EVIDENCE REVIEW & ECONOMIC ANALYSIS OF EXCESS WINTER DEATHS

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

Review 1

Factors determining vulnerability to winter- and cold-related mortality/morbidity

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Glossary

Excess winter death (EWD)	By convention established by Curwen for the UK,[1] the deaths per day in the four coldest 'winter' months (December, January, February, March for the northern hemisphere), minus the deaths per day over other, 'non-winter' months, all divided by the average deaths per day over the non-winter months $$\frac{\frac{\sum_{deaths}[Dec, Jan, Feb, Mar]}{120} - \frac{\sum_{deaths}[Aug, Sep, Oct, Nov, Apr, May, Jun, Jul]}{245}}{\frac{\sum_{deaths}[Aug, Sep, Oct, Nov, Apr, May, Jun, Jul]}{245}}$$
Fuel poverty	The traditional definition of fuel poverty was said to apply if a household needs to spend more than 10% of its income on fuel to maintain a satisfactory heating regime (usually 21 degrees for the main living area, and 18 degrees for other occupied rooms). However, the UK government has recently set out a new definition which it intends to adopt under the Low Income High Costs (LIHC) framework.[2] Under the new definition, a household is said to be in fuel poverty if: • Its required fuel costs are above the national median level • At that level of expenditure the household would be left with a residual income below the official poverty line
Lag (time series studies)	The lag in time series studies refers to the time lag (delay), usually measured in days, between exposure and health effect. This refelects the fact that, for example, cold outdoor temperature today may not only affect mortality today (lag 0) but also tomorrow (lag 1 day), the day after that (lag 2 days) and so forth. Typically, cold effects on health are observed for periods of two weeks or more following the day of cold.
Socio-economic group	The group to which an individual belongs by virtue of his or her social and economic position — usually classified on the basis of occupation. Groups are typically defined to reflect a broad ranking of income and 'social status': e.g. professional groups; managers; non-manual workers; skilled manual workers; semi-skilled workers; and unskilled workers.
Standard Assessment Procedure (SAP) rating	An index (measured on a logarithmic scale) that reflects the cost of heating unit floor area under a standard heating regime.[3] The scale goes from 1 (highly inefficient) to 100 (highly efficient). The index depends on the rate of heat loss from the dwelling, determined by building fabric, degree of insulation, ventilation, and the cost of supplying heat, determined by heating efficiency, fuel price, and solar gain. It is not affected by characteristics of the household occupying the dwelling (e.g. household size, heating patterns, temperatures).
Time-series study	In the context used in this report, a time series study is one which examines the relationship between the occurrence (count) of health events, such as deaths, hospital admissions or emergency room attendance, usually measured at daily level, and variation in environmental factors measured as similar temporal resolution.[4] Time-series studies commonly entail analysis of several years of daily health event data which are approximately Poisson distributed, overdispersed (i.e. where variance is greater than the mean), and positively autocorrelated. Analyses of such data in relation to outdoor temperature provide the usual

	basis for attribution of deaths to heat and cold. The (time-varying) confounding factors for such analyses include season, long term trends, outdoor air pollution and periods of influenza. Population characteristics such as age, gender, socio-economic status are best thought of as potential effect-modifiers and not as confounders.

Abbreviations

A&E	Accident and emergency
AF	Atrial fibrillation
BMI	Body Mass Index
CI	Confidence interval (95%)
CMD	Common mental disorder
COPD	Chronic obstructive pulmonary disease
COLD	Chronic obstructive lung disease
CVD	Cardiovascular disease
DJF	December, January, February (UK/northern hemisphere temperate region 'winter')
DJFM	December, January, February, March: EWD months of winter
ED	Enumeration district
EHS	English Housing Survey
EHCS	English House Condition Survey
EWD	Excess winter death
F	Female
FEV_1	Forced expiratory volume in 1 second (lung function)
GHQ	General Health Questionnaire
JJA	June, July, August (UK/northern hemisphere temperate region 'summer')
HSE	Health Survey for England
ICD	International Classification of Diseases ('ICD-9': 9th revision, 'ICD-10': 10th revision)
M	Male
MAM	March, April, May (UK/northern hemisphere temperate region 'spring')
MTS	Mental test score
OR	Odds ratio
PEFR	Peak exploratory flow rate
PM	Particulate matter (air pollutant)
PICH	Primary intra-cerebral haemorrhage
QoL	Quality of Life
RH	Relative humidity
Rn	Radon
RR	Relative risk
SAP	Standard Assessment Procedure
SON	September, October, November (UK/northern hemisphere temperature region 'autumn')
Tmax	Maximum daily temperature
Tmin	Minimum daily temperature
VOC	Volatile organic compound
w.r.t.	with respect to
YLD	Years Lived with Disability
YLL	Years of life lost

Contents

Executive summary

Background England has a large winter excess of mortality and morbidity which is generally viewed as indicating avoidable vulnerability to the effects of cold weather and other winter-related phenomena. However evidence remains limited on the determinants of vulnerability particularly in relation to socio-economic factors including fuel poverty, and the role of thermally inefficient housing. This review was undertaken to identify populations vulnerable to the consequences of cold temperatures and poorly heated or expensive to heat homes, and to identify the factors that contribute to vulnerability and how these factors interact.

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. Quantitative observational studies from OECD countries, excluding intervention studies, 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 One hundred and thirty nine studies were selected for inclusion. They were heterogeneous in terms of study design, setting and quality of evidence. They were scrutinised for evidence relating to a range of personal and other potential vulnerability factors for seasonal- and cold-related mortality/morbidity. The seasonal fluctuation in mortality/morbidity and the strength of association with low outdoor temperature appears to be greater in England than it is in Scandinavia and selected countries of northern continental Europe. Correlation studies suggest that the seasonal and cold-related excess of mortality/morbidity is lower in settings that have greater protection against low outdoor temperatures because of better thermal efficiency standards of housing and the thermal quality of clothing worn by the population. A number of personal vulnerability factors were identified including age. Women appear to have slightly greater risk than men. There was insufficient evidence to draw conclusions about the effect of ethnicity. Rural populations appear to have no greater risk than urban populations. A wide range of disease outcomes show evidence of seasonal variation and to have a relationship with low outdoor temperatures, but the evidence is strongest for cardiorespiratory outcomes. The risk of slips and falls also shows some degree of seasonal fluctuation, but with more modest increases in risk in the elderly population than in working age groups during periods of cold or inclement weather. The available evidence suggests a generally flat or weak relationship between socio-economic status and risk of winter/cold-related mortality/morbidity. There is limited direct and indirect evidence to suggest that the thermal efficiency of housing and fuel poverty are important determinants of vulnerability.

Conclusions The review identified a number of factors that appear to contribute to vulnerability to seasonal- and cold-related mortality/morbidity, which can help in the development of health protection strategies. The relative flatness of the relationship with socio-economic factors, the importance of age, and the wide range of health outcomes affected, suggest that the risk of winter- and cold-related mortality/morbidity is fairly widely distributed, especially in the elderly population, which has bearing on the targeting of interventions. The evidence of this review needs to be interpreted alongside the evidence of subsequent reviews which includes evidence on interventions.

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, with additional input from Payel Das and Ben Armstrong. 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 by Paul Wilkinson as well as by at least one other member of the review team, and assessment scores agreed where necessary.

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

1 Introduction

1.1 Context

This is the first part of the 2013/14 review for NICE on excess winter death and morbidity. Its focus is on vulnerability to excess winter deaths and morbidity and the health risks associated with cold weather and cold homes. The review examines the current state of the evidence, focusing on quantitative epidemiologic studies.

England has a large seasonal fluctuation in mortality and morbidity, with rates highest during the winter months. Much of this winter excess of mortality/morbidity appears to be related to the effects of exposure to low ambient temperatures, which have been shown in the scientific literature to be associated with a range of adverse health outcomes.[5 6] There are local and national initiatives aimed at reducing this burden including through actions targeted at vulnerable population groups and through strategies aimed at reducing fuel poverty and housing-related risks.

The contribution of potential vulnerability factors to excess winter- and cold-related mortality/morbidity continue to be debated. Much attention has been drawn to the issue of fuel poverty,[7] which was subject to the 2012 'Hills review' *Getting the measure of fuel poverty*.[8] Cold homes and fuel poverty were also the focus of a 2011 report by the Marmot Review Team, which set out the case for action on housing to help alleviate the burdens of winter and cold-related illness and mortality. Action to improve energy efficiency in the housing sector is also an objective to meet climate change mitigation targets.

However, the evidence about many potential determinants remains inconclusive. Although there is strengthening evidence about a range of housing and behavioural factors, the importance of socio-economic status has been unclear, for example.[9 10]

1.2 Aim

To identify at risk populations vulnerable to the consequences of cold temperatures and poorly heated or expensive to heat homes.

1.3 Research questions

The review represents an analysis of epidemiological data which highlights i) the intrinsic and extrinsic characteristics of populations at risk of excess winter deaths and related health consequences and ii), how these characteristics interact with each other.

<u>Specific questions</u>

- Which subpopulations are more vulnerable to cold temperatures and poorly heated or expensive-to-heat homes?

- What factors contribute to vulnerability and how do these factors interact with each other?

We interpreted these questions as needing to identify and quantify the contribution of factors that explain variations in seasonal and/or specific cold-related health burdens, including those of snow and ice, with respect to person, time or place. This included specific interest in the potential variations by (modifying effects of) time-period, age, sex, gender, ethnicity, illness, socio-economic deprivation/fuel poverty, and housing quality.

2 Methods

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 literature search involved searching a wide range of databases in October 2013 and grey literature resources. The search strategies were developed using a combination of subject indexing and free text search terms. Search terms were identified through discussion between the research team, by scanning background literature and 'key articles' already known to the research team, and by browsing database thesauri. 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)

