TI,AB((falls OR falling) NEAR/3 (winter OR snow OR ice OR weather)) OR TI,AB((accident* OR injury OR injuries OR injured OR fracture* OR trauma*) NEAR/3 (winter OR snow OR ice OR weather)) OR TI,AB((grit OR gritted OR gritting OR gritter*) NEAR/3 (road* OR pavement* OR sidewalk* OR driveway* OR pathway* OR path*1)) OR TI,AB((forecast* OR alert* OR warning* OR alarm*) NEAR/3 (cold OR colder OR weather OR winter OR "met office" OR "meteorological office")) OR TI,AB("health forecast*")

Key:

TI,AB	searches are restricted to the title and abstract fields
NEAR	searches for adjacent terms
NEAR/3	searches for terms within three words of each other
*	truncation symbol
*1	truncation restricted to one character
" "	phrase search

ICONDA International (Ovid). 1976-2013/Oct. Searched 25 October 2013.

1	(winter adj4 (death$ or fatalit$ or mortalit$ or morbidit$ or illness$ or disease$)).ti,ab.	3
2	(weather adj3 (death$ or fatalit$ or mortalit$ or morbidit$ or illness$ or disease$)).ti,ab.	2

3 (temperature$ adj3 (death$ or fatalit$ or mortalit$ or morbidit$ or illness$ or disease$)).ti,ab. 0
4 ((cold or colder) adj4 (spell$ or season$ or month$ or period$ or condition$ or event$1 or related or excess or excessive or severe or severity or extreme)).ti,ab. 246
5 (death$ or fatalit$ or mortalit$ or morbidit$ or illness$ or disease$).ti,ab. 2252
6 4 and 5 0
7 ((excess or excessive or severe or severity or exposure) adj3 winter).ti,ab. 39
8 (winter adj4 (vulnerab$ or risk$1 or suceptib$)).ti,ab. 5
9 (temperature$ adj3 (vulnerab$ or risk$1 or suceptib$)).ti,ab. 13
10 (weather adj3 (vulnerab$ or risk$1 or suceptib$)).ti,ab. 17
11 ((cold or colder) adj3 (vulnerab$ or risk$1 or suceptib$)).ti,ab. 3
12 (season$ adj3 (death$ or fatalit$ or mortalit$ or morbidit$ or risk$1 or vulnerabl$ or suceptib$)).ti,ab. 7
13 1 or 2 or 3 or 6 or 7 or 8 or 9 or 10 or 11 or 12 87
14 ((fuel or energy or gas or electricity) adj3 (poverty or poor or afford or affordable or affordability or tariff$)).ti,ab. 116
15 (winter adj3 fuel).ti,ab. 1
16 (winter adj3 (payment$ or allowance$ or benefit$ or grant$ or voucher$)).ti,ab. 4
17 ((cold or weather) adj3 (payment$ or allowance$ or benefit$ or grant$ or voucher$)).ti,ab. 8
18 ((heat$ or gas or electricity) adj3 (payment$ or allowance$ or benefit$ or grant$ or voucher$)).ti,ab. 46
19 14 or 15 or 16 or 17 or 18 174
20 ((cold or freez$ or frozen) adj3 (home or homes or house or houses or household$ or housing)).ti,ab. 36
21 ((warm$ or heat$ or underheat$ or temperature$) adj3 (home or homes or house or houses or household$ or housing)).ti,ab. 396
22 ((damp$ or humid$ or mold or moldy or mould or mouldy or condensation$) adj3 (home or homes or house or houses or household$ or housing)).ti,ab. 88
23 ((cold or freez$ or frozen) adj3 (accommodation$ or rent or rents or rented or tenancy or tenancies or dwelling$)).ti,ab. 2
24 ((warm$ or heat$ or underheat$ or temperature$) adj3 (accommodation$ or rent or rents or rented or tenancy or tenancies or dwelling$)).ti,ab. 52
25 ((damp or humid or mold or moldy or mould or mouldy) adj3 (accommodation$ or rent or rents or rented or tenancy or tenancies or dwelling$)).ti,ab. 9
26 (energy efficien$ adj3 (home or homes or house or houses or household$ or housing)).ti,ab. 294
27 (energy efficien$ adj3 (accommodation$ or rent or rents or rented or tenancy or tenancies or dwelling$ or domestic$)).ti,ab. 30
28 (home energy adj2 (program$ or assist$)).ti,ab. 2
29 (insulat$ adj2 (home or homes or house or houses or household$ or housing)).ti,ab. 103
30 (insulat$ adj2 (accommodation$ or rent or rents or rented or tenancy or tenancies or dwelling$)).ti,ab. 35
31 (Warm Front or Warm Deal or Green Deal or Warm Zone or Energy Company Obligation).ti,ab. 12

32 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 1009
33 ((falls or falling or slip or slips or slipping) adj3 (winter or snow or ice or weather)).ti,ab. 15
34 ((accident$ or injury or injuries or injured or fracture$ or trauma$) adj3 (winter or snow or ice or weather)).ti,ab. 34
35 ((grit or gritted or gritting or gritter$) adj3 (road$ or pavement$ or sidewalk$ or driveway$ or pathway$ or path$1)).ti,ab. 2
36 33 or 34 or 35 51
37 ((forecast$ or alert$ or warning$ or alarm$) adj3 (cold or colder or weather or winter or met office or meteorological office)).ti,ab. 50
38 health forecast$.ti,ab. 0
39 37 or 38 50
40 13 or 19 or 32 or 36 or 39 1353
41 limit 40 to (english and yr="1993 -Current") 492

Key:
.ti,ab. searches are restricted to the title and abstract fields
adj searches for adjacent terms
adj3 searches for terms within three words of each other
$ truncation symbol
$1 truncation restricted to one character
or/1-4 combine sets 1 to 4 using OR

PsycEXTRA (Ovid). 1908-2013/Oct. Searched 25 October 2013.

1 (winter adj4 (death$ or fatalit$ or mortalit$ or morbidit$ or illness$ or disease$)).ti,ab. 3
2 (weather adj3 (death$ or fatalit$ or mortalit$ or morbidit$ or illness$ or disease$)).ti,ab. 4
3 (temperature$ adj3 (death$ or fatalit$ or mortalit$ or morbidit$ or illness$ or disease$)).ti,ab. 2
4 ((cold or colder) adj4 (spell$ or season$ or month$ or period$ or condition$ or event$1 or related or excess or excessive or severe or severity or extreme)).ti,ab. 51
5 (death$ or fatalit$ or mortalit$ or morbidit$ or illness$ or disease$).ti,ab. 20625
6 4 and 5 8
7 ((excess or excessive or severe or severity or exposure) adj3 winter).ti,ab. 3
8 (winter adj4 (vulnerab$ or risk$1 or suceptib$)).ti,ab. 3
9 (temperature$ adj3 (vulnerab$ or risk$1 or suceptib$)).ti,ab. 2
10 (weather adj3 (vulnerab$ or risk$1 or suceptib$)).ti,ab. 7
11 ((cold or colder) adj3 (vulnerab$ or risk$1 or suceptib$)).ti,ab. 5
12 (season$ adj3 (death$ or fatalit$ or mortalit$ or morbidit$ or risk$1 or vulnerabl$ or suceptib$)).ti,ab. 1
13 or/1-3,6-12 33
14 ((fuel or energy or gas or electricity) adj3 (poverty or poor or afford or affordable or affordability or tariff$)).ti,ab. 5
15 (winter adj3 fuel).ti,ab. 0
16 (winter adj3 (payment$ or allowance$ or benefit$ or grant$ or voucher$)).ti,ab. 0

17 ((cold or weather) adj3 (payment$ or allowance$ or benefit$ or grant$ or voucher$)).ti,ab. 1
18 ((heat$ or gas or electricity) adj3 (payment$ or allowance$ or benefit$ or grant$ or voucher$)).ti,ab. 3
19 or/14-18 9
20 ((cold or freez$ or frozen) adj3 (home or homes or house or houses or household$ or housing)).ti,ab. 0
21 ((warm$ or heat$ or underheat$ or temperature$) adj3 (home or homes or house or houses or household$ or housing)).ti,ab. 14
22 ((damp$ or humid$ or mold or moldy or mould or mouldy or condensation$) adj3 (home or homes or house or houses or household$ or housing)).ti,ab. 2
23 ((cold or freez$ or frozen) adj3 (accommodation$ or rent or rents or rented or tenancy or tenancies or dwelling$)).ti,ab. 0
24 ((warm$ or heat$ or underheat$ or temperature$) adj3 (accommodation$ or rent or rents or rented or tenancy or tenancies or dwelling$)).ti,ab. 0
25 ((damp or humid or mold or moldy or mould or mouldy) adj3 (accommodation$ or rent or rents or rented or tenancy or tenancies or dwelling$)).ti,ab. 0
26 (energy efficien$ adj3 (home or homes or house or houses or household$ or housing)).ti,ab. 0
27 (energy efficien$ adj3 (accommodation$ or rent or rents or rented or tenancy or tenancies or dwelling$ or domestic$)).ti,ab. 0
28 (home energy adj2 (program$ or assist$)).ti,ab. 6
29 (insulat$ adj2 (home or homes or house or houses or household$ or housing)).ti,ab. 0
30 (insulat$ adj2 (accommodation$ or rent or rents or rented or tenancy or tenancies or dwelling$)).ti,ab. 0
31 (Warm Front or Warm Deal or Green Deal or Warm Zone or Energy Company Obligation).ti,ab. 0
32 thermal comfort.ti,ab. 13
33 or/20-32 34
34 ((falls or falling or slip or slips or slipping) adj3 (winter or snow or ice or weather)).ti,ab. 5
35 ((accident$ or injury or injuries or injured or fracture$ or trauma$) adj3 (winter or snow or ice or weather)).ti,ab. 24
36 ((grit or gritted or gritting or gritter$) adj3 (road$ or pavement$ or sidewalk$ or driveway$ or pathway$ or path$1)).ti,ab. 0
37 or/34-36 29
38 ((forecast$ or alert$ or warning$ or alarm$) adj3 (cold or colder or weather or winter or met office or meteorological office)).ti,ab. 28
39 health forecast$.ti,ab. 0
40 or/38-39 28
41 13 or 19 or 33 or 37 or 40 126
42 limit 41 to (english language and yr="1993 -Current") 93

Key:
.ti,ab. searches are restricted to the title and abstract fields
adj searches for adjacent terms

adj3	searches for terms within three words of each other
$	truncation symbol
$1	truncation restricted to one character
or/1-4	combine sets 1 to 4 using OR

Appendix 3: Bibliography of included studies

1. Saeki K, Obayashi K, Iwamoto J, et al. Influence of room heating on ambulatory blood pressure in winter: a randomised controlled study. *J Epidemiol Community Health* 2013; **67**(6): 484-90.
2. Woodfine L, Neal RD, Bruce N, et al. Enhancing ventilation in homes of children with asthma: pragmatic randomised controlled trial. *Br J Gen Pract* 2011; **61**(592): e724-32.
3. Heyman B, Harrington B, Heyman A. A Randomised Controlled Trial of an Energy Efficiency Intervention for Families Living in Fuel Poverty. *Housing Studies* 2011; **26**(1): 117-32.
4. Jackson G, Thornley S, Woolston J, Papa D, Bernacchi A, Moore T. Reduced acute hospitalisation with the healthy housing programme. *J Epidemiol Community Health* 2011; **65**(7): 588-93.
5. Braubach M, Heinen D, Dame J. Preliminary Results of the WHO Frankfurt Housing Intervention Project Copenhagen: World Health Organization, 2008.
6. Howden-Chapman P, Matheson A, Crane J, et al. Effect of insulating existing houses on health inequality: cluster randomised study in the community.[Erratum appears in BMJ. 2007 Jun 23;334(7607).]. *Bmj* 2007; **334**(7591): 460.
7. Chapman R, Howden-Chapman P, Viggers H, O'Dea D, Kennedy M. Retrofitting houses with insulation: a cost-benefit analysis of a randomised community trial. *J Epidemiol Community Health* 2009; **63**(4): 271-7.
8. Howden-Chapman P, Crane J, Chapman R, Fougere G. Improving health and energy efficiency through community-based housing interventions. *Int J Public Health* 2011; **56**(6): 583-8.
9. Howden-Chapman P, Pierse N, Nicholls S, et al. Effects of improved home heating on asthma in community dwelling children: randomised controlled trial. *Bmj* 2008; **337**: a1411.
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Appendix 4: Excluded studies

Abeysekera J, Gao C. The identification of factors in the systematic evaluation of slip prevention on icy surfaces. International Journal of Industrial Ergonomics 2001; 28: 303-13. [Comparison of the friction of shoes, but not a conventional trial]

Elvik R, Fridstrom L, Kaminska J, Frislid Meyer S. Effects on accidents of changes in the use of studden tyres in major cities in Norway: A long-term investigation. Accident Analysis and Prevention 2013; 54: 15-25. [More general analysis of car tyres and vehicle accidents in a country with different prevalence of persistent ice than the UK]

Gillespie-Bennett J, Keall M, Howden-Chapman P, Baker MG. Improving health, safety and energy efficiency in New Zealand through measuring and applying basic housing standards. N Z Med J 2013; 126(1379): 74-85.10 [Not an intervention, but an overview of a (general) healthy housing toolkit]

Laaidi K, Economopoulou A, Wagner V, et al. Cold spells and health: prevention and warning. Public Health 2013; 127(5): 492-9.16 [Not an intervention study. Considers effectiveness of using meteorological thresholds for cold weather warning systems.]

Murray IR, Howie CR, Biant LC. Severe weather warnings predict fracture epidemics. Injury 2011; 42(7): 687-90.21 [Not an intervention study: shows how severe weather warnings are correlated with fractures.]

Laburn-Peart C, Scully E, Parry J. HIA of the Health through Warmth Scheme. Environ Impact Assess Rev 2004; 24(2): 269-79. [A survey of professionals trained to deliver the scheme who reported on the perceived benefits for those who received it.]

Reddel HK, Jenkins C, Quirce S, et al. Effect of different asthma treatments on risk of cold-related exacerbations.[Erratum appears in Eur Respir J. 2012 May;39(5):1280]. Eur Respir J 2011; 38(3): 584-93.26 [Study about reduction of (common) cold-related asthma exacerbations.]

Richardson G, Eick SA. The paradox of an energy-efficient home: is it good or bad for health? Community Pract 2006; 79(12): 397-9.28 [A general paper and discussion rather than an intervention study]

Rudge J, Gilchrist R. Excess winter morbidity among older people at risk of cold homes: a population-based study in a London borough. J Public Health 2005; 27(4): 353-8. [Correlation study]

Windle GS, Burholt V, Edwards RT. Housing related difficulties, housing tenure and variations in health status: evidence from older people in Wales. Health Place 2006; 12(3): 267-78.35 [Not an intervention study]

Appendix 5: Evidence tables

Evidence table 1. Quantitative studies on interventions

Studies are sorted by year of publication (most recent first) and authors.