Inclusion/exclusion criteria for review

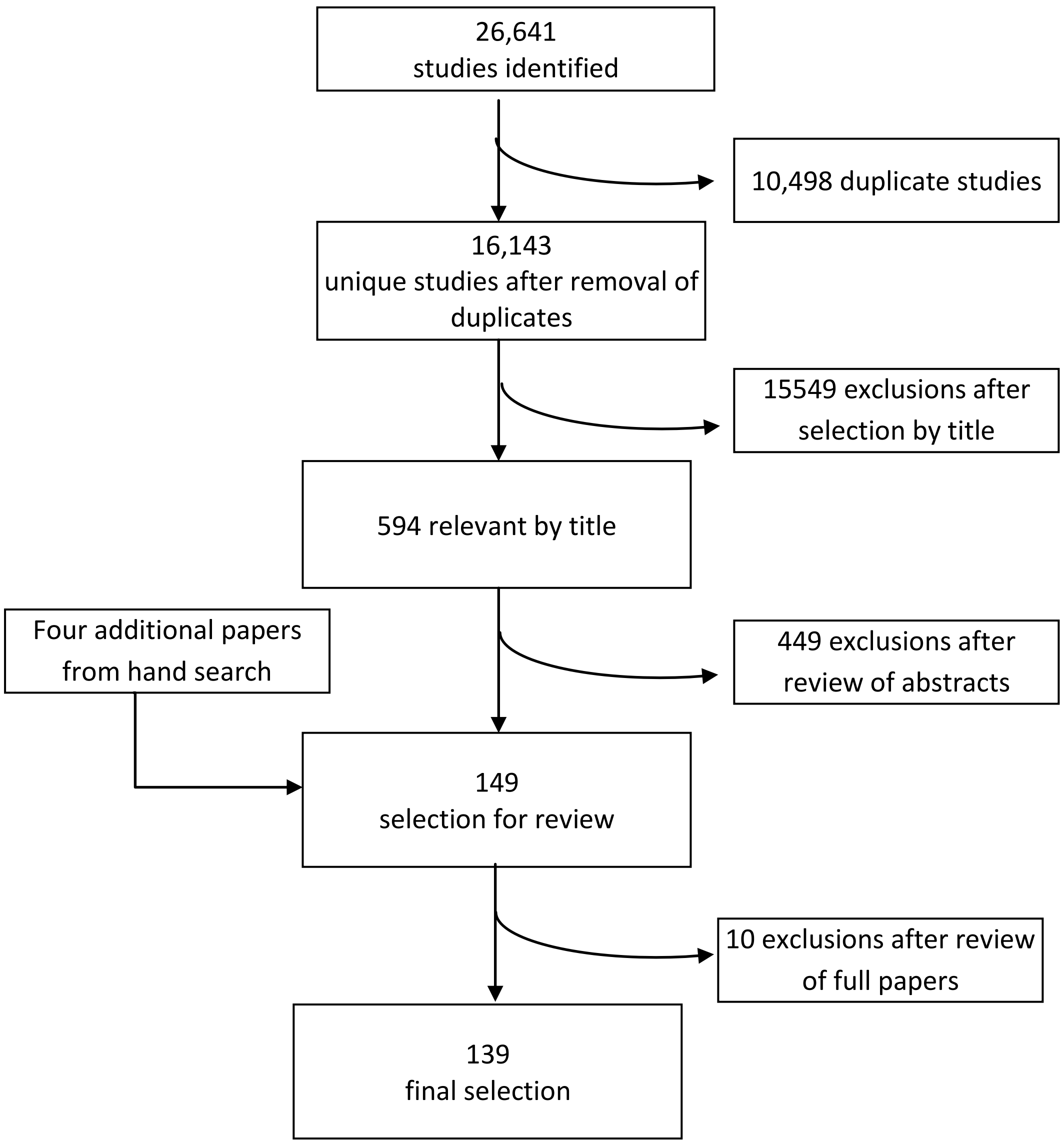
Inclusion

- Quantitative primary research papers reporting evidence on factors relating to vulnerability to winter or 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 seasonal variation in health or cold-related impacts without additional reference to vulnerability factors
- Intervention studies (evidence of interventions studies will be reported in subsequent reviews)
- Qualitative studies (qualitative evidence relating to interventions will be reported in subsequent reviews)
- Studies of seasonal influenza (except with respect to its contribution to excess winter death)
- Studies published as conference abstracts only (without fuller paper or extended abstract)

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 quantitative observational studies and qualitative studies 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. There was generally good agreement between reviewers.

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 or calculation of confidence intervals. Key statistics were reproduced in the most appropriate form to represent the original data.

Criteria for applicability.

Studies were included if they contained data relevant to <u>*effect modification* of any seasonal or cold-related exposure-response function or of risk falls/injuries on snow or ice</u> – i.e. they include at least two sets of risk functions for different groups/characteristics. There was no restriction in terms of health outcome or study design (except for the exclusion of intervention and qualitative study designs.)

Studies which reported seasonal fluctuations or temperature-response functions without evidence relevant to effect modification (e.g. no subgroups by age or results classified by an ecological socio-economic parameter etc) were not included. Nor were studies included that reported data on physiological parameters only. There are many such papers, and a very restrictive definition was applied to achieve a clearer focus and keep the overall number of papers manageable.

We selected papers from countries in the Organization of Economic Cooperation and Development, but also including Taiwan as a high income country. In addition, we did not include evidence derived from intervention studies, including from 'natural experiments,' which is separately considered in subsequent reviews.

Methods of synthesis and data presentation.

The selected literature is extremely heterogeneous and unsuitable for summary using formal meta-analytical methods. Instead, we summarize the studies using narrative summary. In addition the direction of associations for a range of potential vulnerabilities are summarized in Table 1 using a set of headings that indicate different potential vulnerability factors, including personal factors (age, sex, ethnicity), different disease outcomes, socio-demographic factors (urban/rural, deprivation) and factors relating to housing and fuel poverty. In this table the arrows indicate the direction of effect for each particular risk factor. For example, under the 'age' heading, an 'up-arrow' (↑) indicates increasing winter-/cold-related risk at older age, a 'down-arrow' (↓) decreasing risk at older age and a double headed horizontal arrow (↔) evidence of no appreciable change in risk with age. Where an arrow is enclosed in brackets, it signifies mixed evidence or a statistically insignificant result or one that is suggestive only.

3 Findings

Many studies contribute evidence relevant to a number of potential vulnerability factors and the following text considers different factors in turn. In cases where there are multiple studies relevant to the particular factor, the most important and relevant will be briefly described, and the other studies listed with brief commentary on the degree to which they support overall conclusions.

Table 1 below lists all the included studies by year of publication, with the quality ratings and an indication of the evidence they include using arrows to give a broad indication of the main reported associations in each case. Many studies contribute evidence in relation to more than one vulnerability factor. More detailed summaries of these papers are given in Apendix 5.

The evidence is summarized with regard to variations between populations, trends over time, personal vulnerability factors (age, gender, ethnicity), cause-of-death/morbidity, socio-demographic factors, and housing anf fuel poverty.

Table 1. Qualitative summary of evidence. Papers are ordered by year of publication (most recent first) and then alphabetical.
Arrows indicate the direction of effect for each particular risk factor: an 'up-arrow' (↑) indicates increasing winter-/cold-related risk with increasing levels of the explanatory factor, a 'down-arrow' (↓) decreasing risk and a double headed horizontal arrow (↔) evidence of no appreciable change in risk. Where an arrow is enclosed in brackets, it signifies mixed evidence or a statistically insignificant result or one that is suggestive only. For variables without order, a plus sign (+) indicates evidence of variation across groups. Yellow highlighting is to aid readability only and has no interpretational signficance.

Study (ordered by year then authors)	**Ref no.**	**Validty**																							
		Internal	External	Setting	Time trends	Country (region) comparisons	Climate	Age: change in risk with older age	Gender: difference of women vs men	Ethnicity: effect of non-white populations	Rurality: effect in rural vs urban areas	Pre-exisiting disease	Cardiovascular	Stroke	Respiratory	Falls / fractures	Mental illness	Other	Deprivation	Fuel poverty	Housing	Housing tenure: rented (vs OO)	Nursing homes	Other vulnerability factors	Snow-ice
<u>2013</u>																									
Atsumi A et al. *Circ J* 2013; **77(7):**1854-61	11	++	+	JPN				↓					↑	↑				↑							
Callaly E et al. *Euro J Int Med* 2013; **24(6):**546-51	12	+	+	IRE									↑		↑			↑	↔						
de'Donato FK et al. *PLoS One* 2013; **8(4):** e61720.	13	++	+	ITA				(↑)					↑		↑										
de Vries R et al. *J Publ Hlth* 2013; **35(3):** 361-6	14	+	+	ENG																(↑)					
Gomez-Acebo et al. *Publ Hlth* 2013; **127(3):**252-8	15	++	+	ESP				↑	↔				↑	↑				↑							

		Internal	External	Setting	Time trends	Country	Climate	Age	Gender	Ethnicity	Rurality:	Prio r dis	CVD	Stroke	Respiratory	Falls	mental	Other	Depriv	Fuel poverty	Housing	H tenure:	Nursing home	Other factors	Snow-ice
Hajat S et al. Department of Health; 2013	[16]	++	++	ENG				↑	↑				↑		↑	↑		↑	↔						
McAllister et al. *Prim Care Resp J* 2013; **22(3):**296-9	[17]	+	++	SCO											↑				↑						
McGuinn et al. *Int J Biometeorol* 2013; **57(5):** 655-62	[18]	++	+	ENG				↑					↑												
Madrigano J et al. *Epidemiology* 2013; **24(3):** 439-46	[19]	++	+	USA									↑						(↔)						
Modarres R et al. *Int J Biometeorol* 2013;	[20]	++	+	CAN																					
Romero-Ortuno et al. *Ir J Med Sci* 2013; **182:** 513-8	[21]	+	+	IRE														↑							
Tseng CM et al. *PLoS One* 2013; **8(3):** e57066	[22]	+	+	TAI				(↑)							↑										
Webb et al. *JECH* 2013; 67: 280-5	[23]	+	+	ENG											↑						↑	↑			
<u>2012</u>																									
Barnett AG et al. *Environ Res* 2012; **112:**218-24	[24]	++	++	USA									↑		↑										
Hales et al. JECH 2012; **66:**379-84	[25]	+	+	NZ				↑	↔	↔	↓								↑			↑			
Hori et al. *Int J Environ Hlth Res* 2012; **22(5):**416-430	[26]	++	+	ESP																					

		Internal	External	Setting	Time trends	Country	Climate	Age	Gender	Ethnicity	Rurality:	Prio r dis	CVD	Stroke	Respiratory	Falls	mental	Other	Depriv	Fuel poverty	Housing	H tenure:	Nursing home	Other factors	Snow-ice
Miron et al. *Int J Biometeorol* 2012; **56(1):**145-52	27	+	+	ESP	↓														(↓)						
Modarres R et al. *Bone* 2012;**50(4):**909-16	20	+	+	CAN												↑									
Morabito M. *Sci Total Environ* 2012; **441:**28-40	28			ITA				↑																	
Morency P et al. *Can J Publ Hlth* 2012; **103(3):**218-22	29	+	+	CAN												↑									
Office for National Statistics. 2012	30	+	+	E&W	↓	()		↑	↑				↑		↑			↑							
Phu Pin S. *J Am Med Dir Assoc* 2012; **13(3):**309.e1-7	31	+	-	FRA				↑															↑		
Turner LR et al. *BMJ Open* 2012; **2(4)**	32	++	++	AUS									↑		↑										
von Klot S et al. *Environ Health* 2012; **11:**74	33	++	+	USA	()																				
Wichmann J et al. *Environ Health* 2012; **11:**19	34	++	++	DNK				↓	↓				↑						↓						
2011																									
Beynon C et al. *Environ Health* 2011; **10(1):**60	35	+	+	ENG												↑									↑
Gallerani M et al. *Clin Cardiol* 2011; **34(6):**389	36	-	-	ITA				↔	↔				↑												
Morabito M et al. *Stroke* 2011; **42(3):**593-600	37	+	+	ITA				(↑)						↑											

		Internal	External	Setting	Time trends	Country	Climate	Age	Gender	Ethnicity	Rurality:	Prio r dis	CVD	Stroke	Respiratory	Falls	mental	Other	Depriv	Fuel poverty	Housing	H tenure:	Nursing home	Other factors	Snow-ice
Magalhaes R *Cerebrovasc Dis* 2011; **32(6):**542-51	[38]	++	++	POR										↑											
Murray IR et al. *Injury* 2011; **42(7):**687-90	[39]	+	+	SCO												↑									↑
Nielsen J et al. *BMC Infect Dis* 2011; **11:**350	[40]	++	++	DEN																					
Office for National Statistics. 2011	[41]	+	+	E&W	↓	()		↑	↑				↑		↑			↑							
Parsons N et al. *Emerg Med J* 2011; **28(10):**851-5	[42]	+	++	UK												↑									+
Rocklov J et al. *OEM* 2011; **68(7):**531-6	[43]	++	+	SWE									↑		↔										
Turner RM et al. *Osteoporos Intl* 2011; **22(4):**1183-9	[44]	+	+	AUS												↑									
Wu PC et al. *OEM* 2011; **68(7):** 525-30	[45]	+	+	TAW				↑			↑		↑												