Ref no.	Study and reference	Aim	Study design	Qual scores (++, + or -)		Population and setting	Methods of allocation (intervention/ control)	Outcomes	Methods of analysis	Results	Notes
				Int	Ext						
	Housing interventions										
2013											
1	Saeki K, Obayashi K, Iwamoto J, Tanaka Y, Tanaka N, Takata S, Kubo H, Okamoto N, Tomioka K, Nezu S, Kurumatani N. Influence of room heating on ambulatory blood pressure in winter: a randomised controlled study. *J Epidemiol Community Health* 2013; **67**(6): 484-90.[1]	To determine whether intensive room heating in winter decreases ambulatory BP as compared with weak room heating	Parallel group, assessor blinded, simple RCT	++	+	Japan 146 healthy participants	Randomization: assessor blinded	Ambulatory blood pressure	Ambulatory BP measurements: - Morning BP systolic & diastolic - Morning systolic BP surge - Sleep-trough surge - Prewaking surge - Nighttime BP - Evening BP	All results show mean (SD) unless otherwise indicated, followed by difference and 95% CI *Morning BP (mm Hg)* *Systolic* Intensive room heating 114.0 (11.6) Weak room heating 121.1 (14.5) Difference (95% CI), p-value −5.8 (−9.3 to −2.4), <0.01 *Diastolic* Intensive room heating 72.6 (9.0) Weak room heating 78.3 (11.3) Difference (95% CI), p-value −5.1 (−7.9 to −2.3) <0.01	

										<u>Morning systolic BP surge (mm Hg)</u> *Sleep-trough surge* Intensive room heating 14.3 (8.7) Weak room heating 21.9 (10.9) Difference (95% CI), p-value −7.2 (−10.5 to −3.9), <0.01 *Prewaking surge* Intensive room heating 9.7 (8.4) Weak room heating 14.9 (9.6) −5.2 (−8.2 to −2.1) <0.01 *<u>Night-time BP (mm Hg)</u>* *Systolic* Intensive room heating 105.7 (10.1) Weak room heating 105.9 (11.7) Difference (95% CI), p-value −0.3 (−3.5 to 2.8) 0.83 *Diastolic* Intensive room heating 62.1 (7.8) Weak room heating 63.0 (7.7) Difference (95% CI), p-value −1.1 (−3.3 to 1.1), 0.31 *<u>Evening BP (mm Hg)</u>* *Systolic* Intensive room heating 118.6 (12.9) Weak room heating 124.5 (14.9)	

										Difference (95% CI), p-value −5.1 (−8.9 to −1.3), 0.01 *Diastolic* *Intensive room heating* 72.9 (10.4) Weak room heating 78.0 (10.2) Difference (95% CI), p-value −4.5 (−7.4 to −1.6) <0.01 Author conclusions: intensive room heating (in winter) decreases morning blood pressure and the morning blood pressure surge	
2012											
15	Gilbertson J, Grimsley M, Green G. Psychosocial routes from housing investment to health: Evidence from England's home energy efficiency scheme. Energy Policy 2012; 49: 122-33.[15]	To utilise quantitative data from the Warm Front evaluation model to elaborate psychosocial pathways to health and to gauge the relative impact of improved living conditions compared with the	Before and after survey, with controlled cross-sectional comparisons.	+	+	2,685 low income householders in 3,489 dwellings participating in the Warm Front Scheme in five urban areas of England (Birmingham, Liverpool, Manchester, Newcastle, Southampton).	Warm Front Scheme provided grants of up to £2,500 for improving home insulation and heating systems between 2001 and 2005. The pre-intervention phase of observation in those scheduled for improvement served as controls for those who had already	Indoor temperature and humidity, a household questionnaire and a household diary. Main health outcomes were self reported health and well-being measures using GHQ-12, EQ-5D and SF-36.	Pathways to self reported health modelled by logistic regression.	Of all the dimensions of health examined, only self reported mental health (GHQ-12 score 4 or more) was directly associated with the Warm Front measures: Insulation only AOR=0.64 (95% CI 0.46-0.89); Heating only AOR=0.78 (95% CI 0.57-1.07); Heating and insulation AOR=0.65 (95% CI 0.50-0.86). Intermediary variables higher temperatures, satisfaction with the heating system, greater thermal comfort, reductions in fuel poverty and lower stress were also significantly correlated with	

		alleviation of fuel poverty.					undergone WF improvement. First wave of surveys conducted during winter 2001/02 and second wave in winter 2002/03 (after improvements).			improved health. Alleviating fuel poverty and reducing stress appeared to be the main routes to health.	
2011											
2	Woodfine L, Neal RD, Bruce N, Edwards RT, Linck P, Mullock L, Nelhans N, Pasterfield D, Russell D, Russell I. Enhancing ventilation in homes of children with asthma: pragmatic randomised controlled trial. Br J Gen Pract 2011; 61(592): e724-32.[2]	To evaluate the effectiveness of installing ventilation systems, and central heating where necessary, in the homes of children with moderate or severe asthma	Pragmatic randomized controlled trial Researchers were blind to allocation.	++	++	Wrexham County Borough, Wales, UK. Households with asthmatic child	(Individual) randomization to either immediate or delayed intervention	Parent-completed asthma-specific module of PedsQL, a validated QoL measure in children (three dimensions): Overall asthma, physical health and psychosocial scale. Absence from school.	Intention-to-treat, with multivariable adjustment for baseline differences. Imputation used for missing data, with sensitivity analyses. Analyses reported here related to the subgroup with heating + ventilation inte4rvention (not ventilation alone)	PedsQL summary scores 12months after randomization for ventilation and central heating (n = 19 + 19) *Mean difference in PedsQL adjusted for baseline (95% CI)* Overall asthma scale 9.3 (–1.9, 20.6) Physical scale 10.3 (–1.7, 22.4) Overall psychosocial scale 0.6 (–10.1, 11.3) Author conclusions: tailored improvement of the housing of children with moderate to severe asthma significantly increases parent-reported asthma-related quality of life and reduces physical problems. Collaborative housing initiatives have potential to improve health.	

3	Heyman B, Harrington B, Heyman A. A Randomised Controlled Trial of an Energy Efficiency Intervention for Families Living in Fuel Poverty. Housing Studies 2011; 26(1): 117-32.[3]	To measure the impact of fuel efficiency interventions on room temperature, fuel expenditure, satisfaction with home warmth and a range of health indicators for households living in full or marginal fuel poverty.	Pragmatic randomized controlled trial with partial crossover.	+	+	Households in north east England. Intervention and control groups matched on fuel poverty (measured by the estimated proportion of disposable household income spent on fuel), housing tenure, age, presence of longstanding health problems in the household.	Households assessed as living in full or marginal fuel poverty were randomised during year one into intervention and control groups. Intervention group (129) received an energy efficiency (heating and insulation) intervention package in year three (tailored to the needs of each household). Control group (108) received an energy efficiency intervention package in year four. Packages were worth an average of £727 (range £0–3335), and included loft	Health of respondent and other household members assessed in a variety of ways (all of which relied on respondent answers to survey questions). Simple questions used to determine health of household and changes in health due to intervention. Checklists used to identify symptoms experienced over recent months. Standardised questionnaires (Mastery Scale and SF36) used to measure self-	Four-year period starting in 2000/2001 (though different intervention times for intervention and control groups).	The intervention improved SAP ratings by 12 points, generating room temperature increases of about one degree Celsius. Families did not respond to energy efficiency gains by reducing their heating expenditure. The intervention generated improvements in satisfaction with household warmth. Intervention receipt was not associated with gains in self-reported health. There was modest correlation between room temperatures and better social functioning, as measured by the SF36.	High attrition rate (only 60% completed).

							insulation (54%), cavity wall insulation (53%), draught exclusion (29%) heating controls (20%), central heating (13%) and other measures as required.	reported health.			
8	Howden-Chapman P, Crane J, Chapman R, Fougere G. Improving health and energy efficiency through community-based housing interventions. Int J Public Health 2011; 56(6): 583-8.[8]	To find cost-effective ways to improve the characteristics of older homes, ill-fitted for New Zealand's climate, in order to improve the occupants' health	Two community single-blinded randomised trials.	++	++	1) 4,407 people in 1,350 homes in seven communities in New Zealand built before insulation was required in which there was at least one occupant with a chronic respiratory condition. 2) 409 households in five communities in New Zealand in which there was a 6 to 12 year old child with doctor-diagnosed asthma, living in a household where the main form of heating was a plug-in electric heater or an unflued gas	1) Retrofitted insulation. Intervention group received retrofitted insulation before the first winter. 2) More effective heating. Low emission heaters capable of generating at least 6 kW thermal output were installed in the intervention group before the beginning of the follow-up winter period 2006.	1) Self-report measures as well as independent measures of outcome for the winter months were obtained wherever possible, including general practitioner visits and power bills. 2) Households collected a broad range of data, supplemented by independent hourly measures of temperature and relative humidity, as		1) In intervention group, there was a small increase in bedroom temperatures during the winter (0.5°C) and decreased relative humidity (-2.3%). Bedroom temperatures were below 10°C for 1.7 fewer hours each day in insulated homes than in uninsulated ones. These changes were associated with reduced odds of having fair or poor self-rated health (AOR 0.50, 95% CI 0.38–0.68), self reports of wheezing in the past 3 months (AOR 0.57, 95% CI 0.47–0.70), self reports of children taking a day off school (AOR 0.49, 95% CI 0.31–0.80), and self reports of adults taking a day off work (AOR 0.62, 95% CI	

						heater.		well as measures of NO2. Children kept daily diaries with twice-daily recordings of lung function (PEFR and FEV1), respiratory symptoms and medication. Independent measures of outcome for the winter months included records of school attendance.		0.46–0.83). Visits to general practitioners were less often reported by occupants of insulated homes (AOR 0.73, 95% CI 0.62–0.87). Hospital admissions for respiratory conditions were also reduced (AOR 0.53, 95% CI 0.22–1.29), but this reduction was not statistically significant (p = 0.16). 2) Indoor temperatures increased by 1.1°C in the living room (p<0.001) and 0.53°C in the bedroom (p = 0.002). Exposure to low temperatures was ~50% less in intervention compared to control group in living room (p<0.001) and bedroom (p<0.001). Parents in the intervention group reported less poor health (AOR 0.44; 95% CI 0.28–0.70, p<0.001) and lower levels of asthma symptoms. Sleep disturbance by wheeze (AOR O.51; 95% CI 0.32–0.81, p=0.005) and dry	

										cough (AOR 0.50; 95%CI 0.31–0.82, p=0.01) were also reduced. Diaries showed reduced lower respiratory symptoms (p=0.01), less coughing at night (p=0.003) and reliever use in the morning (p 0.05). Independent school records showed children in the intervention group had 1.8 days less of school during the 50 days of the winter term (95% CI 0.11–3.13; p=0.04); fewer visits to GP (0.13, 95% CI 0.05–0.20, p=0.005); and to pharmacists (AOR 0.06, 95% CI 0.03–0.07, p=0.007). Mãori (15% of the New Zealand population) deliberately oversampled.	
4	Jackson G, Thornley S, Woolston J, Papa D, Bernacchi A, Moore T. Reduced acute hospitalisation with the healthy housing programme. *J Epidemiol Community Health* 2011; **65**(7): 588-93.[4]	To investigate the impact of the Healthy Housing Programme in reducing acute hospitalisations in South Auckland,	Before and after evaluation (within-person, crossover design)	+	++	9,736 residents of 3,410 homes in suburbs of Mangere, Manurewa or Otara in South Auckland, New Zealand from September 2001 to December 2007. All lived in areas of relative deprivation and	Housing modifications to reduce overcrowding, insulation and ventilation improvements. Participants in the programme were considered cases following their house's intervention	Analysis of routinely collected data. Main outcome measure was acute hospitalisation rates before, during and after the intervention using hospital	Cox proportional hazard model with estimates of crude and adjusted hazard ratios.	In the post-intervention group compared with the control group, hazard ratios (HR) were: *0-4 years* 0.89 (95% CI 0.79, 0.99) *5-34 years* 0.77 (95% CI 0.70, 0.85) *35 years+* 1.04 (95% CI 0.95, 1.15) When the causes of hospitalisation were restricted to those related	

		New Zealand.				almost all self-identified as Pacific ethnic group.	and counterfactuals /controls prior to the intervention.	data gathered from July 1999 to January 2009. Also a subset of 'housing related' outcomes (e.g. respiratory hospitalisatio ns) determined by expert opinion.		to housing, HRs were: *0 to 4 years* 0.88 (95% CI 0.74, 1.05) *5-34 years* 0.73 (95% CI 0.58, 0.91) 35 years+ 1.31 (95% CI 1.09, 1.56). Authors conclude that a package of care that addresses housing conditions that impact on health and improves access to health and social services is associated with a reduced acute hospitalisation rate for 0-34 year olds.	
2010											
10	Free S, Howden-Chapman P, Pierse N, Viggers H, Housing H, Health Study Research T. More effective home heating reduces school absences for children with asthma. J Epidemiol Community Health 2010; 64(5): 379-86.[10]	To determine whether more effective home heating affects school absence for children with asthma.	Single-blinded randomis ed controlled trial.	++	++	New Zealand. 409 households containing an asthmatic child aged 6-12 years, where the previous heating was an open fire, plug-in electric heater or unflued gas heater. Complete data obtained for 269 out of 409 children.	Installation of a more effective heater of at least 6 kW before the winter of 2006 in half the houses. Intervention group n=200 at baseline. Control group n=209 at baseline.	Term-by-term school absence for 2006 and previous years (where available).	Generalised linear models (including most important confounders and the quasi-Poisson link function).	Compared with the control group, children in households receiving the intervention experienced on average 21% (p=0.02) fewer days of absence after allowing for the effects of other factors. Children in the intervention group had a statistically significant reduction in the number of days absent (effect ratio 0.79, CI 0.66 to 0.96). Children of Pacific Island ethnicity (effect ratio 1.24, CI 1.00 to 1.55), children from low-income	Author-noted limitations: Study had more low-income households than population and more Maori/Pacific Island households. No information on mechanism by which intervention affected school absence.

										households (effect ratio 1.39, CI 1.12 to 1.72) and children from households were there was smoking inside (effect ratio 1.29, CI 1.04 to 1.59) had significantly more days off school. There was no significant difference for children of Maori ethnicity, or by sex, parental history of asthma, or type of school.	
11	Osman LM, Ayres JG, Garden C, Reglitz K, Lyon J, Douglas JG. A randomised trial of home energy efficiency improvement in the homes of elderly COPD patients. Eur Respir J. 2010; 35(2): 303-9.[11]	To determine whether improving home energy efficiency improves health-related quality of life in COPD patients.	Randomised trial.	+	++	Aberdeen, UK. 178 patients in with a previous hospital admission for chronic obstructive pulmonary disease (COPD).	118 patients were randomised, 60 agreed to monitoring only. Energy efficiency upgrading was carried out in 42% of homes randomised to intervention. Independent energy efficiency action was taken by 15% of control participants and 18% in the monitoring group.	Respiratory and general health status. Home energy efficiency. Hospital admissions.	(i) Intention-to-treat analysis and (ii) pragmatic analysis by individual action. Multiple regression analysis (or ANCOVA) used for main analysis.	No difference in outcomes between the intervention and control groups. In 45 patients, who had energy efficiency action independent of original randomisation, there were: improvements in respiratory symptom scores: adjusted mean 9.0, (2.5, 15.5); decreases in estimated annual fuel costs: -£65.3 (-£1.9, -£98.7); improved home energy efficiency rating: 1.1 (0, 1.4). COPD patients are unlikely to take up home energy efficiency upgrading, if offered. Secondary "pragmatic" analysis suggests that those who do take action may	A sample size of 140 was calculated as necessary for 80% power at α=0.05 to detect a 4-point difference in SGRQ means between groups in the randomised trial, a difference regarded as clinically significant.

										achieve clinically significant improvement in respiratory health, which is not associated with an increase in indoor warmth.	
2009											
17	Walker J, Mitchell R, Petticrew M, Platt S. The effects on health of a publicly funded domestic heating programme: a prospective controlled study. J Epidemiol Community Health 2009; 63(1): 12-7.	To assess the effect of a publicly funded domestic heating programme on self-reported health.	Prospective controlled study.	+	++	1,281 households in Scotland receiving new central heating under a publicly funded initiative. 1,084 comparison households not receiving new heating.	Comparison group matched to heating recipients by tenure, household composition, socioeconomic group and location. Initial wave of interviews conducted between November 2002 and February 2004. Final interviews held between December 2004 and March 2006. Usable data obtained from 61.4% of 3,849 respondents.	Self-reported diagnosis of asthma, bronchitis, eczema, nasal allergy, heart disease, circulatory problems or high blood pressure. Number of primary care encounters and hospital contacts in the past year. SF-36 Health Survey scores.	2-year period between first and final interviews. Continuous outcomes analysed via analysis of covariance (ANCOVA). Outcomes representing counts modelled via Poisson regression.	Heating recipients reported higher scores on the SF-36 Physical Functioning scale (difference 2.51; 95% CI 0.67 to 4.37) and General Health scale (difference 2.57; 95% CI 0.90 to 4.34). They were less likely to report having received a first diagnosis of heart disease (OR 0.69; 95% CI 0.52 to 0.91) or high blood pressure (OR 0.77; 95% CI 0.61 to 0.97). Covariate-adjusted associations between ''treatment group'' membership (heating recipient vs comparison group household) also indicated no clear difference in 'ever diagnosed with asthma' OR 0.92 (0.63 to 1.34) or whether respondent has ever been diagnosed with bronchitis OR 1.29 (0.97 to 1.72). The groups did not differ significantly in use of primary care or hospital	Small observed effects (though statistically significant). Author identified limitations: Imprecise estimation of the ''true'' effects of the intervention (due to dilution of distinction between 'treatment' groups). Large number of tested outcomes (increased probability of a spuriously significant result due to random chance).

										services.	
7	Chapman R, Howden-Chapman P, Viggers H, O'Dea D, Kennedy M. Retrofitting houses with insulation: a cost-benefit analysis of a randomised community trial. J Epidemiol Community Health 2009; 63(4): 271-7.	To value the health, energy and environmental benefits of retrofitting insulation, through assessing a number of forms of possible benefit.	Cluster randomised controlled trial.	++	++	1350 houses, in which at least one person had symptoms of respiratory disease, in predominantly low-income communities in New Zealand.	Retrofitting insulation in predominantly low-income communities. 1,350 households (4,407 people) randomised within communities to receive retrofitted insulation during or after the study. Intervention group n=1,390. Control group n=1,346. 85% household retention rate and 75% individual retention rate.	Self-reported measures of health, comfort and wellbeing and primary care (GP) visits, and days off school and work. Independent measures of temperature, relative humidity, mould (speciation and mass), endotoxin, β-glucans, house dust mite allergens, GP and hospital visits.	Study performed over 2 years (2000-2001). Baseline data were collected over the first winter. Analysis based on 'intention to treat.	Almost all differences between the intervention and control groups on measured outcome variables were statistically significant. Proportional change in GP visit rate (per 1000 respondents): +48. Net change in hospitalisation rate (per 1000): children (<19): -7.5 inpatient nights, 4.9 outpatient admissions. adults (19-64): 0 inpatient nights, 0 outpatient admissions; older people (65+): 100.3 inpatient nights, 5.4 outpatient admissions. Reduction in rate of days off school (days off per 1000 children): children (6-11): 512; teenagers (12-18): 1316. Reduction in rate of days off work (days off per 1000 adults): adults (19-64): 102	Heterogeneity in delivery of intervention (about 90% of households received around 80% or more of the intervention). Discrepancy between self-reports of visits to GPs and visits recorded by the stated household GP.
2008											
5	Braubach M, Heinen D, Dame J. Preliminary Results of the WHO	To assess the impact of	Before and after controlled	-/+	+	131 insulated and 104 non-insulated dwellings (with	Health-monitoring project	Environmental: indoor temperature	Bivariate statistics only (preliminary	Thermal insulation had a strongly positive impact on thermal conditions and	Limited analysis (no formal statistical

	Frankfurt Housing Intervention Project Copenhagen: World Health Organization, 2008.[5]	thermal insulation changes on indoor environments, and evaluate potential effects on residents' health.	trial (preliminary results)			220 and 155 residents, respectively) in Frankfurt, Germany.	implemented by the WHO's Housing and Health Programme in cooperation with a large housing agency. The project performed health surveys and collected environmental data (e.g. indoor temperatures and humidity) in spring 2006 before renovation work, and re-contacted all households in spring 2007 after renovation was carried out. A control group without interventions was used to identify changes caused by building rehabilitation. Renovation included new energy-efficient	and relative humidity (wall and air), noise, visible mould, hygrothermal conditions. Self-reported health outcomes: general health status, depression symptoms, acute respiratory illnesses.	analysis).	thermal comfort as perceived by the residents, and decreased relative humidity in renovated dwellings. Results for direct effects on the occurrence of mould in renovated dwellings were weak, but indicated the major role of humidity levels and air exchange for adequate indoor climate. Direct associations of thermal insulation with health effects were also weak and limited to smaller prevalence differences of respiratory diseases and cold. Additional effects of the refurbishment were increased satisfaction and living conditions as perceived by residents, and a clear reduction of noise exposure.	methods). Uncommonly low (external) temperatures were experienced during baseline survey phase and much higher temperatures during follow up survey. Authors highlight need for refurbishment to be carried out professionally and to consider the need for adequate air exchange.

							glazing, increased insulation, and new heating systems.				
16	El Ansari W, El-Silimy S. Are fuel poverty reduction schemes associated with decreased excess winter mortality in elders? A case study from London, U.K. Chronic Illn 2008; 4(4): 289-94.	To determine if the LB of Newham's fuel poverty reduction scheme was associated with decreased excess winter mortality in people aged >=65 years.	Before-after comparison of EWM in people aged >=65 years in Newham with that in the rest of London. Based on data covering the period of the Newham Warm Zone project.	+	+	The London Borough of Newham, London which piloted the Warm Zone scheme (a government-led fuel poverty reduction scheme) assessed in this study.	Retrospective analysis of winter mortality data for Newham, compared with data for the whole of London.	Excess winter mortality.	Comparison of the yearly EWM indices for people aged >=65 years for all of London, and for Newham over 12 years (1993-2005).	No clear evidence of the effect of the Warm Zone on EWM. Authors noted: "Those in privately owned housing might be 'masked' (underestimated) in their vulnerability to fuel poverty."	Author noted limitations: (i) Sample size, (ii) whether other fuel poverty reduction schemes were simultaneously in operation elsewhere in London, (iii) difficulties of the measurement and interpretation of health impact relating to fuel poverty.
12 13	Green G, Gilbertson J. Warm front, better health: health impact evaluation of the Warm Front scheme: Centre for Regional Economic and Social Research, Sheffield Hallam University, Sheffield; 2008. [12] <u>which summarizes</u>	To determine the effect of the Warm Front home energy efficiency scheme on health & health-related	Controlled before-and-after comparison of a natural experiment intervention.	+	+	Survey of dwellings/households participating in the original Warm Front programme in five areas (Birmingham, Liverpool, Manchester, Newcastle, Southampton).	First wave surveys in the winter of 2001/02, second wave in the winter of 2002/03. For each winter the aim was to target surveys at dwellings before Warm	Indoor temperatures and relative humidity; energy use; health status; quality of life (Short-Form 36, General Health		<u>Temperatures</u> Living room, daytime (deg C) Pre-intervention 0 Insulation only 0.73 (0.11,1.35) Heating only: 1.58 (0.99, 2.18) Heating + insulation: 1.67 (1.17, 2.17) Bedroom, night-time (Deg	

	Warm Front Study Group. Summary of papers. London: DEFRA, 2006.[13]	exposures .					Front improvement and at dwellings after such improvement.	Questionnaire EuroQol 5D); modelled cold- and winter-related changes in mortality; dwelling air infiltration/air quality characteristics ; in-depth interviews with a household member in subsample of 49 dwellings		C) Pre-intervention 0 Insulation only 1.31 (0.65,1.97) Heating only: 2.46 (1.82, 3.10) Heating + insulation: 2.75 (2.21, 3.28) Warm Front improvements increased temperatures most in the coldest dwellings (an increase of approximately 2.5 degrees Celsius in the coldest dwellings c.f. one degree Celsius in warmer dwellings). Appreciable beneficial changes were seen in 'normalized' estimates of relative humidity - lower by around 3 to 7 percent in post heating-improvement dwellings. <u>Satisfaction with heating</u> • A substantially greater proportion of post-intervention householders were fairly or very satisfied with the heating system, and they reported less difficulty paying bills, and with draughts and damp in the home. <u>Quality of Life</u> • No clear evidence of	

										improvement in terms of SF36 or EQ5D questionnaire scores. • Proportion of respondents with adverse (4+) scores on the GHQ-12 was appreciably lower among respondents from post-intervention properties. OR for GHQ-12 score of 4+ Pre-intervention 1.0 Insulation only 0.36 (0.20, 0.68) Heating only: 0.51 (0.29, 0.88) Heating + insulation: 0.44 (0.28, 0.71) (p=0.004 for trend) Or with standardized living room temp. <16 1.0 16- 0.91 (0.53, 1.54) 18- 0.62 (0.37, 1.03) 20- 0.63 (0.37, 1.08) 22- 0.38 (0.19, 0.74) (p=0.009 for trend) Or with standardized bedroom temp. <15 1.0 15- 0.72 (0.45, 1.14) 17- 0.71 (0.44, 1.15) 19- 0.50 (0.29, 0.85) 21- 0.37 (0.18, 0.76) (p=0.001 for trend)	

										Health and health care utilization • No convincing evidence of impact on symptoms of medical illness and health care utilization. Mortality and hospital admission • If vulnerability in relation to cardiovascular death can be reversed by increasing indoor temperatures, Warm Front heating improvements are estimated to reduce the risk of excess winter death by around 8 to 12% in improved homes (equivalent to a gain in life expectancy of around 0.3 month for a man aged 65 years and 0.2 month for a woman of 65 years). Air infiltration and energy use • Fan pressure tests showed that Warm Front improvements had little effect on ventilation. The average infiltration rate of the post-intervention dwellings was marginally lower (by 3%) compared to the pre-intervention dwellings, while before-after comparisons showed	

										an average increase of 13% in the air infiltration rate following the installation of a central heating system. • Warm Front energy efficiency improvements appear to have little effect on space heating fuel consumption, even though theoretical considerations suggest that there should be significant savings. This discrepancy is likely to be due to a number of factors, including the incomplete insulation of the properties. <u>Cost-benefit</u> • See economic assessment section. [The results suggest that temperature-related improvement in life-expectancy achieved by Warm Front interventions are cost-effective when calculated across sectors. Insulation only is the most cost-effective form of improvement, but grants for heating system up-grading or installation are also justified over the longer term and may be needed to achieve desired temperature increases for the coldest homes.] <u>In-depth interviews</u> • See table of qualitative	

										studies.	
9	Howden-Chapman P, Pierse N, Nicholls S, et al. Effects of improved home heating on asthma in community dwelling children: randomised controlled trial. BMJ 2008; 337: a1411.[9]	To assess whether non-polluting, more effective home heating (heat pump, wood pellet burner, flued gas) has a positive effect on the health of children with asthma	Randomized controlled trial	++	++	409 children aged 6-12 years with doctor diagnosed asthma in households in five communities in New Zealand	Installation of a non-polluting, more effective home heater before winter. The control group received a replacement heater at the end of the trial.	Primary: change in lung function (peak expiratory flow rate and forced expiratory volume in one second, FEV(1)) Secondary: child reported respiratory tract symptoms and daily use of preventer and reliever drugs. Parent-reported child's general health, use of health services, overall respiratory health, and housing conditions. Nitrogen dioxide levels and temperatures in the living room and	Regression and analysis of covariance models (intervention vs control)	Improvements in lung function were not significant (difference in mean FEV(1) 130.7 ml, 95% confidence interval -20.3 to 281.7). Children in the intervention group had: -- 1.80 fewer days off school (95% confidence interval 0.11 to 3.13) -- 0.40 fewer visits to a doctor for asthma (0.11 to 0.62), -- 0.25 fewer visits to a pharmacist for asthma (0.09 to 0.32). -- fewer reports of poor health (adjusted odds ratio 0.48, 95% confidence interval 0.31 to 0.74) -- less sleep disturbed by wheezing (0.55, 0.35 to 0.85) -- less dry cough at night (0.52, 0.32 to 0.83) -- and reduced scores for lower respiratory tract symptoms (0.77, 0.73 to 0.81) than children in the control group. The intervention was associated with a mean temperature rise in the living room of 1.10 degrees C (95% confidence interval 0.54 degrees C to 1.64	

								child's bedroom.		degrees C) and in the child's bedroom of 0.57 degrees C (0.05 degrees C to 1.08 degrees C). Lower levels of nitrogen dioxide were measured in the living rooms of the intervention households and in the children's bedrooms	
18	Lloyd EL, McCormack C, McKeever M, Syme M. The effect of improving the thermal quality of cold housing on blood pressure and general health: a research note. J Epidemiol Community Health 2008; 62(9): 793-7.[18]	To examine the effect of improving the thermal quality of housing on blood pressure and general health.	Before and after study	+	+	Residents of four blocks of flats in the Easthall area of Easterhouse, Glasgow.	Two blocks of flats were upgraded from being cold, damp and mouldy to being comfortably warm, dry and mould free throughout. 68 residents (42 intervention and 26 control) agreed to participate. 36 residents (27 intervention and nine control) completed the study.	Changes in blood pressure, general health and financial status.	Two year follow-up period after study. Student's paired t-test used to compare changes in blood pressure readings in the intervention group and separately in the control group. Student's two-sample t-test used to compare differences between groups in the ''population'' readings, and the changes in blood pressure between the	In intervention subjects, there was a very significant fall in both systolic (p<0.000) and diastolic (p<0.000) blood pressure following the intervention. In the control group, there was a small nonsignificant (p=0.396) rise in systolic pressure, and a small marginally significant (p<0.011) rise in diastolic pressure. There was also an improvement in general health in intervention subjects as reported subjectively, and as indicated by a reduction in the use of medication and in hospital admissions. There was also a markedly reduced expenditure on heating costs and other previous expenses.	

									intervention and control groups.		
2007											
39	Shortt N, Rugkasa J. "The walls were so damp and cold" fuel poverty and ill health in Northern Ireland: results from a housing intervention. *Health Place* 2007; **13**(1): 99-110.[39]	To report an evaluation of a fuel poverty programme	Before-after comparison	+	+	Armagh and Dungannon Health Action Zone, Northern Ireland: energy efficiency measures, including some central heating systems, were installed in 54 homes. Surveys were conducted both pre and post intervention and analysed to assess any changes.	Installation of central heating systems and other energy efficiency measures in homes across the zone.	Questionnaire survey of various dimensions of health: Thermal comfort Satisfaction with heating Self-reported illnesses, incl: angina, arthritis, asthma, chest infections/bronchitis, pneumonia, mental illness Temperature measurement in small subsample of dwellings (n=12)	Before-after change in intervention and control dwelloings	Improvement in satisfaction with heating For total intervention households there was a significant decrease in both the numbers of householders reporting arthritis/rheumatism (p<0:05) and the numbers reporting an 'other' form of illness (po0:05). Although each of the remaining conditions decreased slightly, results were not statistically significant Qualitative reports of improved health from interviews. Indirect evidence of reduction in the use of health services.	
19	Barton A, Basham M, Foy C, Buckingham K, Somerville M, Torbay Healthy Housing G. The Watcombe Housing Study: the short term effect of improving housing conditions on the health of residents. J Epidemiol Community	To assess the short term health effects of improving housing.	Randomised to waiting list	++	++	119 council owned houses in south Devon, UK. About 480 residents of these houses. For the self completed questionnaires	A randomised to waiting list design agreed with residents and the local Council. Upgrading houses (including	All residents completed an annual health questionnaire: SF36 and GHQ12 (adults). Residents reporting	Mann–Whitney U test. Conducted on an intention to treat basis.	The interventions improved energy efficiency. There was no difference between self reported asthma or severity of disease between occupants of intervention and control houses.	No information on residents' actual expenditure on heating, or any alternative use of savings such as increased expenditure on food.