		Internal	External	Setting	Time trends	Country	Climate	Age	Gender	Ethnicity	Rurality:	Prio r dis	CVD	Stroke	Respiratory	Falls	mental	Other	Depriv	Fuel poverty	Housing	H tenure:	Nursing home	Other factors	Snow-ice
2010																									
Barnett AG et al. *Environ Res* 2010; **110(6):**604-11	46	++	++	USA																					
Bayentin L et al. *Int J Health Geogr* 2010; **9:**5	47	+	+	CAN									↑						↑						
Bhaskaran K et al. *BMJ* 2010; **341:**c3823	48	++	++	E&W				↑				↑	↑												
Chen VY et al. *Sci Total Environ* 2010; **408(9):**2042-9	49	+	-	TAW							↑		↑						↑						
Gomez-Acebo I et al. *Publ Health* 2010; **124:**398-403	50	+	+	ESP				↔																	
Harris J et al. NatCen/EAGA Charitable Trust; 2010	51	++	++	ENG									↔				↑				↑				
Iniguez et al. *Int J Env Res Publ Hlth* 2010; **7:**3196-10	52	+	+	ESP			↑						↑		↑										
Montero et al. *Sci Total Environ* 2010; **408:**5768-74	53	++	+	ESP																					
Rau R et al. Princeton University 2010	54	+	+	USA															↔						
2009																									
Abrignani MG et al. *Int J Cardiol* 2009; **137(2):**123-9	55	-	-	ITA				↑	↑				↑												

		Internal	External	Setting	Time trends	Country	Climate	Age	Gender	Ethnicity	Rurality:	Prio r dis	CVD	Stroke	Respiratory	Falls	mental	Other	Depriv	Fuel poverty	Housing	H tenure:	Nursing home	Other factors	Snow-ice
Anderson & Bell. *Epidemiology* 2009; **20(2):**205-213	56	++	++	USA			↑			(↑	↔								(↔)						
Bryden C et al. *Respir Med* 2009; **103(4):**558-6	57	+	+	ENG											↑										
Croxford B. Oxford: Routledge, 2009; 142-54	58	+/	+/-	EUR											↑		↑	↑			↑				
Ekamper P et al. *Demogr Res* 2009; **21:**385-425	59	+	+	NRL	↓			↑																	
Fearn V & Carter J. *Health Stat* 2009; **44:**69-79	60	+	+	E&W																					
Kysely J et al. *BMC Public Health* 2009; **9:**19	61	+	+	CZR				↓	(↔)				↑												
Makinen TM et al. *Respir Med* 2009; **103(3):**456-62	62	+	+	FIN											↑										
Tenias JM et al. *Bone* 2009; **45(4):**794-8	63	+	+	ESP												↑									
Yang TC et al. *Sci Total Environ* 2009; **407(10):**3421-4	64	-	-	TAW			↑						↑												
2008																									
Analitis A et al. *AJE* 2008; **168(12):**1397-1408	65	++	+/++	EUR			↑	↑					↑	↑	↑										

		Internal	External	Setting	Time trends	Country	Climate	Age	Gender	Ethnicity	Rurality:	Prio r dis	CVD	Stroke	Respiratory	Falls	mental	Other	Depriv	Fuel poverty	Housing	H tenure:	Nursing home	Other factors	Snow-ice
Barnes M et al. NatCen/EAGA/Shelter , 2008	[66]	+	+	ENG											↑		↑				↑				
Brock A. *Health Stat* 2008; **40:**66-76	[67]	+	+	E&W																					
Jimenez-Conde et al. *Cerebrovsc Dis* 2008; **26:**348-54	[68]	+	+	ESP										↑											
Jordan RE et al. *Br J Gen Pract* 2008; **58(551):**400-2	[69]	++	++	ENG											↑				↔					↑	
Osman LM et al. *Eur J Publ Hlth* 2008; **18:**399-405	[70]	+	+												↑						↑				
Rocklov, Forsberg. *Scand J Publ Hlth* 2008; **36:**516-23	[71]	++	++	SWE				↑					↑		↑										
<u>2007</u>																									
Bischoff-Ferrari et al. *Osteop Intl* 2007; **18:**1225-33	[72]	++	++	USA			↑	↓								↑									
Davie GS, et al. *BMC Public Health* 2007; **7:**263	[73]	+	+	NZ	↔	↔			↑	↔			↑		↑				↔						
Hajat S et al. *OEM* 2007; **64(2):**93-100	[74]	++	++	E&W		+		↑	↔				↑		↑			↑	↑				↑		
Medina-Ramon & Schwartz. *OEM* 2007; **64(12):** 827-33	[75]	++	++	USA			↔						↑												

		Internal	External	Setting	Time trends	Country	Climate	Age	Gender	Ethnicity	Rurality:	Prio r dis	CVD	Stroke	Respiratory	Falls	mental	Other	Depriv	Fuel poverty	Housing	H tenure:	Nursing home	Other factors	Snow-ice
Morris C. NISRA 2007; Occasional Paper 25	[76]	+	++	NI	↓						(↑)		↑		↑					(↑)	(↑)				
Myint PK et al. *Neuroepidemiol* 2007; **28(2):**79-85	[77]	+	++	ENG				↑						↑											
<u>2006</u>																									
Carson C et al. *AJE* 2006; **164(1):**77-84	[78]	+	++	ENG	↓								↑		↑			↑							
Diaz J et al. *Intl J Biometeorol* 2006; **50(6)** 342-8	[79]	++	+	ESP					↑									↑							
Frank DA et al. *Pediatrics* 2006; **118**(5): e1293-1302	[80]	+	+	USA																↑					
Gerber Y, et al. *JACC* 2006; **48(2)**:287-92	[81]	+	+	USA								↓	↑												
Medina-Ramon et al. *EHP* 2006; **114:**1331-6	[82]	++	+	USA				(↑)	↔	↔		↔	↑	↔	↔										
Misailidou M et al. *Eur J Card Prev Rehb* 2006; **13:**846-8	[83]	+	+	GRE				↑	↔				↑												
Morabito M et al. *Environ Res* 2006; **102(1):**52-60	[84]	+	+	ITA			(↑)																		
Reinikainen et al. *Acta Anaes Scand* 2006; **50:**706-11	[85]	++	+	FIN											↑			↑							
Southern DA et al. *Can J Cardiol* 2006; **22(1):**59-61	[86]	+	+/-	CAN									(↑)												(↑)

		Internal	External	Setting	Time trends	Country	Climate	Age	Gender	Ethnicity	Rurality:	Prio r dis	CVD	Stroke	Respiratory	Falls	mental	Other	Depriv	Fuel poverty	Housing	H tenure:	Nursing home	Other factors	Snow-ice
Wang H et al. *J Med Sci* 2006; **55(2):** 45-51	[87]	+	+	JPN									↑												(↑)
<u>2005</u>																									
Barnett et al. *JECH* 2005; **59:**551-7	[88]	+	+	INT			↑		↑			↔	↑												
Basu R, et al. *Epidemiology* 2005; **16(1):**58-66	[89]	+	+	USA									↔												
Cagle, Hubbard. *Ann Hum Biol.* 2005; **32(4):**525-37	[90]	+	+	USA									↑												
Carder M et al. *OEM* 2005; **62(10):**702-10	[91]	++	++	SCO				↑					↑		↑			↑							
Diaz J et al. *Int J Biometeorol* 2005; **49(3):**179-83	[92]	+	+	ESP				↔					↑		↑										
Heyman B et al. *Housing Studies* 2005; **20(4):**649-64	[93]	-	-	SCO																	↑				
Howieson, Hogan. *J R Soc Prom Hlth* 2005; **125:**18-22	[94]	-	-	SCO															↑						
Mirchandani S et al. *Orthopedics* 2005;**28(2):**149-55	[95]	+	+	USA												↑									
Morabito M et al. *Int J Cardiol* 2005; **105(3):** 288-93	[96]	+	+	IYTA									↑												

		Internal	External	Setting	Time trends	Country	Climate	Age	Gender	Ethnicity	Rurality:	Prio r dis	CVD	Stroke	Respiratory	Falls	mental	Other	Depriv	Fuel poverty	Housing	H tenure:	Nursing home	Other factors	Snow-ice
Rudge J, Gilchrist R. *J Public Health* 2005; **27(4):**353-8	97	++	++	ENG											↑					↑					
Schwartz J. *Epidemiology* 2005; **16(1):**67-72	98	++	++	USA				↑	↑	↑					↑										
<u>2004</u>																									
Aronow & Ahn. *J Ger A Biol Sci Med Sci* 2004; **59:**146-7	99	-	+	USA									↑										+		
Goodman P et al. EHP 2004; **112:**179-85	100	++	+	IRE				↑					↑		↑			↑							
Hajat S, et al. *Eur J Epidemiol* 2004; **19(10):** 959-68	101	+	++	ENG									↔		↑										
Maheswaran R et al. *Public Health* 2004; **118(3):**167-76	102	+	+	ENG	↓			↑	↑				↑		↑				↔						
Panagiotakos DB et al. *Intl J Cardiol* 2004; **94:**229-33	103	+	+	GRE				↑	↑				↑												
Wilkinson P et al. *BMJ* 2004; **329(7467):**647	104	++	++	UK				(↔)	↑			↔	↔		↑				↔		↑			↔	
<u>2003</u>																									
Crawford JR & Parker MJ. *Injury* 2003; **34(3):**223-5	105	++	++	ENG												↑									
Donaldson & Keatinge. *JECH* 2003; **57(10):**790-1	106	+	+	E&W					↔										↔						

		Internal	External	Setting	Time trends	Country	Climate	Age	Gender	Ethnicity	Rurality:	Prio r dis	CVD	Stroke	Respiratory	Falls	mental	Other	Depriv	Fuel poverty	Housing	H tenure:	Nursing home	Other factors	Snow-ice
Healy JD. *JECH* 2003; **57(10):**784-9	107	+	+	EUR		+	↑												↑	↑	↑				
Hong YC, et al. *Epidemiology* 2003; **14(4):** 473-8	108	+	+	KOR				↑	↑					↑										↑	
Johnson H, Griffiths C. *Health Stat* 2003; **20:**19-24	109	+	++	E&W	↓																				
O'Neill et al. *AJE* 2003; **157(12):**1074-82	110	++	++	USA																					
Sullivan S et al. EAGA Charitable Trust; 2003	111	-	+	ENG																	(↑)				
<u>2002</u>																									
Braga AL et al. *EHP* 2002; **110(9):**859-63	112	++	++	USA			+						↑		↑										
Chesser TJ, et al. *Age Ageing* 2002; **31(5):**343-8	113	++	++	ENG												↔									
Curriero FC et al. *AJE* 2002; **155(1):**80-7	114	++	++	USA			↑												(↑)		(↑)				
Lawlor DA et al. *JECH* 2002; **56(5):**373-4	115	+	+	ENG							↔								↔						
Mitchell R et al. *Int J Epidemiol* 2002; **31(4):**831-8	116	+	+	UK									↑								↑				
Stewart S et al. *JACC* 2002; **39(5):**760-	117	+	++	SCO				↑	(↑)				↑												

		Internal	External	Setting	Time trends	Country	Climate	Age	Gender	Ethnicity	Rurality:	Prio r dis	CVD	Stroke	Respiratory	Falls	mental	Other	Depriv	Fuel poverty	Housing	H tenure:	Nursing home	Other factors	Snow-ice
2001																									
Aylin P et al. *Int J Epidemiol* 2001; **30(5):**1100-8	118	+	++	UK				↑											↔		(↑)				
Donaldson et al. *Int J Biometeorol* 2001; **45(1):**45-51	119	+	+	EUR																				↑	
Huynen MM et al. *EHP* 2001; **109(5):**463-70	120	++	++	NRL				↑					↑		↑			↑							
Nafstad P et al. *Eur J Epidemiol* 2001; **17(7):**621-7	121	+	+	NOR									↑		↑										
van Rossum et al. *Int J Epidemiol* 2001; **30(5):**1109-16	122	+	++	ENG				↔				↑	↑											↔	
Watkins SJ et al. *J Public Health Med* 2001; **23:**237-41	123	-	+	ENG									↑						↔						
Wilkinson P et al. Policy press Bristol; 2001	124	+	+	ENG				↑	↑				↑		↑				↔		↑	↑			
2000																									
Bulajic-Kopjar M. *Inj Prev* 2000; **6(1):**16-9	125	+	+	NOR												↑									↑
Clinch JP, Healy JD. *JECH* 2000; **54(9):**719-20	126	-	+	NOR/ IRE		↑							↑		↑										
Gemmell I et al. *Interntl J Epidemiol* 2000; **29(2):**274-9	127	+	+	SCO	↓								↑	↑	↑				↔						