	Health 2007; 61(9): 771-7.					and health interviews, response rates, as a proportion of our baseline sample, were 99% and 86%, respectively, in the first year, 87% and 86% in the second, and 91% and 66% in the third.	central heating, ventilation, rewiring, insulation, and re-roofing) in two phases a year apart.	respiratory illness or arthritis were interviewed using condition-specific questionnaires, the former also completing peak flow and symptom diaries (children) or spirometry (adults). Data on health service use and time lost from school were collected.		For those living in intervention houses, non-asthma-related chest problems (Mann–Whitney test, p = 0.005) and the combined asthma symptom score for adults (Mann–Whitney test, z = 2.7, p = 0.007) diminished significantly compared with control houses. There was no difference between intervention and control houses seen for SF36 or GHQ12.	
14	Critchley R, Gilbertson J, Grimsley M, Green G. Living in cold homes after heating improvements: Evidence from Warm-Front, England's Home Energy Efficiency Scheme. Applied Energy 2007; 84(2): 147-58.	To investigate explanatory factors for persistent cold temperatures in homes which have received heating improvem	Analysis of data from a national survey of dwellings and households.	+	++	Households in England occupied by low-income residents that had received heating improvements or repairs under the Warm Front Scheme.	888 households, which had received high level heating interventions. 222 households were identified as occupying cold homes, with mean bedroom temperature below 16 °C or mean living room	Bedroom and living room temperatures. Self-reported thermal comfort, feeling of security and various health outcomes (mental health, physical health, well-being,	Binary logistic regression.	Residents of cold homes were less likely to have long-standing illness or disability, but more likely to experience anxiety or depression.	

		ents.					temperatures below 18 °C. Random telephone survey of 79 of the 222 occupying cold homes.	longstanding illness or disability). Survey responses on attitudes and behaviours relating to cold homes.			
6	Howden-Chapman P, Matheson A, Crane J, et al. Effect of insulating existing houses on health inequality: cluster randomised study in the community. BMJ 2007; 334(7591): 460.[6]	To determine whether insulating existing houses increases indoor temperat ures and improves occupants ' health and wellbeing.	Communit y based, cluster, single blinded randomis ed study.	++	+	1,350 households containing 4,407 participants in seven low income communities (three urban, four rural) in New Zealand.	Installation of a standard retrofit insulation package. Participants selected through local organisations. Selected households were in uninsulated dwellings; at least one household member had reported respiratory symptoms in the past year or had a history of asthma, pneumonia, or chest infections; and members were planning to remain in the dwelling for the	Environmenta l: indoor temperature and relative humidity, energy consumption. Self-reported health outcomes: wheezing, days off school and work, visits to general practitioners, admissions to hospital.	Data analysed on an intention to treat basis. Analysis of covariance (ANCOVA), adjusted for sex, ethnic origin and age group.	Insulation was associated with a small increase in bedroom temperatures during the winter (0.5°C) and decreased relative humidity (−2.3%). Bedroom temperatures were below 10°C for 1.7 fewer hours each day in insulated homes than in uninsulated ones. These changes were associated with: reduced odds in the insulated homes of fair or poor self-rated health Adjusted OR 0.50 (95% CI 0.38, 0.68), self reports of wheezing in the past three months Adjusted OR 0.57 (95% CI 0.47, 0.70), self reports of children taking a day off school Adjusted OR 0.49 (95% CI 0.31, 0.80), self reports of adults taking a day off work Adjusted OR 0.62 (95% CI 0.46, 0.83), visits to general	Author highlighted limitations: Study only single blinded (not possible to install interventions without knowledge of householders or landlords). Targeted uninsulated households where at least one member had current respiratory symptoms (may increase effect sizes). Population contained a disproportionatel y high proportion of Maori and Pacific people, who have higher

							next two winters. Households randomly allocated to the intervention group had their houses insulated after the baseline measures were taken in the study's first winter (June to August 2001). Intervention consisted of installing ceiling insulation, draught stopping around windows and doors, and fitting sisalated paper beneath floor joists and a polythene moisture barrier on the ground beneath the house.			practitioners Adjusted OR 0.73 (95% CI 0.62, 0.87), (statistically insignificant) reduction in hospital admissions for respiratory conditions Adjusted OR 0.53 (95% CI 0.22, 1.29).	morbidity and premature mortality.
2006											

20	Richardson G, Barton A, Basham M, et al. The Watcombe housing study: the short-term effect of improving housing conditions on the indoor environment. Sci Total Environ 2006; 361(1-3): 73-80.	To assess the effect of improving housing conditions in 3–4 bedroom, single-family unit, social rented sector houses on the health of the occupants.	Randomised before and after study.	+	+	119 houses in Watcombe, an estate of social rented sector properties in Torquay, UK.	Houses were randomly allocated to be upgraded in 1999 (n=50, Phase I) or 2000 (n=69, Phase II). Phase II houses acted as a control for Phase I houses. Phase I houses received extensive upgrading including wet central heating, on demand ventilation, double-glazed doors, cavity wall and roof/loft insulation. An identical intervention for Phase II houses was delayed for one year.	Discrete measurements were made of indoor environmental variables in each house. Survey of health conditions (SF36 and GHQ12).	Non-parametric tests. Primary measure was comparison of changes in 2000. Data also presented for three years to clarify observed trends.	In 2000, there was a significant difference between the changes from 1999 to 2000 between Phase I (upgraded) and II (not then upgraded) houses for bedroom temperatures (p=0.002). Changes in wall surface dampness and wall dampness in Phase I houses were also significantly different to the change in Phase II houses in 2000 (p=0.001). By 2001 Phase I houses had reverted to the same dampness levels they had before upgrading. The housing upgrades increased bedroom temperatures in all houses. Other indoor environmental variables were not affected. Changes in health outcomes were not significantly different for Phase 1 residents, except for prevalence of non-asthmatic respiratory illness and adult asthma symptoms.	
2004											
21	Leech JA, Raizenne M, Gusdorf J. Health in	To examine	Prospective	+/-	+/-	267 people in 105 homes in New	Intervention group were 52	Self-reported: range of	Follow up interview after	Case occupants' summative symptom scores improved	Author highlighted:

	occupants of energy efficient new homes. Indoor Air 2004; 14(3): 169-73.	reported changes in health status in occupants of new energy efficient homes one year after occupancy in comparison with health status in the year before occupancy.	questionnaire (pilot) study.			Brunswick and Nova Scotia, Canada.	R-2000TM homes (128 occupants) built to preset and certified criteria for energy efficient ventilation and construction practices (air tight with MVHR). The control group were 53 new homes (149 occupants) built in the same year in the same geographic area and price range. One adult occupant was interviewed by telephone (within 3 months of programme registration), answering for all family members regarding the home and all occupants health characteristics in the previous	general and respiratory symptoms, diagnosis of asthma, chronic obstructive lung disease (COPD) or heart condition, medication use. Symptoms graded by frequency (never, sometimes, often, or always were scored 1–4, respectively).	one year. Summary score of symptoms for the entire household at baseline was compared with one year later by Wilcoxon rank sum test. Total symptom change scores over the year analysed in an analysis of variance examining for the effect of age, sex, and case versus control home status. Change scores examined by symptom and compared between case and control new homes by two-tailed unpaired t-test.	significantly over the year of occupancy (Wilcoxon rank sum test, p<0.006). Analysis of variance of individuals total symptom scores showed a significant effect of the type of house (p<0.0001), with lower change of scores in case buildings, but not of age or sex. When the data was analyzed by each symptom score change and compared between case and control new homes: throat irritation (p<0.004), cough (p<0.002), fatigue (p<0.009), irritability (p<0.002) were significantly more likely to improve in case occupants. In symptoms unlikely to be related to indoor air there was clearly no significant difference (nausea p=0.37, diarrhea p=0.59), while in some other respiratory symptoms there was a trend towards a difference in case over control homes (runny nose p=0.01, sneezing p=0.02, wheeze p=0.08, not significant at the <0.01 level). The main changes in symptom scores were from “sometimes” to	Unable to exclude is possibility that, having paid a small premium to purchase the case home, the occupant answering the questionnaire for the family simply believes the air is indeed better and health is improved.

							year. 83% response rate in intervention group. Similar response rate (79%) in control homes.			"never".	
2000											
22	Somerville M, Mackenzie I, Owen P, Miles D. Housing and health: does installing heating in their homes improve the health of children with asthma? Public Health 2000; 114(6): 434-9.	To evaluate the use of NHS money to improve heath by improving housing conditions .	Before and after study.	+	+	Cornwall, UK. 72 children with previously-diagnosed asthma living in 59 damp homes.	Installation of central heating. Installation of gas central heating in 28/59 (47%) houses, electric storage heaters in 22/59 (37%) houses, solid fuel central heating in 7/59 (12%) houses and oil-fired central heating in 2/59 (4%) houses.	Symptom-based questionnaire for asthma. Included frequency (in previous month) of breathlessness at different times scored on a scale of 0 (never) to 4 (every day), and time (number of days) lost from school in the previous 3 months.	Repeat assessment of each house and each child's respiratory status carried out at least 3 months following the intervention.	Initially, 69/72 (92%) of bedrooms were unheated and 44/72 (61%) were damp. Following improvements, 10/72 (14%) were unheated and 15/72 (21%) were damp. All respiratory symptoms were significantly reduced after intervention ($p<0.001$). There were no significant changes in symptoms not thought to be associated with damp housing (diarrhoea, hay fever, $p>0.05$). The greatest reduction was seen in nocturnal cough, from median score of 3 (most nights) to 1 (one or several nights) ($p<0.001$) in the previous month. Following intervention, children lost significantly less time from school for asthma in the previous three months (9.3 days per	Authors identified: lack of control group, parental reporting of symptoms, and lack of blinding to intervention.

										100 vs. 2.1 days per 100 afterwards, p<0.01): mean difference in rates 7.27 (95% CI 3.32-11.21, P<0.001 by paired t-test). Time lost for reasons other than asthma did not change significantly: mean difference in rates -1.80 (95% CI -3.86-0.26).	
1996											
23	Hopton J, Hunt S. The health effects of improvements to housing: A longitudinal study. Housing Studies 1996; 11: 271-86.	To evaluate the effects of an improved heating system on the symptoms of children living on a peripheral housing estate.	Longitudinal (before and after) study.	+	+	997 households on an isolated Scottish housing estate.	Installation in all rooms of a controlled heating system which responds to external temperature (the "Heat with Rent" scheme). 532 households interviewed following intervention. Information was available pre- and post-intervention on 251 children. For households with children, intervention (Heat with Rent) n = 55, no intervention n = 77.	Self-reported health status, including symptoms and reported health status of adults and any children present, use of health services, chronic illness in the household.	Follow up period was 12 months. Interviews performed at three times: time 1—prior to installation of the new heating system; time 2—approximately 6 months later; and time 3—approximately 12 months after time 1.	There was a general deterioration in children's symptomatic health over the year. Mean overall symptom score increased from 3.34 at time 2 to 3.82 at time 3 (n = 132). Of symptoms associated in the literature with dampness/mould, wheezing, runny nose, sore throat, headaches and persistent cough declined or stayed the same in the households where the heating had been improved while they showed a marked increase in the households where the heating had remained the same (McNemar test p < 0.05). Change in reporting the house was too cold was the only significant predictor of	Authors noted high attrition rate and reluctance for residents to take part in survey.

							Interviews included questions on perceived dampness, mould and cold.			change on the overall symptom score in households reporting problems with cold at time 3, but not at time 1, and a relatively small decrease in households where problems with cold had been alleviated. Change in reported level of dampness was the only significant predictor of change in reporting of runny nose (t = 2.41; p < 0.01). The results suggest that the elimination of dampness/mould prevented a further deterioration in health rather than bringing about an improvement.	
Housing simulations											
24	Wilkinson P, Smith KR, Davies M, et al. Public health benefits of strategies to reduce greenhouse-gas emissions: household energy. Lancet 2009; 374(9705):1917-29.	To examine the effect of hypothetical strategies to improve energy efficiency in the UK housing stock.	Simulation study of indoor environment with quantitative health impact assessment.	-/+	++	Entire UK housing stock.	Interventions to improve the energy efficiency of heating of the housing stock through changes to the dwelling fabric, ventilation control, fuel use, and occupant behaviour.	Modelled changes in indoor winter temperatures, PM2.5, environmental tobacco smoke (ETS), carbon monoxide (CO), mould and radon. Modelled health	Building physics based simulations of changes in environmental exposures in the UK housing stock. Health outcome estimates derived from attributable burdens calculated with	The magnitude and even direction of the changes in health depended on details of the intervention, but interventions were generally beneficial for health. For a strategy of combined fabric, ventilation, fuel switching, and behavioural changes, there were 850 fewer disability-adjusted life-years (DALYs), and a saving of 0.6 megatonnes	Modelling study to assess the 'co-benefits' of greenhouse gas mitigation strategies. Intended to be illustrative.

								outcomes were winter excess cardiovascular mortality (cold), respiratory symptoms (mould), acute carbon monoxide mortality, cardiopulmonary mortality (PM2.5), lung cancer (PM2.5, radon), myocardial infarction (ETS), and cerebrovascular accident (ETS).	adaptation of WHO Comparative Risk Assessment (CRA) method.	of CO2 per million population in one year.	
Health forecasting systems											
25	Bakerly ND, Roberts JA, Thomson AR, Dyer M. The effect of COPD health forecasting on hospitalisation and health care utilisation in patients with mild-to-moderate COPD. Chron Respir Dis 2011; 8(1): 5-9.	To test whether COPD exacerbations and admissions can be reduced by predicting periods of cold weather coupled with	Before and after study.	+	+	Patients with mild-to-moderate COPD from three primary care practices in Salford, UK, a district with high COPD prevalence.	Met Office 'Healthy Outlook' alert service for COPD patients. The intervention period (1 Nov 2008 to 31 Mar 2009) was compared to the same patients for the same period 12	The primary outcome was number of emergency COPD admissions to secondary care. Secondary outcomes were number of hospital bed-days, all-cause	Results expressed as means and mean differences with bias-corrected bootstrap analysis used to calculate 95% confidence intervals around the mean estimates.	There was a non-statistically-significant increase in hospital admissions per patient (0.07 to 0.076; p=0.83). The number of general practice visits per patient dropped from 4.9 to 3.8 (p=0.001), with drop in average number of visits to patients by out-of-hours services from 0.52 to 0.14 (p=0.013).	

		patients' alerts and education .					months earlier (1 Nov 2007 to 31 Mar 2008), before the alert service. A total of 157 (34% of target COPD population) patients took part in the project, with five weather alerts generated (first alert reached 150 patients; second reached 146; third reached 138 patients; fourth reached 137 patients; and the fifth reached 125 patients) during the intervention period.	consultations provided by general practice (surgery visits and telephone advice), home visits provided by general practice, accident and emergency (A&E) presentations, home visits by the COPD early supported discharge (ESD) team, and by on-call medical services (out-of-hours services).		The average number of home consultations provided by general practice increased from 0.05 to 0.92 (p=0.001). Cost per patient increased by an average of £142 (95% CI -£128 to £412). The authors concluded that the anticipatory care model was not associated with reduction in admissions from COPD exacerbations.	
26	Halpin DM, Laing-Morton T, Spedding S, Levy ML, Coyle P, Lewis J, et al. A randomised controlled trial of the effect of automated interactive calling combined with a health risk forecast on frequency and severity of exacerbations of	(i) To assess whether the EXACT-PRO health forecasting system can predict	Prospective randomised controlled trial.	+	+	79 people aged over 40 with a diagnosis of COPD at three general practices in Devon, UK. All eligible patients were invited to participate.	Automated alert calls made to patients' normal telephone service if an elevated risk of exacerbations was forecast. Patients	Patient reported outcome measures using EXACT system. Primary outcomes were frequency of	Exacerbation and event rates compared using a negative binomial model to allow for inter-subject variability. Ability to predict periods	58% in intervention group experienced one or more exacerbation compared with 68% in control group. Exacerbation frequency (+/- standard error of the mean) in patients receiving alert calls was lower (0.95±0.27 v 1.17±0.29, p=0.52) but not statistically significant.	The evaluation team included those from the service provider (UK Met Office).