		Internal	External	Setting	Time trends	Country	Climate	Age	Gender	Ethnicity	Rurality:	Prio r dis	CVD	Stroke	Respiratory	Falls	mental	Other	Depriv	Fuel poverty	Housing	H tenure:	Nursing home	Other factors	Snow-ice
Keatinge et al. *Int J Circumpolar Hlth* 2000; **59:**154-9	128	+	+	EUR		↑															↑			↑	
Lawlor DA, et al. *J Publ Hlth Med* 2000; **22(2):**176-81	129	+	+	ENG															↔						
<u>1999</u>																									
Donaldson GC et al. *Eur Respir J* 1999; **13(4):**844-9	130	+	+	ENG											↑										
Gorjanc ML et al. *AJE* 1999; **49(12):**1152-60	131	+	+	USA				↓()	(↑)				↑	↑	↑										
Jacobsen SJ et al. *Osteoporos Intl* 1999; **9(3):**254-9	132	++	++	USA												↑									↑
Shah S, Peacock J. *JECH* 1999; **53(8):**499-502	133	+	+	ENG															↔						
Sheth T et al. *JACC* 1999; **33(7):**1916-9	134	+	+	CAN				↑					↑	↑											
<u>1998</u>																									
Levy AR et al. Epidemiology 1998; **9(2):**172-7	135	++	+	CAN				↓	↓							↑									
<u>1997</u>																									
Ballester F et al. *Intl J Epidemiol* 1997; **26(3):**551-61	136	+	+	ESP				↑					↑		↑			↑							
Bjornstig U et al. *Accid Anal Prev* 1997; **29(2):**211-5	137	+	+	SWE				↑	↑							↑									↑

		Internal	External	Setting	Time trends	Country	Climate	Age	Gender	Ethnicity	Rurality:	Prio r dis	CVD	Stroke	Respiratory	Falls	mental	Other	Depriv	Fuel poverty	Housing	H tenure:	Nursing home	Other factors	Snow-ice
Christophersen O. *Popul Trends* 1997; **(90):**11-7	138	+	+	E&W																					
Donaldson GC, Keatinge WR. *JECH* 1997; **51(6):**643-8	139	+	+	ENG									↑		↑										
Donaldson GC, Keatinge WR. *BMJ* 1997; **315:**1055-6	140	+	+	ENG	↓																				
Seretakis D et al. *JAMA* 1997; **278(12):**1012-4	141	-	+	USA	(↓)																				
The Eurowinter Group. *Lancet* 1997; **349:**1341-6	142	+	+	EUR																					
<u>1995</u>																									
Jacobsen SJ, et al. *AJE* 1995; **141(1):**79-83	143	++	++	USA				(↓)								↑									↑
Laake K, Sverre JM. *Age Ageing* 1996; **25(5):**343-8	144	+	+	NOR/E&W		↑		↑																	
Langford, Bentham. *Intl J Biometeorol* 1995; **38:**141-7	145	+	+	ENG									↑	↑	↑										
Lau EM et al. *Aust J Publ Hlth* 1995; **19(1):**76-80	146	++	++	AUS												↑									
<u>1994</u>																									
Parker & Martin. *Eur J Epidemiol* 1994; **10(4):**441-2	147	+	+	ENG												↔									

		Internal	External	Setting	Time trends	Country	Climate	Age	Gender	Ethnicity	Rurality:	Prio r dis	CVD	Stroke	Respiratory	Falls	mental	Other	Depriv	Fuel poverty	Housing	H tenure:	Nursing home	Other factors	Snow-ice
<u>1993</u>																									
Kunst AE et al. *AJE* 1993; **137(3):**331-41	148	+	+	NRL									↑		↑			↑							
Macey & Schneider. *Gerontologist* 1993; **33:**497-500	149	+	+	USA					↓	↑	↑														

Specific vulnerability factors

(1) Variations between populations/countries

The fact that England has a substantial seasonal fluctuation in mortality with a peak in winter is well established and is the primary motivation for the review in this topic area. The numbers based on the simple Excess Winter Death (EWD) index have been regularly reported by the Office for National Statistics (see for example the reports of 2012[30] and 2011[41]). Studies that report variations in winter or cold-related mortality/morbidity within or between countries help to inform the question of the determinants of excess winter death. Those that include data for England (UK) as well as other countries provide more direct evidence on the degree to which the English population is more vulnerable to the effects of winter/low temperatures than populations in neighbouring areas of continental Europe and particularly Scandinavia.

A range of studies provide evidence relevant to these questions. They include studies of two country comparisons -- of England & Wales *vs* Norway (Lake and Sverre 1996,[144] quality rating +/+) and of Ireland *vs* Norway (Clinch and Healy 2000,[126] rating -/+) as well as multi-country comparisons within the European region (Healy 2003,[107] +/+; the Eurowinter Group 1997,[142] +/+, and Keatinge et al 2000,[128] (+/+). Time-series studies that quantify the relationship of mortality or morbidity with outdoor temperature have compared the relationships in cities or regions within countries. These include a study of cities of Spain (Iniguez et al 2010,[52] +/+) and of the United States (Curriero et al 2002,[114] ++/++; Braga et al 2002,[112] ++/++; Medina-Ramon and Schwartz 2007,[75] ++/++; Anderson and Bell 2009,[56] ++/++) as well as across Europe (Analitis et al 2008,[65] rating ++/++) and worldwide (Barnett et al 2005, +/+).[88]

Early studies raised hypotheses about the contrasting differences in the burden of winter-related mortality in different settings, but provided only limited and indirect, ecological evidence relevant to the explanations for those differences. A 1996 study by Laaki and Sverre,[144] showed that the excess winter mortality (defined for the four months of December to March) in England and Wales was markedly higher than in Norway, and that the relative excess showed a steeper correlation with monthly temperature in the four winter months, while the relationship between excess winter mortality and influenza was similar in the two populations. Though not based on modern time-series methods, this study suggested a smaller vulnerability to temperature in Norway despite otherwise broadly similar populations in England and Wales and Norway. The authors did not offer likely causal explanations for the greater winter mortality in England & Wales. A year 2000 study by Clinch and Healy comparing Ireland and Norway,[126] pointed to the similarity of the two populations in terms of similar crude and proportionate mortality rates for cardiovascular and respiratory disease, but a much greater relative excess winter mortality for these two cause-of-death groups in Ireland. They hypothesized poor housing standards in Ireland as a possible important contributory factor. This hypothesis was further developed by an ecological analysis by Healy in 2003,[107] who compared the coefficients of seasonal variation in mortality (CSVM, a variant of the excess winter death index) across 14 countries of the European Union (EU-14). The CSVM, 1988-97, in the EU-14 was highest in countries to the west and south of Europe with milder winters – Portugal, Spain, Ireland, the UK, Greece – and lowest in Finland, Germany, the Netherlands, Denmark and Luxembourg with comparatively harsher winters (Table 2).

Table 2. Coefficient of seasonal variation in mortality (CSVM) and 95% confidence intervals in EU-14, 1988-97. Data from Healy.[107]

Country	Seasonal variation in mortality (95% CI)
Austria	0.14 (0.12 to 0.16)
Belgium	0.13 (0.09 to 0.17)
Denmark	0.12 (0.10 to 0.14)
Finland	0.10 (0.07 to 0.13)
France	0.13 (0.11 to 0.15)
Germany	0.11 (0.09 to 0.13)
Greece	0.18 (0.15 to 0.21)
Ireland	0.21 (0.18 to 0.24)
Italy	0.16 (0.14 to 0.18)
Luxembourg	0.12 (0.08 to 0.16)
Netherlands	0.11 (0.09 to 0.13)
Portugal	0.28 (0.25 to 0.31)
Spain	0.21 (0.19 to 0.23)
UK	0.18 (0.16 to 0.20)
Mean	*0.16 (0.14 to 0.18)*

Through cross-country comparisons, Healy also noted that the thermal efficiency standards in housing were poorer in countries demonstrating the highest excess winter death (Portugal, Greece, Ireland, the UK). Socioeconomic indicators of wellbeing (poverty, income inequality, deprivation, and fuel poverty) were also associated with cross country levels of excess winter mortality.[107]

Earlier work by the Eurowinter Group (1997)[142] (rating +/+) assessed the question of the degree to which the increase in deaths per day per 1°C fall in temperature below 18°C varied across Europe. They found that the percentage increase in all-course mortality for each 1°C fall in temperature was greater in the warmer regions than in colder regions (e.g. Athens 2.15% (95% CI 1.20, 3.10) versus South Finland 0.27% (95% CI 0.15, 0 .40%)). Moreover, for an equivalent outdoor temperature (7°C) the mean living room temperature was somewhat lower in Athens (19.2°C) than in South Finland (21.7°C). People in cooler climates were also likely to protect themselves more against the cold with appropriate clothing. The conclusion of the Eurowinter Group was that mortality increases to a greater extent with a given fall in temperature in regions with warmer winters, and that populations in such regions (including the UK) have cooler homes at a given low outdoor temperature and are likely to wear less thermally protective clothing than those from cooler climates. This argument was further developed in Keatinge et al 2000,[128] which showed that for those aged 65-74, high levels of protection against indoor and outdoor cold at given outdoor temperatures were found mainly in countries with cold winters, and were associated with low levels of excess mortality at a given level of outdoor cold. The authors concluded that 'regions such as London that had poor protection against cold and/or high baseline mortalities had higher levels of winter excess mortality than expected for the coldness of their winters.'[128]

More recent comparisons using more sophisticated time series methods with appropriate control for season and distributed lag models have been made as part of the PHEWE project. Analitis et al 2008,[65] compared the effects of cold weather on mortality in 15 European cities from the North to South of Europe including (among others) London and Dublin, Helsinki and Stockholm in the North and Athens, Barcelona and Valencia in the South. They found clear evidence that a decrease in temperature was associated with an increase in total natural deaths, and in deaths from cardiovascular, respiratory and cerebro-vascular causes. (The meta-analytic results suggested largely monotonic increases in risk as apparent temperature fell without clear evidence of a threshold.) As Keatinge had found, there was evidence that the increase in risk per degree Celsius fall in temperature was greater in the warmer (Southern) cities. The exposure-response relationship in London (the only city representing England) was near to the middle of the distribution across the 15 cities, though point estimates for Helsinki and Stockholm were lower.

A similar conclusion was reached by Barnett et al (2005)[88] in relation to cold periods and coronary events based on an analysis of data from 21 countries using the World Health Organisation's MONICA data for 1980 to 1995. Coronary event rates increased more in populations living in warmer climates than populations living in cold climates, where the increases were relatively slight.

Other studies have compared variations across cities within individual countries. Iniguez et al (2010)[52] examined the temperature-mortality association in 13 Spanish cities from across a wide range of climatic and socio-demographic conditions. Most cities showed a V-shaped temperature-mortality relationship, with the minimum mortality temperature (the vertex of the V) at generally higher temperatures in cities with warmer climates. Again, the cold effects were also greater in cities with warmer climates but lesser in cities with higher temperature variability. Similarly, Curriero et al (2002)[114] analysed the temperature-mortality association for 11 large eastern US cities, 1973-1994, using log-linear regression analysis for time-series data and found clear cold temperature-mortality relationships which varied with latitude, with a greater effect of colder temperatures on mortality risk in more southern (warmer) cities. Also in the United States, a 2007 study by Medina-Ramón and Schwartz[75] analysed patterns of mortality in 50 cities in relation to extremes of cold *defined in percentile terms*, and found them to be fairly homogeneous across cities with different climates (though heat effects were more heterogeneous). Braga et al 2002,[112] showeed that greater variance of winter temperature was associated with larger effects for cold days on respiratory deaths. Another US study (Anderson and Bell 2009[56]) found a degree of heterogeneity in effects from city to city that suggests that weather-mortality relationships from one community may not be applicable in another, but they also concluded that there is evidence of acclimatization to local climatic conditions (because of the smaller spatial variations of temperature effect in relation to relative temperature (percentiles) compared with absolute temperature).