	COPD assessed clinically and using EXACT PRO. Primary Care Respiratory Journal 2011; 20(3): 324-31.	periods of higher risk, and (ii) and to assess the effect of the service on the frequency and severity of COPD exacerbations.				All who completed trial daily diary were entered into the study.	randomised to either receive alert calls or not. 40 people in intervention group, 39 controls.	exacerbations (defined using Anthonisen criteria) and proportion of patients experiencing one or more exacerbation. Secondary outcomes were ability to predict increased frequency of exacerbations, frequency, severity and duration of events, and changes in health status.	of increased risk analysed using a mixed linear model.	No difference in mean EXACT scores between study groups. 34% of intervention group experienced one or more EXACT exacerbation compared with 53% in control group. Authors suggest that the ability of the forecast to predict high risk periods was confirmed unequivocally.	
27	Maheswaran R, Pearson T, Hoysal N, Campbell MJ. Evaluation of the impact of a health forecast alert service on admissions for chronic obstructive pulmonary disease in Bradford and Airedale. J Public Health. 2010; 32(1): 97-102. [27]	To examine if a forecasting alert service reduced COPD admissions.	Before and after comparison study.	+	++	Bradford and Airedale during winter of 2007-08.	Retrospective analysis of Met Office COPD exacerbation forecasting system. Analysis of anonymised admissions data for all local practices for the winters of 2006-0 (when no forecasting system) and 2007-08 (with	Practice level COPD admission counts during the two winter periods.	Poisson regression used to model COPD admission counts.	Admission rate ratios for practices using the service were 0.98 (95%CI: 0.78–1.22) for December to March, and 0.82 (CI: 0.57–1.18) and 0.95 (CI: 0.72–1.26) for the 7- and 14-day post-alert periods, respectively. When proportion of patients entered on the alerts system and the duration for which practices participated in the service were taken into account, admission rate	Author-noted limitations: Relatively small number of practices took up the service and few entered most of their patients onto the system. Relatively few alerts during the periods compared.

							forecasting system). Forecasting system used automated telephone call to warn people with COPD.			ratios for practices fully using the service were 1.11 (CI: 0.80–1.52), 1.22 (CI: 0.73–2.04) and 1.21 (CI: 0.82–1.78) for the three corresponding periods. The study failed to show that any change in admissions associated with the forecasting service was significant.	
28	Marno P, Chalder M, Laing-Morton T, Levy M, Sachon P, Halpin D. Can a health forecasting service offer COPD patients a novel way to manage their condition? J Health Serv Res Policy. 2010; 15(3): 150-5. [28]	To explore the acceptability and utility of a health forecasting service to patients with COPD and its perceived impact on their behaviour and disease management.	Cross-sectional questionnaire survey (pilot study).	-	+	3288 COPD patients from 189 general practices in England, Scotland and Wales at the end of winter 2007-08.	All general practices in each area invited to participate. Most used an opt-in to the system, though one used an opt-out. Every patient received an information pack. Survey conducted in April 2008. No control group.	Self-reported (survey) information on characteristics of service user, views on acceptability of service, satisfaction with service, and perceived impact on their behaviour. No explicit health outcomes.	Descriptive statistics, cross-tabulations and chi-squared tests.	85% of those returning a questionnaire reported at least one exacerbation during the study period and 8% had been admitted to hospital on one or more occasion. The majority of respondents deemed the information pack useful while the automated calls were generally said to be convenient, easy to understand and reassuring. Those less satisfied with the service felt they were already sufficiently aware of the prevailing weather conditions or felt more detailed information was needed. Most benefit was reported by those patients who were willing to be proactive in the management of their	Pilot questionnaire survey with no control group and limited response rate. Authors include members of the service provider (UK Met Office).

										condition, with the service encouraging 36% of respondents to seek a repeat prescription, 28% to reread their information pack and 12% to consult their GP for worsening of symptoms.	
Influenza vaccination											
	Kiyohara K, Kojimahara N, Sato Y, Yamaguchi N. Changes in COPD mortality rate after amendments to the Preventive Vaccination Law in Japan. Eur J Public Health. 2013; 23(1): 133-9.[29]	To assess the effects of the amendment to Japan's Preventive Vaccination Law in 2001 to augment influenza vaccine coverage of elderly people on the nationwide COPD mortality rate.	Before and after study based on retrospective analysis of mortality data.	+	+	Japan (nationwide).	Retrospective analysis of national COPD mortality data for January 1995 to November 2001 (pre law change) and December 2001 to December 2009 (post law change).	Monthly national COPD mortality obtained from 'Monthly Vital Statistics Reports of the Ministry of Health, Labour and Welfare' for January 1995 to December 2009.	Poisson regression. Performed separately for ages <65 years and >65 years.	After amendments to the law, a statistically significant reduction in COPD mortality rates was observed in January (RR 0.84; 95%CI 0.81–0.88), February (RR 0.85; CI 0.81–0.89) and March (RR 0.92; CI 0.88–0.96) among the population aged >65 years. However, in the population aged <65 years, no statistically significant changes in the COPD mortality rate were found. The authors conclude that a legal approach to improving influenza vaccine coverage for the elderly population would contribute to reducing the risk of COPD deaths during the influenza season.	Uncontrolled. Main registered cause of deaths for COPD patients may not be COPD.
	de Diego C, Vila-Corcoles A, Ochoa O, et al. Effects of annual influenza vaccination on winter mortality in elderly people with	To assess the effects of annual influenza vaccinatio	Prospective cohort study.	+	+	1,340 community-dwelling individuals 65 years or older who had chronic heart disease	Individuals were followed from January 2002 to April 2005. For each year,	Primary outcome was all-cause death during the study period.	Multivariable Cox proportional-hazard models adjusted by age, sex, and	Influenza vaccination was associated with a significant reduction of 37% in the adjusted risk of winter mortality during the overall period 2002–2005.	

	chronic heart disease. Eur Heart J 2009; 30: 209-16.[31]	n on winter mortality in older adults with chronic heart disease.				(congestive heart failure or coronary artery disease) in the region of Tarragona, Catalonia, Spain.	information on their influenza vaccination status was determined by a review of the Primary Health Care Centres' clinical records.		comorbidity were used to evaluate vaccine effectiveness.	The attributable mortality risk reduction in vaccinated people was 8.2 deaths per 1,000 person-winters. The authors estimated that one death was prevented for every 122 annual vaccinations (ranging between 49 in Winter 2005 and 455 in Winter 2003). They concluded that the results suggest a benefit from the influenza vaccination and support an annual vaccination strategy for elderly people with cardiac diseases.	
	Vila-Corcoles A, Ochoa O, de Diego C, et al. Effects of annual influenza vaccination on winter mortality in elderly people with chronic pulmonary disease. Int J Clin Pract. 2008; 62(1): 10-7.[30]	To assess the effects of annual influenza vaccinatio n on winter mortality in older adults with COPD.	Prospectiv e cohort study.	+	+	1,298 community-dwelling individuals 65 years or older who had chronic heart disease (congestive heart failure or coronary artery disease) in the region of Tarragona, Catalonia, Spain.	Individuals were followed from January 2002 to April 2005. For each year, information on their influenza vaccination status was determined by a review of the Primary Health Care Centres' clinical records.	Primary outcome was all-cause death during influenza periods.	Multivariable Cox proportional hazard models adjusted by age, sex and comorbidity were used to evaluate vaccine effectiveness.	Influenza vaccination was associated with a non-statistically significant 16% reduction in winter mortality among vaccinated COPD patients [unadjusted hazard ratio (HR): 0.84; 95% CI: 0.60–1.17]. Multivariable analysis showed that there was an insignificant trend towards a reduced mortality in the vaccinated group considering overall influenza periods 2002–2005 (adjusted HR: 0.76; 95% CI: 0.52–1.06; p=0.098).	

										The authors estimated that, in the total COPD population, one death was prevented for every 187 annual vaccinations. Authors conclude that the data suggest there is benefit from the influenza vaccination and support an annual vaccination strategy for elderly COPD patients.	
	Vila-Corcoles A, Rodriguez T, de Diego C, et al. Effect of influenza vaccine status on winter mortality in Spanish community-dwelling elderly people during 2002–2005 influenza periods. Vaccine 2007; 25: 6699-707.	To assess the relationship between the reception of conventional inactivated influenza vaccine and winter mortality.	Prospective cohort study.	++	+	11,240 community-dwelling individuals 65 years or older who had chronic heart disease (congestive heart failure or coronary artery disease) in the region of Tarragona, Catalonia, Spain.	Individuals were followed from January 2002 to April 2005. For each year, information on their influenza vaccination status was determined by a review of the Primary Health Care Centres' clinical records.	Primary outcome was all-cause death during the study period.	Multivariable Cox proportional-hazard models adjusted by age, sex, and comorbidity were used to evaluate vaccine effectiveness.	Influenza vaccination was associated with a significant reduction of 23% in winter mortality risk during overall influenza periods. The attributable mortality risk in non-vaccinated people was 24 deaths per 100,000 person-weeks within influenza periods, the prevented fraction for the population was 14%, and one death was prevented for every 239 annual vaccinations (ranging from 144 in Winter 2005 to 1748 in Winter 2002).	
Anti-fall devices											
33	Berggard G, Johansson C. Pedestrians in wintertime—Effects of using anti-slip devices. Accident Analysis and Prevention 2010; 42: 1199-1204.[33]	To examine the effect of using anti-slip devices on daily walking	Randomized trial	-/+	-/+	Healthy adults in northern Sweden during February to April 2008. Recruited from employees at Luleå University of Technology,	Respondents were randomly divided into an intervention group, a control group (with similar distribution of	-- daily diary of distance walked and occurrence of incidents or accidents reported weekly	Fishers exact test. Chi-square test.	Half of the respondents stated that they had previous experience of using anti-slip devices. 52% of the respondents used anti-slip devices.	Reviewer noted Small sample; main result not based on initial randomization, but on whether user or non-user

		journeys and preventio n of slips and falls.				Luleå, Sweden.	gender and age) and a comparison group. Intervention group were equipped with one of three different types of anti-slip devices: a heel device, a foot-blade device or a whole foot device. The comparison group were simply informed, in writing, about the importance of their participating in a travel survey.	-- detailed incident or fall report, and -- experiences of using anti-slip devices for those who used these devices during the trial period.		Anti-slip devices improved the walking capability during wintertime. <u>Among those using appropriate anti-slip devices</u>, the average daily walking distance was found to be statistically significantly longer compared to people not using anti-slip devices. *Relative incident or fall rate and actual fall rate on days when using or not using anti-slip devices.* Users Non-users No. of days 356 2107 Mean daily walking distance (km) 4.08 2.66 Number of incidents or falls 9 55 Incident or fall per day 0.025 0.026 Incident or fall per km 0.0062 0.0098 Fall per km 0.0007 0.002 The study indicates that an increase in daily walking distance can be made without increasing the risk of slips/falls when using anti-slip devices.	of devices; simple analysis. Potential for substantial selection bias.

34	Parkin L, Williams SM, Priest P. Preventing winter falls: a randomised controlled trial of a novel intervention. N Z Med J 2009; 122(1298): 31-8.[34]	To investigate the hypothesis that wearing socks over shoes improves traction on icy footpaths.	Randomised controlled trial.	-/+	-	30 pedestrians (median age 21 years, range 18–70) travelling in a downhill direction on icy public footpaths at two sites in Dunedin, New Zealand.	Intervention: different coloured (acrylic-blend) socks applied over normal footwear or usual practice (unadulterated footwear). Pedestrians intercepted travelling downhill. Randomly assigned to intervention (socks) or control (no socks) groups. Performed on 15 August 2008.	Primary outcome: difference in mean self-reported slipperiness on a 5-point scale. Secondary outcomes: falls, observer-rated slipperiness, observer-rated confidence, time to descend study slope.	Data analysed according to intention to treat. Groups compared using a t-test for the continuous or ordinal variables and a Fisher's exact test for the categorical variables.	Two-thirds of participants (65%) had previously fallen on ice. Wearing socks over normal footwear was associated with a statistically significant improvement in traction; the difference in mean self-reported slipperiness scores between the control (n=15) and intervention (n=14) groups was 1.3 (95%CI: 0.4–2.3). There was no evidence of risk compensation in the intervention group (difference in mean descent times 1.9 seconds, 95%CI: -6.1–10.0). Agreement between self-rated and observer-rated slipperiness was high (r=0.70). A higher proportion of the intervention group (71% vs 53%) appeared confident. One member of the control group fell. There was no evidence of risk compensation in the intervention group (difference in mean descent times 1.9 seconds, 95%CI: -6.1–10.0).	Author identified: not possible to blind participants or outcome assessors; apart from sex, no adjustment was made for imbalances in the baseline characteristics of the groups.
35	McKiernan FE. A simple	To	Prospectiv	+	+	Ambulatory, fall-	113 participants	The number	Analysis on	There were 93 indoor slips,	High level of

	gait-stabilizing device reduces outdoor falls and nonserious falls in fall-prone older people during the winter. Journal of the American Geriatrics Society 2005; 53(6): 943-7.[35]	determine whether Yaktrax Walker, a non-medical gait-stabilizing device, prevents outdoor falls and injurious falls in fall-prone older people during the winter.	e, randomized, interventional trial.			prone people aged 65 and older in Marshfield and Minocqua, WI, USA during winter 2003/04. Participants recruited from a falls registry (who had fallen at least once during the past year).	were randomised to wear Yaktrax Walker or their usual winter footwear outdoors. Yaktrax Walker is a proprietary injection-moulded thermal plastic elastomer netting sized to conform to the external length and width of a boot or shoe. Final study population consisted of 109 people.	of indoor and outdoor slips, falls, and injurious falls was recorded daily in a diary. A winter footwear satisfaction survey was completed following the study.	intention-to-treat basis. Chi-square, negative binomial model, and Fisher exact tests used to test difference of outcomes between the intervention and control groups.	13 indoor falls, 714 outdoor slips, and 62 outdoor falls. The tendency for both groups to slip/fall indoors was comparable. The relative risk (RR) of outdoor slip using Yaktrax Walker was 0.50 ($p<0.04$) for all diary days and 0.61 ($p=0.14$) when only days walked on snow and ice was the exposure variable. The RR of outdoor fall for Yaktrax Walker was 0.42 ($p<0.03$) when only days walked on snow and ice was the exposure variable. RR of injurious falls per day walked on snow and ice for Yaktrax Walker was 0.13 ($p<0.02$). 12/19 outdoor falls occurred when Yaktrax Walker subjects were not wearing their assigned device. No serious injury or fracture occurred in either group. The number needed to treat for the Yaktrax Walker to prevent one non-serious injurious fall in one winter was six.	contamination in study. Authors state that manufacturers of Yaktrax Walker had no involvement in conception, design, implementation or analysis of the study.

	Thermal clothing										
36	Barnett AG, Lucas M, Platts D, et al. The benefits of thermal clothing during winter in patients with heart failure: a pilot randomised controlled trial. BMJ Open 2013; 3: e002799.[36]	To examine whether providing thermal clothing to heart failure patients improves their health during winter.	Randomised controlled trial (pilot).	+	+	A heart failure clinic in a large tertiary referral hospital in Brisbane, Australia. Eligible participants were those with known heart failure over 50 years of age living in Southeast Queensland. Participants were excluded if they lived in a residential aged care facility, had incontinence or were unable to give informed consent.	Participants randomised to the intervention received two thermal hats and tops and a digital thermometer. Control group received the usual care. Patients completed a paper diary to record when they wore the hat and top and the indoor temperature. 55 participants were randomised and 50 completed.	Primary outcome was the mean number of days in hospital. Secondary outcomes were the number of GP visits and self-rated health (V.1 of the SF-36 questionnaire).	Generalised linear mixed regression model using a binomial distribution with a random intercept for each participant to control for repeated results. Bias corrected bootstrap used to create non-parametric 95% CIs for differences between two groups.	The mean number of days in hospital per 100 winter days was 2.5 in the intervention group and 1.8 in the usual care group, with a mean difference of 0.7 (95% CI -1.5 to 5.4). The intervention group had 0.2 fewer GP visits on average (95% CI -0.8 to 0.3), and a higher self-rated health, mean improvement -0.3 (95% CI -0.9 to 0.3). The thermal tops were generally well used, but even in cold temperatures the hats were only worn by 30% of the participants.	Small study using mainly self reported data. Compliance was poor among those who did not feel the cold or did not like tight-fitting clothes. Compliance with the hat was also poor.

Evidence table 2. Qualitative studies on interventions

Ref no.	Study: authors, year. Citation	Quality score (++, +, -)	Research parameters	Population and sample selection	Outcomes and methods of analysis	Notes by review team
54	Bates, K. B., L. Lane, et al. (2012). High rise hope: the social implications of energy efficiency retrofit in large multi-storey tower blocks (CASE report 75).[54]	-	To assess the social impacts of energy efficiency measures in buildings in low-income areas, as part of a regeneration project. The scheme had multiple regeneration objectives, the major one being to improve the energy efficiency of the buildings.	48 residents interviewed in their homes. Recruitment methods unclear though sample stated to be largely representative of the residents on the estate.	Semistructured questionnaire used, covering how people felt about their home, the estate, their sense of security, their energy costs, levels of social interaction and community, participation on the estate, and about their experiences of the regeneration work to date. A third of respondents described using energy saving measures, some of which have been implemented by the council (eg, draught reducers). Almost 40 per cent said they cannot save more than they already do, are already careful with energy usage, or think the best way to save energy is simply not to use it. A quarter are not inclined to change their usage.Only a few interviewees mentioned the insulation works as a potential source of energy saving.	Unclear whether it is qualitative or quantitative, or a mix, or how interviewees were recruited, or how analysis was conducted.
37	Gilbertson J, Stevens M, Stiell B, Thorogood N, Warm Front Study G. Home is where the hearth is: grant recipients' views of England's home energy efficiency scheme (Warm Front). Soc Sci Med 2006; 63(4): 946-56. [37]	++	Research question: to determine grant recipient's perceptions and experiences of the Warm Front interventions and impacts on health and well-being. Semi-structured interviews were carried out in a purposive sample of 49 households which	Five urban areas (Birmingham, Liverpool, Manchester, Newcastle, Southampton) Sample recruited at time of installation of Warm Front energy efficiency measures. Each household had received installation, replacement or	Most householders reported improved and more controllable warmth and hot water. Many also reported perceptions of improved physical health and comfort, especially of mental health and emotional well-being and, in several cases, the easing of symptoms of chronic illness. There were reports of improved family relations, an expansion of the domestic space used during cold months, greater use of kitchens and improved nutrition, increased privacy, improved social interaction, and an increase in comfort and atmosphere within the home.	

			received home energy improvements	refurbishment of the heating system +/- insulation of the cavity wall, loft or both, plus draught-proofing.	Greater warmth and comfort also enhanced emotional security, and recipients were more content and at ease in their homes. However there was little evidence of substantially lower heating bills. These results provide evidence that Warm Front home energy improvements are accompanied by appreciable benefits in terms of use of living space, comfort and quality of life, physical and mental well-being, although there is only limited evidence of change in health behaviour.	
38	Harrington BE, Heyman B, Merleau-Ponty N, Stockton H, Ritchie N, Heyman A. Keeping warm and staying well: findings from the qualitative arm of the Warm Homes Project. Health Soc Care Community 2005; 13(3): 259-67.[38]	++	Research question: qualitative arm of the Warm Homes Project, a programme of research concerned with the nature of fuel poverty, its alleviation and its relationship to family health.	Data for the present study were obtained through qualitative interviews with household members about the above issues.	Expectations of those in fuel poverty about staying warm, and their beliefs about the relationship between warmth and health, vary considerably. Fuel poverty often had wider ramifications, impacting on quality of life in complex ways. Respondents took steps to alleviate cold, but their strategies varied. Coping was affected by informational limitations as well as cost constraints. Authors note: “Measures designed to alleviate fuel poverty should take into account its wider social meaning within the lives of household members.”	