Taken together, the evidence of these studies is that in a European context at least there are variations in the excess winter death index (EWDI) and in the steepness of the exposure-response relationships for cold that suggest greater cold temperature-mortality impact in populations with generally milder winter climates, including the UK, which inversely correlate with various measures of adaptation to low temperatures in terms of housing and clothing. However, it is worth noting the following in relation to the interpretation of this comparative evidence:

(i) The EWDI is a useful but relatively simple measure of winter harm that does not take account of the different temperature distributions in different climatic settings. Thus, while in England, the coldest months of winter are mostly concentrated in the months of December to March, the cold periods are more prolonged in Scandinavia which may somewhat dilute the relative excess for those same 'winter' months.

(ii) The steepness of the exposure-response relationship for cold reflects only one aspect of the impact of cold, and does not take account of the distribution of temperatures which vary from setting to setting. This is relevant for two reasons. Firstly, a given (absolute) temperature may be at very different percentile points on the distribution of temperatures for different populations. This prompts some researchers to study exposure-response relationships using temperatures defined in relative (percentile) rather than absolute terms (as Medina-Ramón and Schwartz did). Thus, what may be a relatively extreme low temperature for England is likely to be much less exceptional for Scandinavian and other countries with harsher winters. Secondly, even if the exposure-response relationship is shallower in settings with colder climates, the fact that such settings have more cold days and greater extremes of cold, will tend to increase their overall cold-attributable burden of mortality compared to areas with milder temperatures. (Recall that the cold attributable burden is the product both of the risk at given levels of low temperature and the frequency with which those low temperatures occur, so many days of low temperature will increase the total attributable burden.)

Within England and Wales, analyses of routine data by the Office for National Statistics (2012, 2011) show that there are region to region variations in excess winter deaths, but no clear patterns of geographical trends. [30 41] Analysis of data by region of England for the 2013 Evaluation of England's Cold Weather Plan (CWP), shows relatively subtle variations in thresholds and exposure-response functions for different regions.[16]

Table 3. Percentage change in deaths for every 1°C decrease in temperature below the 'cold threshold'. Data from Hajat et al 2013.[16]

Region:	Threshold (°C)	% change in deaths (95% CI)
North East	6	3.99 (2.74, 5.23)
North West	5	2.82 (2.04, 3.61)
Yorkshire & Humberside	5	4.22 (3.15, 5.31)
East Midlands	7	4.11 (3.16, 5.07)
West Midlands	7	4.38 (3.43, 5.34)
East England	4	5.39 (4.43, 6.35)
London	5	3.96 (3.21, 4.71)
South East	5	2.66 (1.98, 3.34)
South West	8	3.35 (2.43, 4.28)

ES1.1 Summary evidence statement -- variations between populations and countries

15 studies provide strong evidence relating to the overall relationship between temperature and excess winter deaths in various countries and show a link between winter temperatures and the difference between summer and winter temperatures. There is strong evidence from six studies (-/+ ([126]), +/+ ([107 144 88 142]) one ++/++ [65]) showing a relatively higher rate of EWD in countries with milder winters than in those with colder winters. The role of housing standards ([107]) and appropriate

clothing ([142]) is hypothesized as being important by some. This is supported by moderate evidence from three studies looking at variations within countries (+/+ [52], ++/++ [114] [75]). Two (from Spain,[52] and the US[114]) found that effects of cold were greater in cities with warmer climates ([52 114]) but lesser in cities with higher temperature variability ([52]). Medina-Ramon ([75]) found that the effect of extreme cold (defined as a percentile) was homogeneous across cities with different climates, suggesting that only the unusualness of the cold temperature (and not its absolute value) had a substantial impact on mortality. Three studies (+/+ [30], [41], and ++/++ [74]) looked at differences between regions within England and Wales. Two [30], [41], found no clear patterns of geographical trends and one[74] found relatively subtle variations in thresholds and exposure functions for different regions.

This evidence includes comparisons within England and Wales and between England and other countries as well as comparisons between non UK countries. As a result it is considered to be applicable to the UK.

(2) Trends in vulnerability to excess winter death over time

Evidence on the change in excess winter deaths for England and Wales, 1950/51–2011/12, by year and five-year central moving average, has been published by the Office for National Statistics (2012, rating +/+).[30] The data show a progressive decline, albeit with some fluctuation, since the early 1950s, when the annual winter excess was around 70,000 deaths, to an annual average of 26,400 excess winter deaths each year between 2000/01 and 2011/12.[30] The data suggest some degree of levelling off in the decline over the last decade or so.

A decline over time was also reported by Maheswaran et al (2004, rating +/+)[102] who analysed the pattern of excess winter mortality, 1981 to 1999, and emergency hospital admissions in the South Yorkshire Coalfields Health Action Zone: the excess winter mortality ratios decreased significantly over the 18-year period for cardiovascular disease and for all other causes.[102] In Scotland, Gemmell and colleagues (2000,[127] rating +/+) reported a fall in seasonal variation in mortality from around 38% in 1981-1983 to around 26% in 1991-1993. Although there was no clear evidence of a relationship between socioeconomic status and seasonal mortality, the extent of the fall in seasonal variation was greater in deprived areas than in affluent areas.[127]

A study by Carson and colleagues (2006,[78] rating +/+) suggests that the decline in excess winter deaths in London, and specifically of cold-related deaths, has occurred across the 20th century. This decline has occurred against a background of an ageing population but progressive socio-economic improvement, a small rise in average winter temperatures, and appreciable changes in health and health care, especially for key temperature-sensitive (cardio-respiratory) diseases.

The long-term decline in excess winter deaths seen in England has also been observed in other settings, though the evidence is somewhat mixed. Miron and colleagues (2012,[27] rating +/+) analysed the effects of cold on mortality in Castile-La Mancha, 1975 to 2003, and found that while there was no clear trend in cold-related mortality thresholds, there was evidence of a reduction in the lagged effects of cold on mortality, which the authors attributable to improvement in socio-economic conditions over the study period.[27]

A 150 year study of temperature-related excess mortality in the Dutch population by Ekamper et al 2009,[59] (rating +/+) identified a decline in cold effects in infants from about 1930, but an increasing cold effect in the 75+ group (details not shown) and no clear upward or downward trend over time in cold effects overall. Similarly a study of excess winter mortality in New Zealand (Davie 2007, rating +/+) over the relatively short period, 1980-2000, provided no clear evidence of decline in risk.[73]

Thus, there appears to have been a progressive and substantial decline in winter death and vulnerability to cold in England (UK), which has been seen in some other populations. But the evidence does not allow clear understanding of the reason for the decline other than that it has occurred alongside fairly major socio-economic and lifestyle changes, including in housing quality.

ES1.2 Summary evidence statement – time trends

Seven studies examine time trends in excess winter deaths, 4 (all +) in the UK[30 102 127 78] and 3 (all +) internationally.[27 59 73] These studies provide strong evidence of a reduction in excess winter deaths in the countries of the UK when looked at: across England and Wales,[30] within the South Yorkshire Coalfields HAZ,[102] in Scotland[127] and in London.[78] International evidence is more mixed, with 1 + study from Spain[27] showing a reduction in the lagged effects of cold on mortality, 1 + from the Netherlands[59] showing a decline in cold effects in infants but an increase in effects on 75+ age groups and 1 + from New Zealand[73] providing no clear evidence of a decline.

(3) Personal vulnerability factors

Age

There have been many studies on the relationship between winter- and cold-related mortality and age. Most studies of seasonal patterns and time-series studies of temperature effects have reported results by age-subgroups. Among the studies selected for this review, such evidence has been reported in studies from England,[16 18 77 102 122 124] England and Wales,[30 41 48 16] Scotland,[91 117] the UK (Britain),[104 118] Ireland,[100] the Czech Republic,[61] Denmark,[34] France,[31] Greece,[83 103] Italy,[13 28 36 37 55] the Netherlands,[59 120] Norway,[144] Spain,[15 50 92 136] Sweden,[71 137] and Europe,[65] as well as studies from Japan,[11] South Korea,[108] Taiwan,[22 45] and New Zealand,[25] and from Canada[134 135] and the USA.[72 82 98 131 143]

The vast majority of these studies report winter- or cold-related mortality which is greater at older ages, though with a few exceptions. The exceptions include a Japanese study (the Ibaraki Prefectural Health Study, Atsumi et al 2013 [11]) of the relationship between cold temperature and cardiovascular mortality, which assessed effect modification by individual characteristics. In a country with the world's longest life expectancy, their results showed that subjects younger than 80 years (as well as those with hyperglycemia) were more susceptible to cold temperature than older patients. [11]

Another exception is a Danish case-crossover study of Wichmann et al (2012, [34] ++/++) of apparent temperature and acute myocardial infarction hospital admissions in Copenhagen which reported greater susceptibility to cold risk in the 19-65 year age-group (as well as in men and those in the highest SES group), while a study of cardiovascular mortality in the Czech Republic (Kysely et al 2009,[61] rating +/+) found associations with cold spells in all age groups (25-59, 60-69, 70-79 and 80+ years) and in both men and women, but with relative mortality effects that were most pronounced in middle-aged men (25-59 years).[61]

Younger age also appears to be associated with risk of hip fracture in relation to inclement weather in some settings. For example, a Canadian study of hip fracture in Montreal (Levy et al 1998,[135] rating ++/+) reported freezing rain as a particular risk factor and that the association of inclement weather with hip fracture was stronger among younger men and women than for older persons.[135] Similarly, a US study by Jacobsen et al (1999,[143] rating ++/++) of hip fracture incidence among women aged 45 years and older in Rochester, Minnesota, 1952 to 1989, found the risk of hip fracture was increased on days with snow or freezing rain, but among women aged 75 years and older, the effect of ice and snow were not strongly related to fracture occurrence. It is possible these risks for hip fracture are greater in younger adults because of activity patterns which mean working age adults are more likely to go out in inclement conditions than older adults.

Most other studies are broadly consistent in reporting increases in risk of winter- or cold-related mortality and morbidity with age, particularly for cardio-respiratory illnesses. This is true in both relative terms (the elderly have a greater relative risk of excess winter death or a stronger association with low outdoor temperature) and in terms of absolute numbers of cases. Because the death rates rise steeply with age, even a constant excess winter ratio would mean substantially larger numbers of attributable deaths per 100,000 population at older ages.

The evidence for England and Wales is clear. The 2012 ONS report[30] suggests that in 2011/12 the majority of excess winter deaths occurred among those aged 75 and over in both sexes, with females aged 85 and over having the greatest number of excess winter deaths. This report is based on analyses of routine mortality registrations for England and Wales by region using the standard definition of excess winter death.

A 2001 report on winter mortality in England linked to the English House Conditions Survey (EHCS) showed a clear pattern of increasing relative risk with age,[124] with just 1.3% excess deaths in winter the 0-44 years age group, 18.9% in the 45-46 age-group, 21.0% in the 65-74 age group, 22.6% in the 75-84 age group and 30% in those aged 85 years or more. The relative risk for excess winter death in those aged 85 years or more was 1.28 (1.13, 1.46) times that in the 0-44 age group (p-value for trend across age groups <0.001).

A daily time-series analyses of regional mortality data for England undertaken for the a recent evaluation of the Cold Weather Plan (CWP) for England (Hajat et al 2013,[16] rating ++/++) confirm a rise across age-groups (0-64, 65-74, 75-84, 85+) in the relative risk associated with a 1°C drop in temperature below the cold threshold.[16]

ES1.3 Summary evidence statement – age

49 included studies have examined the influence of age on excess winter deaths (14 from parts of the UK - 6 from England (2 ++[16 18], 4 + [77 102 122 124]), 4 from England and Wales (1++ [74], 2 +[41 30], 1 ++ [48]) 2 from Scotland (1++ [91], 1+[117]) and 2 from Britain (1 ++ [104], 1+ [118])), 6 from Italy (3 + [13 28 37], 1 each - [55] -/+ [36]) 5 from the USA (4++ [72 82 98 143] and 1 + [131]), 4 from Spain (1++ [15], 3+ [50 92 136]), 1 from France (+[31]), Greece (1 + [83] + [103]), the Netherlands (1 + [59], 1 ++ [120]), Japan (1 ++ [11]), Taiwan (both +[22 45]), Sweden (1 ++[71], 1 + [137]), Canada (1 + [134], 1 ++ [135]), 1 ++ each from Ireland[100], Denmark[34] and Europe,[65] 1 + each from the Czech Republic,[61] Norway,[144] South Korea,[108] New Zealand.[25]

All apart from 5 [61 34 11 135 143] found greater winter or cold related mortality at older ages. This is the case for both relative and absolute numbers.

2 of the 5 studies showing higher risk at younger age looked at hip fractures and found either a higher risk among younger men and women ([135, ++]) or no strong relationship with age ([143 ++]). A Danish case-crossover study ([34 ++]) found greater susceptibility to myocardial infarction among 19-65 year olds and a study in the Czech Republic ([61, +]) found that relative mortality effects were most pronounced in middle-aged men.

The evidence for England and England and Wales shows the majority of excess winter deaths occurring in those aged 75 and over, with the greatest number among women aged 85 and over ([30, +]). A report linked to the English House Conditions Survey found a relative risk for those aged 85 and over of 1.28 (1.13, 1.46) compared to those aged 0-44 ([124, +]). Analysis of the Cold Winter Plan evaluation[16] confirms a rise across age groups in the relative risk associated with a 1^0C drop in temperature below the cold threshold. This threshold varies by region but is around 6^0C.

Gender

As for age, there have been innumerable studies reporting on variations in risk of winter- or cold-related mortality/morbidity by gender, including studies in England,[102 124] England & Wales,[30 41 106] the UK,[104] Scotland,[117] Czech Republic,[61] Denmark,[34] Greece,[83 103] Italy,[36 55] Spain,[15 79] Sweden,[137] S Korea,[108] New Zealand,[25 73] Canada,[135] USA,[82 98 131 149] and internationally.[88]

The evidence on the difference between men and women is somewhat mixed however. In England and Wales, the ONS analyses of routine mortality registrations (ONS 2011,[30] and ONS 2012,[41] both rated +/+) indicate women have higher levels of risk of excess winter death than men, as does a 2001 analysis by Wilkinson et al (+/+) of winter mortality patterns in England: unadjusted relative risk for women compared with men of 1.03 (1.02-1.05).[124] However, a higher proportion of the female population of England and Wales are aged 75 and over (9.2 per cent compared with 6.4 per cent of males in 2011) and 85 years and over (where women outnumber men two to one). Given the strong effect of age on winter death, this difference may wholly, or partially, explain the higher number of excess winter deaths in women.[30] Time-series analyses by Hajat et al 2007,[74] rating ++/++, of mortality patterns in England and Wales, found very little difference between men and women in the shape of the mortality function with cold.

Donaldson and Keatinge's (2003) analysis of cold-related mortality in England and Wales[106] (rating +/+) provided results stratified by age and sex, which show lower cold mortality risk in men than women in social class 5 (unskilled) in the 50-59 year age-group. This risk difference was less pronounced and not statistically signficant in the 65-74 (retired population) age-group. These authors interpret this pattern as indicating a possible protective effect of work-related factors in men in social class 5, which was not observed in social class 1 (professional). Ecological analyses of excess winter mortality and emergency hospital admissions in the South Yorkshire Coalfields Health Action Zone by Maheswaran and colleagues (2004,[102] rating +/+) found that the winter excess ratios were lower in men than in women for both respiratory mortality $P<0.05$ and respiratory hospital admissions $P<0.0001$. A Scottish study found greater seasonal variation in women than men for heart failure,[117] especially at older ages.

One of the few studies to have examined gender differences with confounder adjustment at individual level was an analysis of data from a cohort of elderly people from UK general practices (Wilkinson et al 2004,[104] rating ++/++). This study found a small excess of risk in women (RR of 1.08 (0.99 to 1.19) after adjustment for region and age), which was slightly stronger (1.11 (1.01 to 1.23)) after additional adjustment for medications, symptoms, whether living alone and deprivation group.

The international study of coronary events based on WHO MONICA data from a 21 country registry with the UK represented by Belfast, (Barnett et al 2005,[88] rating +/+) reported an age-adjusted cold-related excess risk for women relative to men of 1.07 (1.03, 1.11). All populations showed a higher risk for women, and the differences in risk between men and women had a linear relation with mean daily temperature.[88]

Most other studies have not included detailed confounder adjustment, but have reported generally small excess risks for women compared with men, including an Italian (Sicilian) study by Abrignani et al 2009,[55] rating -/- ; a New Zealand study by Davie et al 2007,[73] rating +/+; a Spanish study by Diaz et al 2006,[79] rating ++/+; a US study by Schwartz 2005,[98] rating ++/++; a study by Panagiotakos 2004,[103] rating +/+, of daily admisisons for non-fatal acute coronary syndromes (ACS) to emergency units of hospitals in the greater Athens area, January 2001 to August 2002; a study by Hong et al 2003,[108] rating +/+, of ischemic stroke onset and decrease in temperature over a 3-year period in Incheon, Korea; a Swedish study by Bjornstig et al 1997,[137] rating +/+, of slipping on snow and ice. Several other studies have reported no clear difference: a study by Gomez-Acebo et al 2013,[15] rating ++/+, of the relationship between low winter temperatures and mortality due to cancer, cardiovascular diseases and respiratory diseases in Cantabria (northern Spain); a study by Hales and colleagues 2012,[25] rating +/+, of seasonal mortality in New Zealand; a study by Gallerani et al 2011, rating -/-, of seasonal variation in heart failure hospitalization in Ferrara; a US study by Medina-Ramon et al 2006,[82] rating ++/+, involving a case-only analysis of daily mortality and weather data from 50 U.S. cities for 1989-2000; an ecological study in rural Greece by Misailidou et al 2006,[83] rating +/+, of the effect of ambient temperature on morbidity from acute coronary syndromes (ACS).

Exceptions among the studies included in this review were studies by Levy et al 2006 of hip fracture in relation to weather in Montreal,[135] rating ++/+, and a study by Macey and Schneider 1993,[149] rating +/+, of temperature-related deaths in people aged 60 years or more, who found a male bias for deaths from cold. A Czech study reported that cold spells were associated with positive mean excess cardiovascular mortality in all age groups in both men and women, but that the relative mortality effects were most pronounced and most direct in middle-aged men (25–59 years).[61]. A Danish case-crossover study of acute myocardial infarction hospital admissions in Copenhagen, found that greatest relative susceptibility to cold was observed in men in the 19-65 year old group.[34]

ES1.4 Summary evidence statement – gender

Twenty five included studies consider the role of gender: 7 are from the UK (2 + from England[102 124], three + from England & Wales[30 74 106], one + from Scotland[117] and 1 ++ from the UK[104]) 4 from the USA (2 ++[82 98] and 2 + [131 149]), 2 each from New Zealand (1 + [25 73]), Greece (1 +/- [83], one +[103]), Italy (1 +/-[36], 1 -[55]), Spain (both ++ [15 79]), 1 + each from Czech Republic,[61] Sweden,[137] South Korea,[108] internationally[88] and 1 ++ each from Denmark[34] and Canada.[135]

Of these, one study found an increase in hip fractures in men compared to women ([135, ++]) and one a male bias for deaths from cold in those aged 60+ ([149, +]), while two others reported greater relative risks in men compared to women: one of cardiovascular mortality in the Czech Rebublic (+)[61] and one of acute myocardial infarction in Denmark (++)[34]. The other studies found small excess risks for women ([30 102 73 124 13 55 137 108 98 79]) or no clear difference ([74 83 36 15 25 106]). Two studies have adjusted for potential confounders, including age. These found a small excess of risk in women (1.11, 1.01 to 1.23 in a study from UK general practice [104,++] and 1.07 (1.03, 1.11) in an international study of coronary events [88,+].

Ethnicity

There have been few studies of winter-/cold-related mortality/morbidity in relation to ethnic group, and the evidence is too limited to draw firm conclusions, especially given no direct evidnce for England. A factor in this paucity of evidence is likely to be the limited data and power for testing variations in seasonal or cold-related risk by ethnic group.

Two studies from New Zealand of uncertain relevance to England, by Davie et al 2007 (+),[73] and by Hales et al 2012 (+),[25] found no evidence that patterns of EWM differed by ethnicity, specifically no clear variation in relation to Maori, Pacific or Asian populations compared with ethnic Europeans.[25]

In the United States, Medina-Ramon et al 2006, (++/+), reported evidence that the black population was more at risk of heat-related risk but not of cold,[82] while Anderson and Bell 2009, in an analysis of data from 107 cities, rating ++/++, reported higher susceptibility to cold for communities with a higher percentage of African Americans.[56] Schwartz 2005,[98], rating ++/++, also reported greater vulnerability among the non-white (US) population to cold based on a case-only analysis (OR 1.25; 1.12-1.40). Macey and Schneider 1993,[149] reported slightly greater risk among non-white populations for heat-related mortality, but not for cold, in an elderly US population based on a limited correlation analysis.

ES1.5 Summary evidence statement – ethnicity

6 studies have considered the effect of ethnic group on cold or winter mortality or morbidity, providing inconsistent results. 2 studies are from New Zealand (1 + [73 25]) and 4 from the US (3 ++ [56 82 98] and 1 +[149]). 2 studies from New Zealand (+),[73 25] found no evidence that patterns of EWM differed by ethnicity, specifically no clear variation in relation to Maori, Pacific or Asian populations compared with ethnic Europeans.

In the United States, Medina-Ramon[82] reported evidence that the black population was more at risk of heat-related risk but not of cold while Anderson and Bell,[56] in an analysis of data from 107 cities, reported higher susceptibility to cold for communities with a higher percentage of African Americans. Schwartz,[98] also reported greater vulnerability among the non-white (US) population to cold based on a case-only analysis (OR 1.25; 1.12-1.40). Macey and Schneider[149] reported some evidence of excess cold risk in an elderly US population based on a limited correlation analysis.

(4) Cause-of-death/morbidity

The literature review presented in this report was not designed to capture all studies which provide evidence of any seasonal fluctuation or temperature relationship in mortality or morbidity for specific causes. That would be an overwhelming literature (we estimate thousands of studies) whose collective evidence would reinforce the broad point that many specific conditions, including many infectious diseases, various forms of injury/fall risk, and many categories of chronic disease occurrence have been found in some settings at least to exhibit some form of temporal parttern across the year, sometimes with a temperature relationship. Not only would a comprehensive review be impractical because of the volume of potential studies, but it would be difficult meaningfully to synthesize the very heterogenous literature based on a wide range of study types, definitions and analytical approaches.

Here we have a much more limited objective, therefore, namely to give a broad overview of the patterns of seasonality or temperature-related disease risk, excluding infectious disease categories, observed in the very selective literature gathered for this review of vulnerability by person or place – which specifically did not include studies that only reported patterns of seasonality or temperature dependence without reference to modifying factors. The literature is therefore extremely selective with regard to the potential pool of studies of seasonality and temperature influence on illness, and cannot therefore be viewed as comprehensive or even as fully representative of the wider litereature. The reported studies should rather be interpreted as indicative examples. Nonetheless, even from this very limited literature, it is possible to make observations about the categories of illness which, quantitatively make the largest overall contribution to winter- and cold-related mortality/morbidity, including the categories of most relevance to winter death and morbidity in England.