39	Shortt N, Rugkasa J. "The walls were so damp and cold" fuel poverty and ill health in Northern Ireland: results from a housing intervention. Health Place 2007; 13(1): 99-110.[39]	-	Research question: qualitative results from an evaluation of a fuel poverty programme Surveys were conducted both pre and post intervention and analysed to assess any changes.	54 homes in a rural community in the Armagh and Dungannon Health Action Zone in Northern Ireland. Energy efficiency measures, including some central heating systems, were installed through the programme.	The programme demonstrated that energy efficiency intervention can lead to improvements in health and well-being, increased comfort levels in the home and a reduction in the use of health services, therefore having potential cost savings for the NHS. Some households, however, remain in fuel poverty after having full central heating installed, reflecting the significant contribution of low income on the production of fuel poverty. The	
41	Chalabi Z, Erens B, Hajat S et al. Evaluation of the implementation and health-related impacts of the Cold Weather Plan for England 2012. London: Dept of Health 2013;[41]	+	Qualitative component of an evaluation of the 2012/13 Cold Weather Plan (CWP) for England. Staff interview study: Semi-structured in-depth telephone interviews with health and social care managers (n=52) in 10 purposively sampled LAs in England. Exploration of issues related to the implementation of the CWP and of cold weather planning and response more generally. Thematic analysis.	Staff interview study: Health and social care managers involved in the implementation of the CWP. Localities purposively selected to give spread of geographic regions and socio-economic groups. Names of relevant people requested from CEOs of organisations. Respondents invited by email or telephone to participate. 25 older people recruited door –to-door with a purposive sampling frame to include people thought to be vulnerable during	Staff interview study: Health and social care managers tended to think of 'vulnerability' in terms of socio-economic deprivation and existing clients (i.e. people who were in receipt of social care services such as home care). The authors conclude that this definition may miss some people who are vulnerable during cold weather (such as those who don't use services) and inclue some people who are not (e.g. because they live in a warm home). Many services, such as home care, are contracted out to independent providers. While the CWP and the cold weather alerts were a useful aid to prompt providers about actions that should be taken during cold weather, commissioning managers could not be sure that the actions set out ion the CWP for front-line staff (such as checking room temperature) were being undertaken. Engagement with primary care was variable: While some GPs were said to be actively engaged with	Funded by DH

			Interviews with a sample of older people (n=35): In-depth semi-structured telephone interviews with a sample of older people with long-term conditions undertaken within 2 days of a level 3 cold weather alert. Exploration of views and experiences during cold weather. Thematic analysis.	cold weather (>75 and >90 and with a chronic illness and living alone). 10 people from a rural locality and 15 people from an urban locality. Also 10 people from the rural locality recruited by local AGEUK. Both localities included a mix of men and women. The urban locality included 3 people of Asian origin.	winter welfare initiatives (such as referring patients to household warmth interventions) others were not. Local leadership of implementation of the CWP tended to be with emergency planning staff rather than with public health staff. Emergency planners felt limited in what attention they could give to prevention. Interviews with a sample of older people: While respondents thought cold weather may exacerbate existing conditions there was little knowledge of the cardio-vascular risk association with cold temperatures. Although all respondents were in regular contact with a health professional, none had received any advice or support related to cold weather. There was a universal preference for turning the heating off at night (for comfort). There was also a universal fear of falling during icy conditions which was the greatest concern for participants. As a consequence respondents would stay inside when the risk of falling was thought to be high (i.e. during periods of ice and snow). Respondents would however go out as soon as it was thought safe to do so, to socialise or fulfil responsibilities (such as voluntary work) or simply to 'get out'. Nearly all respondents were reliant on public transport, with participants from the rural case study in particular facing arduous journeys to access facilities such as shops, exposing them to cold outdoor temperatures. The risk of poor health during cold weather was	

					mediated by instrumental social support provided by family (predominantly) or neighbours. This took the form of car journeys, hot meals, shopping, repairs, help with heating technology, and monitoring health and wellbeing.	
55	Cooper, R. and R. O'Hara (2010). "Patients' and staffs' experiences of an automated telephone weather forecasting service." Journal of Health Services & Research Policy 15 Suppl 2: 41-[55]	++	To explore patient perceptions of the automated telephone services (ATS), patients' experiences managing their COPD, staff perceptions of the ATS and experiences in supporting COPD patients.	Qualitative semi-structured telephone interviews with 18 patients and six staff from five primary care centres in Bradford, England. Purposive sampling; the majority of patients interviewed were aged between 60 and 80 years old, with the youngest being 44. All were classified as having moderate to severe COPD.	Thematic analysis. Interviews were undertaken iteratively and analysis of initial interviews was undertaken to identify emergent themes. Some patients considered the service to have been very beneficial and described feeling more prepared for possible changes in the weather. The telephone messages were perceived as more personal, accurate and specific, which empowered them to self-manage their condition. Patients also felt reassured by reminders to order medicines. Some believed that the service gave them priority status for prescriptions and appointments. A number of patients did not perceive the service to have any obvious benefits or impact on the self-management of their condition but did not identify any negative aspects. Two patients viewed the service negatively and were generally sceptical of meteorological forecasting. All patients were emphatic that home telephones were the most appropriate technology for communicating weather warnings. Some patients reported that they had struggled initially with the automated nature of the calls and in particular with the need to provide specific responses. Weather forecasting information emerged as a more significant factor for patients than actual ATS mode of communication. Patients were aware of the significance of the weather for managing their condition and accessed weather information from established sources such as television and radio. A number of patients who were sceptical of weather	Well conducted, methods well described, a lot of data used as quotes to back up the Results. A lot of useful findings in the paper, more than can be pasted into the table.

					forecasting in general doubted the reliability of the information and consequently the value of the ATS. Some found ATS more reassuring than television or radio weather forecasts since it provided additional warning about potentially adverse weather. All staff commented on the failure of the service to access certain *'hard-to-reach'* groups or patients; non-English speaking COPD patients; those with less severe forms of COPD; and those from lower socioeconomic groups.	
40	Gascoigne C, Morgan K, Gross H, Goodwin J. Reducing the health risks of severe winter weather among older people in the United Kingdom: an evidence-based intervention. Ageing and Society 2010; 30(2): 275-97.[40]	+	To translate the relevant scientific literature into practical advice for older people in order to reduce health risk during episodes of severe winter weather ; and to integrate this advice with a severe winter weather 'Early Warning System' developed by the UK Met Office.	37 people aged 64-83 living in Loughborough (62%) and rural Leicestershire (38%). Participants recruited through local newspaper advertisements, and were required to be: over the age of 65; have access to a telephone; be living within 10 miles of Loughborough University; and available at home throughout the two-month 'standby' period	The main outcome of the study was to translate the relevant scientific literature into practical advice for older people in order to reduce health risk during episodes of severe winter weather; and to integrate this advice with a severe winter weather 'Early Warning System' developed by the UK Met. Office.	

Evidence table 3. Economic analyses

Ref no.	Study, reference	Aim	Type of economic analysis and perspective	Qual score /applicability		Applicability	Population and setting	Intervention/ comparator	Outcomes	Methods of analysis	Results	Notes
				Int	Ext							
50	Edwards RT, Neal RD, Linck P, Bruce N, Mullock L, Nelhans N, Pasterfield D, Russell D, Russell I, Woodfine L (2011) Enhancing ventilation in homes of children with asthma: cost-effectiveness study alongside randomised controlled trial. British Journal of General Practice. e733.[50]	To carry out a cost-effectiveness analysis (CEA) of a housing intervention to improve the ventilation and heating systems in households of children with asthma. The CEA is carried out alongside a pragmatic RCT.	A public perspective (NHS & local authorities) is taken into account. The NHS costs included those of primary and secondary care sectors. The local authorities cost include costs of housing interventions.	++	++	England H'holds with child with asthma	The setting is Wrexham County Borough, Wales. The population are households with children (aged 5- 14) with asthma (have received 3+ prescriptions for corticosteroid in the preceding year to the trial).Overall 20/23 general practices in Wrexham participated in the study and a total of 177 children were finally studied. Most children came from owner-occupied households and most parents left full-time education at 16-years.	All selected household received the housing intervention either immediately or after one year ('waiting list' control). The housing interventions were (i) installing ventilation system only and (ii) installing ventilation and heating system	Health outcomes: The main outcome measures were the parent-completed asthma-specific module of PedsQL (a validated quality-of-life measure for children); the generic PedsQL module was also used for assessing physical and psychosocial health. The total score is a number between 0 (worst problems) and 100 (no problems) Health-related outcomes (health service use): Number of GP consultations (surgery visits, telephone home visits); No of out-of-hours GP consultations (surgery visits, telephone home visits); practice nurse consultations;	Two cost components were calculated: cost of housing interventions (funded completely by local authority) and NHS costs (primary & secondary). Cost-effectiveness analysis (CEA) was carried out. The incremental effectiveness is the difference between the PedSQL score of asthmatic children before receiving the housing intervention and 12 months after receiving the intervention. The incremental cost is the counterpart different in healthcare cost augmented by the	Over 12 months, the housing intervention lifted 17% of children from severe asthma to moderate asthma (compared to a 3% lift in the control group). Healthcare costs over 12 months between the intervention and control groups were not statistically significantly different. The cost to Wrexham LA was £1,718 per child in the intervention group or 12,300 per child lifted from severe to moderate asthma. The ICER was £234 per unit improvement in the PedSQL asthma-specific scale (95% CI £140- £590). For severely asthmatic children, the ICER drops to £165 (95% CI £84-£424) The installation of ventilation and heating systems were required are likely to be cost-	The CEA carried out is thorough. The study has addressed well issues to do with uncertainty. As the authors have pointed out, there were several limitations. The main limitations were (i) health outcome was subjective (reported by the parents) and (ii) no measurements were made of the indoor

									No of primary care prescriptions (bronchodilators, corticosteroids, BNF3 respiratory) No of hospital visit (outpatients, inpatients, A&E)	cost of the housing intervention. Incremental cost-effectiveness ratios (ICERs) were estimated. Uncertainty bounds on the ICERs were estimated using bootstrapping and 95% CIs of the ICERs were calculated. Cost-effectiveness acceptability curves (CEAC) were constructed to determine the probability that the housing intervention is cost-effective against a range of cost-effectiveness thresholds.	effective for children with moderate to severe asthma.	environment (e.g. mould presence, indoor temperature).
42	Tarp Jensen H, Keogh-Brown MR, Smith RD, Chalabi Z, Dangour AD, Davies M, et al. The importance of health co-benefits in macroeconomic assessments	To quantify health 'co-benefits' of GHG mitigation strategies, including home energy efficiency measures, additional	Health-focussed macroeconomic assessments of three contingent UK Greenhouse Gas (GHG) mitigation strategies	+	+	UK. (Bsed on a CGE model and anloysis for the UK (England)	UK Analysis of GHG mitigation strategies over 20 years to 2030 to meet 2030 GHG emissions reduction targets	Housing retro-fit insulation measures of the type and scale needed to meet 2030 GHG emissions reduction targets	Health consequences of retro-fit-related changes in the indoor environment (air quality, temperature) – with consequences for health, health and social security costs and GDP	A UK economy-wide dynamically-recursive Computable General Equilibrium (CGE) model is used to calculate the macroeconomic effects over a time horizon of 20 years. The health effects of the specific energy efficiency	*<u>Table 1. Health-related shocks</u> (million £; NPV in 2010 prices): household energy interventions* 1 Net Public Budget Net Savings 1a Social Security Net Savings[a] -80.4 Soc Sec save (labour) 17.6 + Soc Sec save (dependents) -98.1 1b Healthcare Savings[a] 43.0 2 Total Labour Force Change 10,375 3 Total Population Change	

	of UK Greenhouse Gas emission reduction strategies. Climate change. in press.[42]	to those from reduced local air pollution	Perspective: Whole economy							measures were based on health impact assessment of the interventions carried out in a separate study. The impact of the interventions and the associated health impacts (defined in terms of healthy life years lost to disability (YLDs) and years of life lost (YLLs)) were used to perturb the CGE model	24,238 4 YLD (accumulated years) 8,867 4a Working age change 6,927 Labour force change4,938 4b Dependents change 1,940 5 YLL (accumulated years) 24,238 5a Working age change 7,544 Labour force change 5,436 5b Dependents change 16,694 [a] Net Present Value over 2011-2030 (million £) [b] Accumulated years over 2011-2030 without discounting Indicators are linked as follows 1 = 1a + 1b 2 = 2a + 2b 3 = 5 = 5a + 5b 4 = 4a + 4b *Table 2. Standard Assessment (£ million/£ per capita; NPV in 2010 prices)* ΔGDP (2011-30) total effect[a] -24,601 ΔGDP (2011-30) decomposition (marginal effects)[a,e] -24,575 - New technologies 24,408 - Investment costs -49,431 - Health co-benefits[f] 448 ΔPer Capita GDP[b]	

											- 2015 1.9 - 2020 -20.4 - 2030 -46.6 ΔFactor Returns (2030)[c] - Land Return -0.25% - Unskilled wages -0.15% - Skilled wages -0.20% - Capital Return 0.41% ΔTax Rates (2030)[d] - Household Income Tax 0.04% ΔGDP (2011-2030)a,f 448 ΔPer Capita GDPb,f - 2015 0.06 - 2020 -0.04 - 2030 -0.60 [a] Net Present Value over 2011-2030 (million £) [b] Net Present Value of value in 2015, 2020, and 2030 (£ per capita) [c] Percentage changes in 2030 [d] Percentage-point changes in 2030 [e] The marginal effects of the individual parts of the ΔGDP decomposition were measured relative to the counterfactual. The sums of marginal effects differ from the total effects due to interaction terms. Interaction terms are particularly strong in the active travel scenario, where the 16% efficiency gain for urban traffic (due to reduced congestion) only applies to the remaining 59% of urban traffic volumes (after the 41% demand reduction) [f] The health co-benefits are marginal effects produced from the health-related shocks in Table 1. The assessed household energy efficiency strategy is likely to breakeven only over the long	

											term after the investment programme has ceased (beyond our 20 year time horizon). Authors note: "[these strategies] will involve initial net societal costs... Health co-benefits can play a crucial role in bringing down net costs, but our results also suggest the need for adopting holistic assessment methodologies which give proper consideration to welfare-improving health co-benefits with potentially negative economic repercussions (such as increased longevity.."	
52	BRE. A retrospective health impact assessment of housing standard interventions in Derby. Watford, UK: BRE. http://www.bre.co.uk/page.jsp?id=3080 accessed 23 aug 2013.[52]	To quantify the health impacts associated with housing renovation and refurbishment works.	Health impact assessment (modelling study)	+/-	+/-		32 dwellings in Brindley Court, Derby, a poorer block of flats, which underwent housing improvements by Derby City Council.	Health impact assessment using risks and impact estimates derived from the Home Health and Safety Rating System (HHSRS)	Health impacts associated with a range of housing-related harms as defined by the HHSRS: - Damp/mould growth - Excess cold - Entry by intruders - Domestic hygiene, pests and refuse - Food safety - Personal hygiene, sanitation & drainage - Falling on level surfaces etc - Falling on stairs etc - Falling between levels	Costing/monetization of health impacts calculated from the hazards and harm classes defined by the HHSRS <u>Time horizon</u>: results presented for 1, 10 and 25 years, but as simple multiples <u>Discount rate</u>: Zero (implicit)	*Monetized savings to society annually and over 10 & 25 years by hazard* <u>Mean saving to society</u> 1 year 10 years 25 years Damp and mould growth £170 £1,700 £4,250 Excess cold £1,764 £17,644 £44,109 Entry by intruders £68 £681 £1,702 Domestic hygiene, pests and	