Most studies of winter- or cold-related mortality/morbidity that have examined cause-of-death/morbidity groups, have usually done so using fairly large disease groupings, in part because of the power requirements to examine effect variation for more specific causes. The evidence suggests that in most settings the major disease groupings show association with low temperature, including cardiovascular disease and major subgroups, respiratory disease (especially chronic obstructive pulmonary disease, COPD), external causes (injuries), and other causes including malignancy. Among the reviewed studies which provide evidence for specific causes are the following:

Cardio-respiratory and other chronic disease

All papers in this review to some degree address the issue of seasonal variations in health or temperature dependence. The most commonly studied outcomes, especially in time series studies (necessary for temperature attribution) are cardio-respiratory outcomes. The principal relevant studies from this review are summarized in the table below, together with their validity ratings.

All of those listed under the heading of cardiovascular disease showed some evidence of association with cold temperature and/or the winter season. The findings are nearly as universally positive for respiratory outcomes. However, Rocklov et al 2011,[43] showed no clear evidence for association with respiratory mortality, and the study by Medina-Ramon et al 2006[82] found little evidence that COPD as a presenting condition, or of pneumonia as the primary cause of death, were modifiers of the effect of extreme temperature on mortality (though cardiovascular mortality and cardiac arrest as the primary cause of death were associated with higher risk to extreme cold).

Almost by definition, studies negative for an overall temperature or season effect would be unlikely to be included in the review as there would not be an effect with which to investigate effect modification (vulnerability). Hence the very positive (seasonal or cold effect) balance of evidence of these studies does not properly reflect the true balance of findings of main effects in the literature at large. Nonetheless, the range of studies in terms of design and geography does capture the fact that there is a large body of evidence to suggest that cold temperatures, and the winter season in particular, is associated with risk of cardio-respiratory mortality and morbidity. That is fairly evident in that tabulations of routine statistics, such as those produced annually by the Office for National Statistics, repeatedly demonstrate the large winter (December to March) excess in mortality, most of which is made up of cardio-respiratory causes[30,41].

Causes other than the cardio-respiratory group and its subcategories are also often tabulated, though typically as 'other' (i.e. non-cardiuorespiratory) causes, and usually report positive associations with winter/cold. Studies in England,[16 78] England and Wales,[30] Scotland,[91] Ireland,[12 100] Finland,[79] The Netherlands,[148] Spain,[15 79 136] Japan (hyperglycaemia as effect modifier for cardiovascular outcome),[11] and The United States[56] fall in this category among reviewed studies.

Table 2. Summary of the main studies within the reviewed papers that have addressed cardiovascular and respiratory outcomes.					
				Validity	
				Int	Ext
Cardiovascular disease					
England	Hajat et al 2013[16]	Mortality and hospital admissions (epidemiological analyses for the 2013 CWP evaluation)	Time series	++	++
	McGuinn et al 2013[18]	Activation of implanatable cardiac defibrillators (a marker of severe or life-threatening cardiac arrhythmia), SE England	Time series	++	+
	Carson et al 2006[78]	Changing patterns of weather-sensitive disease over the 20th century, London	Time series	+	++
	Maheswaran et al 2004[102]	Excess winter mortality and emergency hospital admissions in the South Yorkshire Coalfields Health Action Zone for cardiovascular (as well as respiratory and other causes)	Excess winter mortality/ad mission	+	+
	Wilkinson et al 2001[124]	Excess winter death for cardiovascular (as well as respiratory and other) causes	EWDI	+	+
	Donaldson and Keatinge 1997[139]	Mortality from ischaemic heart and cerebrovascular disease (as well as respiratory disease)	Poisson analysis of low temperature days	+	+
England and Wales	Office for National Statistics 2012[30]	Analyses of routine mortality registration data by region	Seasonal (EWDI	+	+
	Office for National Statistics 2011[41]	Analyses of routine mortality registration data by region	Seasonal (EWDI	+	+
	Bhaskaran et al 2010[48]	Myocardial infarction in England and Wales	Time series	++	++
	Hajat et al 2007[74]	Temperature-relatd mortality from cardiovascular (as well as from respiratory and external causes)	Time series	++	++
	Langford and Bentham 1995[145]	Death rates from all causes and ischaemic heart disease and cerebrovascular disease (as well as from chronic bronchitis, pneumonia).	Time series	+	+
Northern Ireland	Morris et al 2007[76]	Circulatory (and respiratory) death	Monthly analyses	+	++
Ireland	Callaly et al 2013[12]			+	+
Czech Republic	Kysely et a2009l[61]	Cardiovascular mortality	Analysis of cold spells	+	+
Denmark	Wichmann et al 2012	Acute myocardial infarction admission	Case cross over	++	++
Italy	de Donato et al 2013[13]	Mortality and emergency room	Cold spells	++	+

		attendance: cardiovascular disease and various subcategories (as well as all natural causes, respiratory causes and injuries)			
	Gallerani et al 2011[36]	Heart failure	Seasonal	+	-
	Abrignani et al 2009[55]	Acute myocardial infarction admissions	Daily correlation	-	-
Spain	Gomez-Acebo et al 2013[15]	Mortality from cardiovascular disease (as well as respiratory diseases and cancer)	Case crossover	++	+
	Iniguez et al 2010[52]	cardio-respiratory mortality	Time series	+	+
Sweden	Rocklov et al 2011[43]	Cardiovascular (and respiratory and noncardio-respiratory) mortality, Stockholm	Time series (by season)	++	+
	Rocklov and Forsberg 2008[71]	Cardiovascular and respiratory mortality, Stockholm	Time series	++	++
Europe	Analitis et al 2008[65]	Cardiovascular, cerebrovascular (and respiratory) deaths	Time series	++	++
Japan	Atsumi et al 2013[11]	Cardiovascular mortality	Case cross-over of cohort	++	+
Taiwan	Wu et al 2011[45]	Cardiovascular mortality	Spatial regression	+	+
	Chen et al 2010[49]	Cardiovascular mortality	Spatial regression	+	-
	Yang et al 2009[64]	Cardiovascular mortality	Spatial	-	-
New Zealand	Davie et al 2007[73]	Mortality by cause (diseases of the circulatory system accounted for 47% of all excess winter deaths from 1996–2000 with mortality from diseases of the respiratory system accounting for 31%)	Seasonal (monthly) analysis	+	+
Australia	Turner et al 2012[32]	Ambulance attendance for cardiovascular (and respiratory) conditions	Time series	++	++
Canada	Bayentin et al 2010[47]	Hospital admission for ischaemic heart disease	Time series (+spatial)	+	+
USA	Madrigano et al 2013[19]	Acute myocardial infarction occurrence (in Worcester (MA) metropolitan area)	Case crossover	++	+
	Barnett et al 2012[24]	Cardiovascular (as well as rewpiratory) mortality	Time series + Bayes model	++	++
	Anderson and Bell 2009[56]	Cardiovascular (as well as respiratory) mortality. 107 US communities	Time series	++	++
	Medina-Ramon et al 2007	Mortality from myocardial infarction and cardiac arrest. 50 US cities	Case crossover	++	++
Respiratory disease					

England	Hajat et al 2013[16]	Mortality and hospital admissions (epidemiological analyses for the 2013 CWP evaluation)	Time series	++	++
	Bryden et al 2009[57]	Hospital admissions for exacerbations of chronic obstructive pulmonary disease (COPD)	Analysis of high risk weeks	+	+
	Jordan et al 2008[69]	Winter hospital admission for respiratory disease	Case control	++	++
	Carson et al 2006[78]	Respiratory mortality: changing patterns of weather-sensitive disease over the 20th century, London	Time series	+	++
	Rudge and Gilchrist 2005[97]	Emergency hospital episodes for all respiratory diagnosis codes, London borough of Newham	Small area analysis of winter excess	++	++
	Maheswaran et al 2004[102]	Excess winter mortality and emergency hospital admissions in the South Yorkshire Coalfields Health Action Zone for respiratory (as well as cardiovascular and other causes)	Excess winter mortality/admission	+	+
	Wilkinson et al 2001[124]	Excess winter death for cardiovascular (as well as respiratory and other) causes	EWDI	+	+
	Donaldson et al 1999[130]	Lung function and symptoms in chronic obstructive pulmonary disease (in relation to low temperature)	Survey analysed in relation to daily characteristics	+	+
	Donaldson and Keatinge 1997	Mortality from respiratory disease (as well as ischaemic heart and cerebrovascular disease)	Poisson analysis of low temperature effects	+	+
England and Wales	Office for National Statistics 2012[30]	Analyses of routine mortality registration data by region	Seasonal (EWDI)	+	+
	Langford and Bentham 1995[145]	Death rates from all causes and from chronic bronchitis, pneumonia (as well as ischaemic heart disease and cerebrovascular disease).	Time series	+	+
	Hajat et al 2007[74]	Temperature-relatd mortality from respiratory (as well as from cardiovascular and external causes)	Time series	++	++
UK	Hajat et al 2004[101]	GP consultations for respiratory conditions by elderly people	Time series	+	++
	Wilkinson et al 2004[104]	Excess winter death in relation to pre-existing illness for respiratory conditions	EWDI	++	++
Scotland	McAllister et al 2013[17]	Winter hospital admissions with COPD	Season differences	+	++
	Carder et al 2005[91]	Cardiorespiratory mortality	Time series	++	++

	Gemmell et al 2000[127]	Mortality from respiratory disorders (as well as cardiovascular and ischaemic heart disease)	Weekly time series	+	+
Northern Ireland	Morris et al 2007[76]	Respiratory (and circulatory) death	Monthly analyses	+	++
Ireland	Callaly et al 2013[12]	30-day hospital mortality and hospital presentation for chronic obstructive disease, pneumonia (as well as epilepsy/seizures and congestive heart failure)	Seasonal and cold-related variation	+	+
	Goodman et al 2004[100]	Cardiovascular (as well as respiratory and other) mortality	Time series	++	+
	Clinch and Healy 2000[126]	Mortality from respiratory disease (and cardiovascular disease)	Proportionate and relative winter excess	-	+
Finland	Makinen et al 2009[62]	Respiratory infections in relation to low temperature	Time series	+	+
	Reinikainen et al 2006[85]	Intensive care mortality: respiratory failure was increased in winter	Seasonal comparison	++	+
Italy	de Donato et al 2013[13]	Mortality and emergency room attendance: respiratory causes (as well as cardiovascular disease and all natural causes and injuries)	Cold spells	++	+
Netherlands	Huynen et al 2001[120]	Mortality: respiratory (as well as cardiovascular and from cancer)	Time series	++	++
	Kunst et al 1993[148]	Mortality from respiratory (as well as cardiovascular, cancer, external and other) causes	Time series	+	+
Norway	Nafstad et al 2001[121]	Mortality from respiratory (as well as cardiovascular, gastrointestinal and all) causes	Time series	+	+
Spain	Gomez-Acebo et al 2013[15]	Mortality from respiratory diseases (as well as cardiovascular disease and cancer)	Case crossover	++	+
	Iniguez et al 2010[52]	cardio-respiratory mortality	Time series	+	+
	Diaz et al 2005[92]	Mortality from respiratory (as well as circulatory and all) causes	Time series	+	+
	Ballester et al 1997[136]	Mortality from respiratory diseases (as well as circulatory, malignant tumours and all causes except external ones) in relation to cold	Time series	+	+
Sweden	Rocklov et al 2011[43]	Respiratory (as well as cardiovascular and noncardio-respiratory) mortality, Stockholm – negative for respiratory association	Time series (by season)	++	+
	Rocklov and Forsberg 2008[71]	Respiratory and cardiovascular mortality, Stockholm	Time series	++	++
Europe	Analitis et al 2008[65]	Respiratory (as well as cardiovascular, and cerebrovascular deaths)	Time series	++	++