									- Electrical hazards - Fire - Flames, hot surfaces etc -Structural collapse and falling elements	Uncertainty: Not done	refuse £1 £13 £31 Food safety £1 £13 £31 Personal hygiene, sanitation & drainage £278 £2,779 £6,946 Falling on level surfaces etc £415 £4,150 £10,375 Falling on stairs etc £33 £325 £813 Falling between levels £101 £1,009 £2,522 Electrical hazards £31 £313 £781 Fire £56 £555 £1,388 Flames, hot surfaces etc £8 £75 £188 Structural collapse and falling elements £10 £100 £250 The total cost of works carried out (£65,709) is estimated to have produced savings to the NHS of £23,191and wider society of up to £58,000 annually. The largest health cost savings	

											are to mitigate hazards associated with cold. "The three most common hazards of cold, fire and entry by intruders have been mitigated to remove hazards that are above those expected in an average dwelling. It is estimated that these works will save 36 incidents of harm over a ten year period. Most of these expected harm outcomes would involve visits to GP surgeries or other initial NHS response but some would be expected to involve hospitalisation or death."	
43	Cambridge Econometrics (2012) Jobs, growth and warmer homes. Evaluating the economic stimulus of investing in energy efficiency measures in fuel poor homes. Final Report for Consumer Focus, Cambridge[43]	To assess *ex ante* the economic and environmental impacts of UK Government investment in energy efficiency in fuel poor households	The economic analysis assessed the benefits and costs of Government spending the carbon tax revenue raised from electricity consumers between 2012 and 2027 on providing energy efficiency interventions to fuel poor	+	+	The analysis is applicable because it was carried out for the UK	The setting is the UK and the population targeted is the fuel poor households	Three scenarios were modelled for government spending the tax revenue from carbon taxes on energy efficiency: (i) (EE-all) spend just under 95% of the tax revenue and allow investment on all 9.1 million fuel poor households, (ii) (EE-T) Spend just under 35% of the tax revenue targeted at the 6.8 million fuel	Several benefits for each of the investment scenarios were considered: economic (GDP, employment-jobs), social (reduction in number fuel poverty households, reduction in household energy bills) environmental (reduction on CO2 emissions)	A comprehensive macro-economic model developed by Cambridge Econometrics (MDM-E3) of the UK energy-environment-economy system is used for the economic analysis	It was shown that there are very clear benefits from investing the carbon text revenues on improving energy efficiency of fuel poor households. In the short-term (2015-2016) it was shown that investing in energy efficiency measures (EE-All scenario) in fuel poor households (i) removes 87% of the 9.1 million households from fuel poverty by £200 (ii) has a slightly more positive macro-economic impact than other investment scenarios, (iii) has a positive impact on GDP (0.08 to 0.2%) compared to the baseline scenario, (iv) creates 71,000 jobs. On the longer-term (2027), the energy efficiency investment (EE-All) scenario	The analysis does not estimate directly the health benefits and their impact on economy. The authors refer however to published reports on health benefits.

			households					poor households whose homes can be treated by less than £10,000, and (iii) (EE-EA) Spend 100% of the tax revenue targeted at the 6.8 million fuel poor households whose homes can be treated by less than £10,000 in 2013-2019 and then a share of the revenue in 2020. Four alternative scenarios for spending the carbon tax revenue were used for comparison purposes (i) a general government spending programme (G), (ii) a general government investment programme (GK-T), (iii) a VAT reduction scenario (VAT). (iv) a fuel duty reduction scenario (FUEL).			increases the GDP by 0.38% and jobs by 130,000. In terms of wider benefits, investment in energy efficiency measures in fuel poor households reduces (i) total household energy consumption by 5.4% by 2027 which corresponds to an annual fuel saving of £212 (2008 prices) per household, (i) CO2 emissions by 4 MtCO2 per annum by 2027.	

								All the above scenarios are compared to a baseline scenario which does not involve any spending stimulus.				
45	Liddell C. Cost-benefit Analysis of the Health Impacts of Tackling Fuel Poverty. Report for the NI Department of Social Develpment. Ulster: University of Ulster; 2011.[45]	To assess the health effects and cost savings of the Northern Ireland Warm Homes (NIWH) scheme	(1) Benefits to quality of life (2) Direct costs to the NHS	+	+	The study is also applicable to England	Northern Ireland Warm Homes (NIWH) scheme, 2001-2008 Total inhabitant years for estimated beneficiaries of scheme: --1 elderly person 301,115 --2 elderly people 602,230 --1.5 younger adults 451,673 --1.5 children 451,673 Total person years: elderly 903,345 younger adults 451,673	Pre-post change: health impact and cost-benefit model using combination of Warm Front evaluation results and Home Health and Safety Rating System (HHSRS)	Excess cold Damp and mould growth Falls on level surfaces Falls on stairs Fires Flames and hot surfaces	Calculations done assuming occupation of dwelling over 15 years comprises the following: single pensioner for 5 years; pensioner couple for 5 years; a family of 1.5 adults and 1.5 children for 5 years. Calculations based on risk estimates from the Home Health and Safety Rating System (HHSRS) + estimates of Warm Front evaluation <u>Time horizon</u>: 15 years <u>Discount rate</u>: no information provided <u>Uncertainty</u>: None carried out	*Summary data: HHSRS, QALY and NHS-savings estimates of reduced risk post retrofit* <u>Excess cold -- 'seniors' (n=903,345)</u> Post NIWH reduction: 705 (375) Combined QALYs: 320.7 (170.7) QALY gain (£M): Max (Min): 12.83 (6.83) NHS saving: Max (Min): £478,088 (£254,304) <u>Excess cold -- other adults (n=451, 673)</u> Post NIWH reduction: 294 (147) Combined QALYs: 144.5 (77.0) QALY gain (£M): Max (Min): 5.78 (3.08) NHS saving: Max (Min): £215,140 (£114,437) <u>Damp and mould growth -- Children</u> (n=451,673) Post NIWH reduction: 1355 (903) Combined QALYs: 210.2 (140.0) QALY gain (£M): Max (Min): 8.41 (5.60) NHS saving: Max (Min) £253,845 (£162,353)	No uncertainty or sensitivity analysis were carried out despite the modelling approach has many assumptions.

							child 451,673			although the value of using Monte Carlo simulations is noted	<u>Falls + fires -- seniors (n=903,345)</u> Post NIWH reduction: 680 (401) Combined QALYs: 174.5 (98.6) QALY gain (£M): Max (Min): 6.98 (3.94) NHS saving: Max (Min): £322,072 (£190,847) <u>Flames and hot surfaces -- children</u> (n=451,673) Post NIWH reduction: 224 (112) Combine QALYs: 39.5 (19.8) QALY gain (£M): Max (Min): 1.58 (0.79) NHS saving: Max (Min): £28,895 (£14,448) <u>Mental health and wellbeing -- adults</u> (n=451,673 + 903,345) Post NIWH reduction: 1189 (595) Combine QALYs: 170.3 (85.2) QALY gain (£M): Max (Min): 6.81 (3.41) NHS saving: Max (Min): £217,738 (£108,869) <u>Mental health and wellbeing -- children</u> (n=451,673) Post NIWH reduction: 594 (297) Combine QALYs: 85.23 (42.62) QALY gain (£M): Max (Min): 3.41 (1.71) NHS saving: Max (Min):	

											£189,490 (£94,745) TOTAL (£M) QALY gain: Max (Min): 45.80 (25.36) NHS savings: Max (Min): 1.71 (0.94) These total figures for monetized health impacts are equivalent to a "conservative maximum" offset of the cost of intervention of 42%. Imputing further benefits (based on Clinch & Healy model for Ireland) would create the following estimated offsets : Health : 42% offset; Employment (job creation, lost days from sickness and disability): 70% offset; Carbon reduction and energy savings 100% offset; Other (e.g. education benefits, social cohesion and crime reduction) : 10% offset Altogether this suggests that incorporating all the major benefits of a scheme such as NIWH could yield a 222% offset, indicating a 2.1 return on investment. (Author notes that this resembles the return of the national retrofit program in New Zealand.[6])	
51	Lidell C, Morris C,	To determine	Model-based	+	+	The findings	Kirklees, West Yorkshire; all	Interventions (energy	Health outcomes: mental well-being	Mental health benefits Used	Taking into account the difference between the cost of	The cost-benefit

	Legdon S (2011) Kirklees Warm Zone. The project and its impact on well-being. University of Ulster, Northern Ireland.[51]	the cost-benefits of the Kirklees Warm Zone project (a £24 million three year project started in 2007)	analysis; conducted from the public perspective. The costs of the interventions were compared to the monetised health benefits of the interventions.			and results are widely applicable to England.	households were eligible to housing interventions regardless of whether they were fuel-poor. Interventions were phased starting with most deprived wards but a special protocol was applied for vulnerable households (e.g. those with poor health, aged 60-70 years with an income less than £20,000, those eligible for Warm Front)	efficiency and home safety measures): 42,999 households (HHs) had loft insulation; 21,473 HHs cavity wall insulations; 5,838 HHs fire safety checks; 9, 896 smoke alarms in 5,838; 129,986 CO monitors; 602 HHs central heating via local funding; 407 central heating via Warm Front. Controls: same households pre-intervention.	(common mental disorder, depression, anxiety); physical health (injuries, deaths)	statistical significant odds ratio from epidemiological studies associating self-reported housing condition with self-reported mental well-being outcome: mould (CMD); damp and mould (depression in mothers of young children); cold indoors (CMD); cut down on fuel (CMD); inadequate heating (repeat truancy among children). Used also statistically significant odds ratios from retrofit studies associating housing condition with mental well-being: pre-insulation (low happiness score, moderate to high stress); pre- central heating (moderate to high stress); pre-central heating & insulation (poor mental well-being); draughty (anxiety and depression, low mental well-being score, moderate to	intervention and the monetised health benefits, the net estimated savings were as follows: loft insulation £1,141,500; cavity wall insulation £1,140,000; home safety measures £1,300,500; central heating via local funding £758,520; central heating via Warm Front £512,820; total estimated savings: £4,853,340	assessment had many assumptions but no sensitivity or uncertainty analyses were carried out. It was not clear what the time horizon of the analysis was. Risk of double counting particularly in the mental health impacts.

										high stress); condensation (anxiety and depression, moderate to high stress); lowest thermal comfort-self reported (anxiety and depression, low well-being score, moderate to high stress); very/fairly dissatisfied with heating (anxiety and depression, moderate to high stress); very/fairly finding difficult to pay fuel fuels (anxiety and depression, low mental well-being score, moderate to high stress) <u>Physical health benefits</u> These are divided into two parts: (i) physical health associated with combined heating & insulation only using the Northern Ireland Cost Benefit Analysis (NICBA) model, and (ii) benefits associated benefits associated with the three		

										home safety measures (smoke detectors, fire hazard checks and CO monitors) Monetisation For interventions which affect both physical and mental health, the NICBA model (which uses the HHSRS system of estimating impacts of housing interventions) outputs health benefits in QALYs which are monetised using a value of £ 30,000 per QALY gained (for interventions which affect mental health only, a 5 year life span is assumed for mental health impacts). For health benefits associated with home safety interventions, value of statistical life (VSL) approach is used for monetisation.		
47	Grimes A, Denne T, Howden-Chapman P,	To carry out cost-benefit analysis of	A societal perspective was taken and a	+	+	The analysis was specific	Cost-benefit analysis was undertaken of the Warm Up	The intervention population were the eligible	Benefits and costs were estimated. The benefits included: reduction in energy use, saving in	All the benefits were monetised. The cost-benefit analysis was carried	The present value of the net benefit (total benefit – total cost) of the Warm Up New Zealand Hear Smart	The economic modelling has many

	Arnold R, Telfar-Barnard L, Preval N, Young C (2011) Cost-benefit analysis of the Warm Up New Zealand: Heat Smart Programme. Housing and Health Research Programme, University of Otago Wellington, and Department of mathematics, Victoria University of Wellington; prepared for Ministry of Economic Development, New Zealand.[47]	the *Warm Up New Zealand Heat Smart Programme*	comprehensive cost-benefit analysis was performed.			to New Zealand but the findings are applicable to England if a similar programme is undertaken.	New Zealand Hear Smart Programme. In this programme subsidies are provided towards the costs of retrofitting insulation and/or installing central heating in pre-2000 dwellings. The level of subsidy depends on whether the householders hold Community Service Cards. The total number of houses where insulation retrofits were applied, were 51,663 (2009/2010) 49,096 (2010/2011) and is projected to a cumulative total of 178,259 by 2013. The counterpart figures for clean heating installations were: 12,658 (2009/2010), 11,327 (2010/2011) and projected to	households who had the interventions under the programme. The control population did not get the interventions and were matched to the intervention population was by location, dwelling type, number of levels, age of dwelling, floor area, number of bedrooms, whether the house contained a garage, house construction material (walls and roof), whether or not the house was modernised, and building and roof condition).	CO2 emissions (not included in the fuel price), improvement in health outcomes, producer surpluses (difference between the price and cost of supply of the housing interventions). The costs included: administrative costs of the programme, costs of raising revenue for the subsidies and the costs of the interventions. The health benefits were measured in terms of changes in hospitalisation episodes (circulatory illness & respiratory illness), medication use and mortality. Other health-related information (GP visits, sick days or days off school) were estimated.	out over a time horizon of 10 years for clean heat system installations and 30 years for insulation. A baseline discount rate of 4% was used (and 2.5% and 8% were used as sensitivity analysis).	Programme is $NZ million 1,214 for d =4% ($NZ million 1,557 for d=2.5%, and $NZ million 660 for d=8%). Most of the benefits were associated with healthcare savings ($NZ 1,561 million, d=4%) compared to energy savings ($NZ 19 million, d=4%). The highest cost is that associated with installations ($NZ million 197 for insulation & $NZ million 97 for heating system, d=4%); admin costs were $NZ million 23 (d=4%) and "deadweight cost of tax" were $NZ million 49.	assumptions. The sensitivity analysis was limited to discount rate and assumptions on "additionality" (additionality refers to the proportion of installations that would have occurred without the programme).

							cumulative total of 60,635 in 2012/2013.					
49	Preval N, Chapman R, Pierse N, Howden-Chapman P. Evaluating Energy, Health and Carbon Co-Benefits from Improved Domestic Space Heating: A Randomised Community Trial. Energy Policy 2010; 38(8): 3965-72.[49]	To carry out a cost-benefit analysis of improved domestic space heating in New Zealand	Societal perspective ; a model-based cost-benefit analysis to calculate the health benefits, energy savings and emission reductions from installing healthy heaters and comparing them with the cost of purchasing and installing the heaters	+	+	The findings of the study are applicable to England .	Economic analysis of a community trial conducted in New Zealand. The trial involved 409 households. Key characteristics for inclusion of a household in trial: (i) current use of unflued gas heater or a plug-in electric heater the main source of heating (ii) include of a child (age 7-12) with doctor-diagnosed asthma in the last 12 months	Analysis based on data from a trial conducted over two winters in which 200 households received the intervention (heat pump, pellet burner of flued gas heater) in the first winter (intervention group) and 209 households (control at baseline) received the intervention in the second winter	Health-related data: days of school (records & self-reported); days off work due to illness; visits to GP, nurse, after hours clinic, A&E, hospital, specialist for chest-related concerns (adults & children - data questionnaires); medications: course of non-inhaled steroids, chest-related course of antibiotics (all children); puffs of asthma reliever, asthma preventer (children with asthma – daily diary records); caregiver savings Energy data: electricity company records and self-reported energy use questionnaires. Emissions data: changes in CO2 emissions (estimated reductions in external NOx andPM10 were noted but not analysed) ;	The cost-benefit analysis uses a 12 year-time horizon (lifetime of heaters). Two scenarios are simulated: A (targeted approach) and B (untargeted approach). Scenario A assumes that the average intervention household has a high proportion of asthmatic individuals (1.44 children with asthma, 0.54 children without asthma, 0.72 adults with asthma and 1.23 adults without asthma). Scenario B assumes that the average intervention household has the average NZ asthma rates (0.30 children with asthma, 1.69 children without asthma, 0.29 adults with asthma and 1.66 adults without asthma). All benefits were	The benefit to cost ratio for scenario A (assuming high asthma rates) was 0.34:1 (assuming health related benefits only), 0.99:1 (assuming health related benefits and caregiver savings only) and 1.09:1 (assuming health related benefits, caregiver savings and total energy-related savings); for scenario B, the counterpart benefit to cost ratios were 0.07:1 (health-related benefits only), 0.22:1 (health-related benefits and caregiver savings only) and 0.31:1 (health related benefits caregiver savings and total energy-related savings). Scenario A (targeted approach) breaks even (1:09:1)	The cost-benefit model has many assumptions e.g. householders do not age over the time horizon of analysis or are replaced by householders of the same characteristics. Some sensitivity analysis was carried out. As the authors pointed there are various uncertainties: caregiver savings (looking after ill householders, value of CO2 saving, time horizon of

										monetised (health-related, energy and emissions) were monetised and all the interventions were costed (purchase and installation). Total benefit to cost ration were calculated. The analysis assumes a baseline discount rate of 5% and used 10% as sensitivity analysis		analysis). No uncertainty bounds were presented with the benefit to cost-ratios.
56	Chapman R, Howden-Chapman P, Viggers H, O'Dea D, Kennedy M. Retrofitting houses with insulation: a cost-benefit analysis of a randomised community trial. J Epidemiol Community Health. 2009; **63**(4): 271-7.[56]	To value the health, energy and environmental benefits of retrofitting insulation, through assessing a number of forms of possible benefit	Cost-benefit <u>Perspective:</u> cost savings to the household	+	+		Economic analysis applied to results of a cluster randomised trial--the "Housing, Insulation and Health Study"--of retrofitting insulation in 1350 houses, in which at least one person had symptoms of respiratory disease, in seven predominantly low-income communities in New Zealand.	Housing retro-fit insulation measures RCT of 1350 households (4407 people)	- Visits to GPs - Hospitali-zations - Days off school - Days off work - Energy use - CO_2 savings	30-year time horizon Two discount rates assumed (5%, 7%) for alternative calculations	*Economic value of total benefits (cost savings, NZ$*) over 30-year horizon* At annual discount rate of 5% 7% Changed GP visits 165 133 ↓ hosp adm 2231 1801 ↓ days off schl 242 196 ↓ days off work 179 145 ↓energy use 786 635 ↓ CO_2 emissions† 100 81 TOTAL 3374 2857 *NZ$1 = £0.29 or US$0.42 at 2 Jan 2002 †Valued at NZ$30/tonne	

											The overall cost of retrofitting per household in 2001 was NZ$1800 (excluding value added tax) Thus, total benefits in "present value" (discounted) terms are one and a half to two times the magnitude of the cost of retrofitting insulation. Conclusion: "From an environmental, energy and health perspective, the value for money of improving housing quality by retrofitting insulation is compelling."	
19	Barton A, Basham M, Foy C, Buckingham K, Somerville M, Torbay Healthy Housing G. The Watcombe Housing Study: the short term effect of improving housing conditions on the health of residents. J Epidemiol	To assess the short-term health impacts of home energy efficiency (HEE) interventions	Cost-effectiveness analysis	+/-	+/-	The study is generalizable to other parts of England.	England: Watcombe Housing Study, Torquay, Devon. 119 Properties (480 residents) in an estate of former council owned properties).	Energy efficiency interventions randomised to waiting lists; 50 properties selected for home energy efficiency (HEE) improvements in the first year (intervention) and the remaining properties (control) for the second year. HEE improvements included standard measures such as re-roofing,	Health: general health questionnaires (SF36 & GHQ12), condition-specific questionnaires (respiratory, musculoskeletal), health services contacts (primary care, A&E, hospital admissions); Non-health (for children): times lost from school; Costs: HEE costs; health service contacts	Health service costs were estimated from health service contact data and HEE costs were obtained from Council records; cost-effectiveness analysis was carried out where only the benefits in terms of SF36 were analysed	Interventions improved energy efficiency. There were no significant differences between intervention and control arms in the annual intervention net energy saving costs, health service contact costs, SF36 or GHQ12 scores. The CEA of incremental benefits in terms of SF36 scores showed that it was not possible to establish that HEE improvements are cost-effective. However there were significant benefits in terms respiratory symptoms (p=0.005 for non asthma related problems and p=0.007 for asthma symptoms)	As the authors pointed out, although residents reported improvements in well-being (via structured interviews) this was not reflected in health outcomes possibly because health benefits could time to accrue.

	Community Health 2007; 61(9): 771-7.[19]							full central heating, ventilation systems, double glazed doors, cavity wall, roof insulation and re-wiring)				
57	Levy JI, Nishioka Y, Spengler JD. The public health benefits of insulation retrofits in existing housing in the United States. Environ Health. 2003; **2**(1): 4.[57]	To estimate the health benefits associated with marginal energy usage reductions from housing retro-fit insulation	Development and application of risk-based model to estimate the health benefits associated with marginal energy usage reductions from housing insulation retrofit	+/-	+/-	The approach and findings are applicable to the UK	Hypothetical case study of insulation retrofits in single-family homes in the United States.	Model based. The simulated households with insulation retrofitted are the intervention and the comparator are the same simulated households pre-intervention	- Energy use savings - Air pollution-related emissions reductions and associated mortality/morbidity impacts (Health impacts of air pollution calculated using US EPA (1999) methods: -- US EPA. The Benefits and Costs of the Clean Air Act: 1990 to 2010 Washington, DC, Office of Air and Radiation 1999, -- US EPA Regulatory Impact Analysis - Control of Air Pollution from New Motor Vehicles: Tier 2 Motor Vehicle Emissions Standards and Gasoline Sulfur Control Requirements Washington, DC, Office of Air and Radiation 1999)	50 year time horizon. 5% discount rate.	<u>Cost</u> Total estimated cost of the increased insulation: US$37 billion (<US$800 per existing single-family home available for retrofits). <u>Energy savings and related costs</u> Annual economic benefits associated with the energy savings: approx..US$5.9 billion per year, indicating a payback period of slightly over 6 years (assuming no change in the real price of fuel). With a real discount rate of 5%, the net present value of the economic savings (conservatively assuming a 50-year lifetime for all homes) is approx..US$110 billion, implying a net economic savings (including the cost of insulation) on the order of US$80 billion. <u>Monetized health impact (air pollution-related mortality/morbidity)</u>	<u>Reviewer noted limitations</u> (i) Only considers energy savings costs and health benefits associated with reduction in emissions of outdoor air pollutants (ii) Depends on US value of a statistical life and assumed fuel costs

											When economic values are assigned to the mortality and morbidity outcomes, the environmental externalities averted are approx. US$1.3 billion per year, 99% of which is related to premature mortality. Adding the assumed value of a statistical life to the economic savings for the households would reduce the payback period from over 6 years to approximately 5 years, although this involves combining private and public benefits, has a simple characterization of the time lag of benefits, and does not include the upstream emissions from insulation manufacturing or fuel extraction and processing.	
44	Sefton T (2002) Targeting fuel poverty in England: is the Government getting warm? Fiscal Studies 23 (3), 369-399.[44]	To examine the cost-effectiveness of the Home Energy Efficiency Scheme (HEES) introduced by the UK Government in 2001 and	The economic analysis is addressing four specific questions: (i) what is the impact of HEES on fuel poverty? (ii) what is the impact of HEES on fuel poverty	+	+	The analysis is applicable because it is UK-based	The setting is the UK and the population are low income householders. Low income householders and householders with disability are eligible to HEES grants up to £1,000 for energy efficiency measures including	The setting is the UK and the population are low income householders. Low income householders and householders with disability are eligible to HEES grants up to £1,000 for energy efficiency measures including	The key outcome measures are: (i) the fuel poverty gap (which is defined as the difference between what households can afford to spend - assumed to be 10% of the annual income - and what they need to spend to heat their homes satisfactory), (ii) number of eligible households to the grant scheme, (iii) number of HEES grants given, (iv)	Two energy efficiency measures are simulated: Package 1 (basic insulation) and Package 2 (basic insulation + central heating system). Three scenarios are simulated: "Current HEES" (Package 1 allocated randomly to households that meet original HEES criteria and Package 2 only to old age	The summary of the key results are: percentage reduction in fuel poverty gap (Current HEES 4%, Optimal HEES 33%, Realistic HEES 10%-14%), proportion of grant recipients who are not fuel poor (Current HEES 78%, Optimal HEES 0%, Realistic HEES 44% - 53%), average annual cost of improvement (Current HEES £76, Optimal HEES £118, Realistic HEES: £162-£169), average reduction in required heating costs per annum (Current HEES £97, Optimal	The health impacts of the different scenarios were not quantified.

		whether it can be improved by targeting	if the scheme is targeted? (iii) could the scheme be re-designed to make it more cost-effective? (iv) what is the impact of "fuel poverty dynamics" (e.g. variation over time of householders circumstances and/or house moves)				insulation and fixed heaters. Low-income older householders are eligible to HEES+ grants which go up to £2,000 which can include in addition central heating systems.	insulation and fixed heaters. Low-income older householders are eligible to HEES+ grants which go up to £2,000 which can include in addition central heating systems. The effectiveness of HEES is simulated in comparison to the absence of the scheme. Hypothetical variations on HEES eligibility are considered.	proportion of grant recipients who are not fuel poor, (v) SAP rating, (vi) average annual cost of improvement, (vii) average reduction in required heating cost, cost-effectiveness ratio	householders), "Optimal HEES" (Only fuel poor households are eligible to get the HEES grant and the package that is most cost-effective is allocated, "Realistic HEES"(the nearest pragmatic scheme to "Optimal HEES", two sub-scenarios are considered relating to the strictness of the eligibility criteria).	HEES £328, Realistic HEES £252-£332), cost-effectiveness ratio (Current HEES 1.28, Optimal HEES 2.78, Realistic HEES 1.56-1.96). The main message is that the current HEES is unlikely to have a significant effect on fuel poverty and that targeting HEES is most cost-effective though acknowledging the complications of targeting because they require more information on householders. . Considering the dynamics of fuel poverty (i.e. households moving in and out of fuel poverty) strengthens the case further for targeting.	
48	Clinch JP, Healy JD. Cost-benefit analysis of domestic energy efficiency. Energy Policy. 2000; **29**(2): 113-24.[48] UCD Environmental Studies Research Series WP	An *ex-ante* evaluation of Ireland's programme to improve the thermal efficiency of its housing stock to the 1997	A social perspective is taken for the economics analysis	+	+	The approach and conclusions are applicable to England	Analysis of a national programme of energy efficiency to bring the Irish housing building stock up to the 1997 standards over a 10 year period; involves retrofitting of 1.2 million dwellings prior to before 1997	The interventions are measures required to bring the pre-1997 stock to the 1997 standard, which include: fitting lagging jacket, roof insulation and roof upgrade, draught-stripping, cavity wall insulation,	Cost - Energy use - CO2 (GHG) emissions - CO2 - SO2 - NOx - PM10 Mortality Morbidity Comfort Net Social Benefit	All benefits were monetised. Mortality benefits were valued using the Value of Statistical Life (VSL) approach. Morbidity benefits were valued in terms of costs saving associated with hospitalisation averted and reduction in medication use.	*Costs, benefits and net social benefits under 'predicted' scenario (EuroM)* Discount rate (%) 0 3 5 8 10 Costs -2066 -1766 -1601 -1395 -1280 Energy 6521 3775 2712 1731 1319 CO_2 452 263 189 121 93 SO_2 36 20 15 9 8	Author identified limitations (1) assumptions necessary about behaviour – e.g. comfort and savings on bills (2) Future energy prices (3)

	ESRS 00/02[58]	Irish building regulations over a ten year period						central heating, heating controls upgrade and double glazing.		Reductions in energy use were mapped to fuel bill savings. Environmental benefits were valued in terms of reduction in emissions (CO2,SO2 and NOx)multiplied by monetary values for unit reduction in the emissions. Comfort was monetised by valuing the proportion of energy savings foregone (the proportion of the maximum potential energy savings not realised). Different discount rates were used as a sensitivity analysis (0%, 3%, 5%, 8% and 10%)	NO_x 17 10 8 5 4 PM_{10} 438 255 184 118 91 Mortality 1494 1238 1100 929 Morbidity 110 75 58 42 34 Comfort 728 549 461 361 309 Net soc benefit 773 4417 3124 1920 1412	Uncertainty in health impacts (4) Comfort benefits are particularly challenging because of assumptions about extent to which households choose to forego energy savings.

Appendix 6: Example criteria for assessing study quality

Quantitative interventions studies

- Study: authors, year
- Aim of study
- Study design
- Population and setting Source population, country (developed/non-developed), setting (e.g. primary care, school, etc), location (urban/rural), sample characteristics (age, sex, etc), eligible population (describe how individuals etc were recruited), state if the eligible population is representative of the source population, selected population (inclusion criteria etc), what % of eligible agreed to participate, potential sources of bias, excluded populations

- Methods of allocation to intervention/control How selected individuals/clusters were allocated to intervention or control; how confounding minimized, and the intervention (what was delivered, where, how, by whom, to whom, etc); control/comparisons description (as above
- Outcomes sample sizes at baseline; statistical power; details of all relevant outcomes and whether measures are objective or subjective or otherwise validated; follow-up periods
- Methods of analysis if intention-to-treat or completer analysis used, or if adjustments made for any baseline differences in important confounders;
- Results for all relevant outcomes, with CIs etc. Note any results that impact on inequalities.
- Limitations identified by authors, limitations identified by review team, evidence gaps and/or recommendations for future research, source of funding (e.g. Government (NHS), voluntary/charity, pharmaceutical company, role of funding organizations)

Qualitative studies

- Study: authors, year. Citation
- Research parameters Research questions. Theoretical approach (e.g. grounded in theory, IPA) taken (if specified). State how data were collected: what method, by whom, what settings, when
- Population and sample selection The population the sample were recruited from; how they were recruited. Report how many participants were recruited; specific inclusion criteria; state specific exclusion criteria.
- Outcomes and methods of analysis -- Description of method and processes of analysis. Key themes relevant to this review (with illustrative quotations if available) Limitations identified by the authors. Limitations identified by the review team.
- Limitations identified by review team Evidence gaps and/or recommendations for future research. Sources of funding -- e.g. government (NHS), voluntary/charity, pharmaceutical company, and the role of funding organizations.

Economic analyses

Example for CBA studies

- Is there a well-defined question?
- Is there a comprehensive description of alternatives?
- Was one of the alternatives designated as the comparator against which the intervention was evaluated?
- Is the perspective stated? (Is WTP the public-sector WTP or the aggregated individual WTP? Has the WTP been recalibrated when the basis for its calculation has not coincided with the perspective being used?)
- Are all important and relevant costs and outcomes for each alternative identified? (Check to see if the study is of money-costs and 'benefits' which are savings of future money-costs.)

- Has effectiveness been established?
- Are costs and outcomes measured accurately?
- Are costs and outcomes valued credibly?
- Have all important and relevant costs and outcomes for each alternative been quantified in money terms? (If not, state which items were not quantified, and the likely extent of their importance in terms
- of influencing the benefit: cost ratio.)"
- Are costs and outcomes adjusted for differential timing?
- Has at least one of Net Present Value, B:C ratio and payback period been estimated?
- Were any assumptions of materiality made?
- Were all assumptions reasonable in the circumstances in which they were made, and were they justified?
- Were sensitivity analyses conducted to investigate uncertainty in estimates of cost or benefits?
- How far do study results include all issues of concern to users?
- Are the results generalisable to the setting of interest in the review? (Country differences. Question of interest differs from the CBA question being reviewed.)
- Have equity considerations been addressed in any way?