Japan	Atsumi et al 2013[11]	Cardiovascular mortality	Case cross-over of cohort	++	+
Taiwan	Tseng et al 2013[22]	Exacerbation of COPD	Case crossover	+	+
New Zealand	Davie et al 2007[73]	Mortality by cause (diseases of the circulatory system accounted for 47% of all excess winter deaths from 1996–2000 with mortality from diseases of the respiratory system accounting for 31%)	Seasonal (monthly) analysis	+	+
Australia	Turner et al 2012[32]	Ambulance attendance for respiratory and cardiovascular) conditions	Time series	++	++
USA	Barnett et al 2012[24]	Respiratory (as well as cardiovascular mortality)	Time series + Bayes model	++	++
	Anderson and Bell 2009[56]	Respiratory (as well as cardiovascular) mortality. 107 US communities	Time series	++	++
	Medina-Ramon et al 2006[82]	Mortality from pneumonia (as well as stroke, cardiovascular disease, myuocardial infarction and cardiac arrest)	Case only analysis	++	+
	Schwartz 2005[98]	Mortality during extreme temperature (low and high): COPD predictive of vulnerability (but diabetes, myocardial infarction, pneumonia and congestive heart failure not statistically associated)	Case only analysis	++	++
	Braga et al 2002[112]	Deaths from pneumonia, COPD (not clearly associated with cold) – as well as myocardial infarction and cardiovascular disease mortality	Time series	++	++
	Gorjanc et al 1999[131]	Deaths and deaths due respiratory disease (as well as ischemic heart disease, cerebrovascular diseases) in relation to low temperature and snowfall.	Time series	+	+

Where various disease outcomes have been analysed using the same methods for the same population, the picture is usually that the steepest exposure-response relationship is seen for respiratory outcomes, cardiovascular outcomes are intermediate, and non-cardio-respiratory outcomes show the least steep (but generally still statistically significant) exposure-response relationships -- see for example[16 74 65 56 91 100] Further details of these individual studies are recorded in appendix 5, but the European study by Analitis and colleagues is typical. His study showed that a 1 degrees C decrease in temperature was associated with the following mortality risks

All natural deaths: 1.35% (95% CI: 1.16, 1.53)
Cardiovascular death: 1.72% (95% CI: 1.44, 2.01)

Respiratory death: 3.30% (95% CI: 2.61, 3.99)
Cerebrovascular death: 1.25% (95% CI: 0.77, 1.73)

Similarly, the study by Goodman and colleagues [100] found the following estimates for the percent increase in cumulative 40-day mortality for each 1°C decrease in mean temperature: cardiovascular death 2.5% (95% CI 2.0–3.0%), respiratory 6.7% (95%CI 5.8–7.6%) and other 1.5% (95% CI 0.90–2.0%).

Although cardio-vascular outcomes typically have a less steep association with low temperature than respiratory disease, it may nonetheless account for a larger burden of cold-attributable mortality because of the greater underlying frequency of cardiovascular death.

ES1.6 Summary evidence statement – (non-infectious disease) mortality and morbidity cause

The search strategy for this review was not aimed at identification of all studies examining seasonal or low temperature-related impact on health by cause. Summary of the highly selected subsample used to examine vulnerability questions is therefore inappropriate. However, within that subsample, there are sufficient numbers of highly quality positive studies to conclude very good evidence for seasonal and cold impacts on cardio-respiratory outcomes and other non-infectious disease causes. Such studies include many directly relevant to England, including six studies in England (including three time series studies) (++ or +/++) [16 18 78] and three other designs (+)[102 124 139], as well as three further time series for England and Wales (++) (myocardial infarction) [48] (mortality) [74 145] and national analyses of routine data for seasonal excess (+) by the Office for National Statistics, and one further study (+) for Northern Ireland.

Very similar findings apply to respiratory outcomes, and include the same time series as for cardiovascular disease with the exception of Bhaskaran et al 2010 and McGuinn 2013, together with studies focued on COPD, [57](+) a primary care study of respiratory disease (++)[69] and a small area ecological study of respiratory hospital admission.[97] and a study of lung function[130] (+).

Six ++ included studies (2 from England ++[16 74], 1 each from US ,[56] Europe[65], Scotland[91], and Ireland[100]) look at various disease outcomes using the same methods for the same population. These show that the steepest exposure-response relationship is for respiratory outcomes, followed by cardiovascular outcomes and then non-cardio-respiratory outcomes. Although this association is the least steep it is generally still statistically significant. However, due to the larger number of cardiovascular deaths, the cold attributable mortality is likely to be greatest for cardiovascular outcomes.

Injuries and falls: season, temperature, snow and ice

Regional analyses of cold-related mortality and hospital admission in England,[16] show evidence of an increase of risk of falls in association with low outdoor temperatures, but not of injuries overall or of injuries to the hip and thigh (odds ratio close to 1.0). More detailed analyses examined the effect of periods of heavy snowfall during the winters of 2009/10 and 2010/11, as measured by depth of resting snow. The two periods analysed were associated with an increase in A&E visits of 23.9% (95% CI: 17.4, 30.7) and 5.5% (95% CI 2.3, 8.7) for the diagnosis category 'dislocation/fracture/joint injury or amputation' compared with expected levels at those times of the year. Increases were observed during similar snowfall periods in other regions also (table 3). In all cases, the 2nd snow period was associated with a lower impact than the 1st snow period, even when average snow depth measurement was higher during the 2nd event. When further examined in more detail for the North East region, by age-groups, the increases among the elderly were modest, as well as among children (for which numbers peaked in the summer months for this diagnosis category), but were substantial among those of working age (16-64 years) where the highest relative increases were observed: with increases of 33.7% (95% CI 25.0, 42.8) and 11.3% (95% CI 7.1, 15.7) for the two snow periods respectively. Increases were not observed for A&E visits due to cardiovascular or respiratory causes or for all-cause visits during the snow periods.

Beynon and colleagues,[35] examined the relationship between temperature and emergency hospital admissions for falls on snow and ice in England, using regional emergency admission Hospital Episode Statistics for the winters of 2005/06 to 2009/10. They found overall, a (log-linear) increase in the rate of emergency hospital admissions for falls on snow and ice as temperature falls, with the highest rate of admissions among the elderly and particularly men aged 80 and over (rising to around 1 per thousand resident population). The total inpatient cost of falls on snow and ice in the 2009/10 winter was estimated at £42 million.

In a study of patients presenting with fractures to two adult and one paediatric accident and emergency departments and a minor injuries unit covering a combined population of 778,367 in Edinburgh, UK, Murray and colleagues,[39] investigated the relationship between severe weather warnings, the frequency of fractures, and fracture related workload. They found evidence of statistically significant increases in fractures with cold and inclement weather, mostly low-energy fractures treated with day-case surgery or in fracture clinics. However, the number of patients treated as inpatients for fractures showed a less clear pattern. Hip fractures were not associated with weather. Correlations with maximum daily outdoor temperature in 2008/09 and 2009/10 were: for attendances -0.05 and +0.03; for fractures overall -0.29 and -0.52 (both statistically significant); for fracture admissions -0.24 and -0.46 (the latter statistically significant); and for hip fractures -0.04 and -0.21. Severe weather warnings for icy roads were associated with a 40% (95% confidence limits 20-52%) increase in fractures.

Parsons,[42] undertook a cross-sectional study of the relationship between daily trauma admissions and observed weather variables, using data from the Trauma Audit and Research Network of England and Wales covering 21 accident and emergency departments (ED) located across England, linked to data from the UK Met Office. The study included all patients arriving at one of the selected ED, with a subsequent death, inpatient stay of greater than 3 days, inter-hospital transfer or requiring critical care between 1 January 1996 and 31 December 2006. There were strong seasonal trends in both paediatric and adult trauma admissions (higher in summer). Each 1 degree Celsius rise in maximum daily temperature was associated with a relative risk for admission of 1.003 (1.000 to 1.007) in adults and 1.019 (1.014 to 1.025) for children. The relative risk for a change in minimum daily temperature was 0.994 (0.990 to 0.998) – equivalent to a 3.2% increase in adult admissions for a five degree Celsius fall in temperature, e.g. due to a severe night time frost. Also the presence of snow increased adult trauma admissions by 7.9%.

Crawford and Parker,[105] analysed a prospective series of 3034 consecutive hip fracture patients admitted to a single unit in the United Kingdom over a 12-year period. More hip fractures occurred during the winter 867 (*55.3%*) than summer 693 (*41.7%*) (p=0.002). There was an increase in the number of extracapsular fractures (p=0.006) and tendency to a higher mortality for those patients admitted in the winter months, but no statistically significant difference in patient characteristics between the winter and summer seasons (including age, mean mental test score, mean mobility score, mean total hospital stay).

Chesser et al[113] examined the relationship between the incidence of fractures and daily temperature, months of the year and season in a consecutive series of 818 patients 65+ years of age, who presented to one district general hospital with a fracture of the proximal femur. Somewhat limited in size and not based on formal time-series methods, the results suggested no significant association of fractures with temperatures, changes of temperature, season or month of the year, and no statistically significant difference in the characteristics of patients (age, sex, pre-injury mobility, residence, functional and mental scores) presenting in different seasons or temperature ranges. However, patients presenting in winter months had a significantly longer inpatient stay.

Negative findings in relation to seasonal and weather-related variation were also reported by a small study of 429 patients with a hip fracture that showed that, that other than for ground frost, there was no significant association between the prevailing weather conditions or seasonality in hip fracture.[147]

Elsewhere, Tenias and colleagues have presented a case crossover analysis of the short-term relationship between meteorological variables and hip fractures in people over 45 years of age for a health area of the Autonomous Region of Valencia, Spain, 1996–2005.[63] There were more cases in the autumn and winter months. The case-crossover analysis showed a significant relationship between the daily duration of wind and the incidence of hip fractures (OR 1.32 CI 95% 1.10-1.58 for the windiest quartile of days vs the least windy), but no other statistically significant associations for other meteorological variables, including temperature. The results were comparable across different subgroups classified by age, sex, and type of fracture.

A Swedish study in the Umea health district[137] examined slipping on ice or snow during winter which occurred at a rate of 3.5 injuries per 1000 inhabitants per year, with the highest age-specific rate among the elderly. Most injured were elderly women. Half of all injuries were fractures; two thirds for women 50 years and over, mostly of an upper extremity. The authors concluded that “injury reducing measures, such as more effective snow clearing, sand and salt spreading in strategic areas, better slip preventive aids on shoes, and 'padding' of older women, would reduce the injuries and their consequences.”

From Australia, an observational study by Turner and colleagues[44] examined the relationship between mean daily air temperature and fall-related hip fracture hospitalisations for the period 1 July 1998 to 31 December 2004, in the Sydney region of New South Wales, Australia. After adjustment for season, day-of-week effects, long-term trend and autocorrelation, hip fracture rates were found to be higher in both males and females aged 75+ years when there is a lower air temperature: rate ratios for a 1 degree Celsius increase in temperature of 0.98 (95% CI 0.96, 0.99) in men aged 75-84 years, 0.98 (0.96, 1.00) in men 85+ years; 0.99 (0.98, 1.00) in women 75-84, and 0.98 (0.97, 0.99) 85+ years. These results are broadly consistent with, but extend, the results of an earlier analysis of hip fracture rates in New South Wales (data for 1981, 1983, 1986, 1988, 1989 and

1990), which showed a seasonal pattern in hip fracture rates, with a trough in the summer and a peak in the winter.[146] The investigators found that mean daily minimum temperature was independently and consistently associated with the monthly rates of hip fracture in both younger and older people.

In the US, Bischoff-Ferrari and colleagues,[72] investigated seasonal variation in the incidence of four common fractures, and their association with weather variables in a population-based analysis of individuals age 65 and older, from 5% sample of the US Medicare population, residing in 50 US states 1 July 1986 to 30 June 1990. The study examined fractures of the hip, the distal forearm, the proximal humerus and the ankle. All fractures were most frequent in winter and lowest in summer ($p < 0.05$ at all sites). Winter peaks were more pronounced in warm climate states, in men, and in those younger than 80 years old. In winter, total snowfall was associated with a reduced risk of hip fracture (-5% per 20 inches) but an increased risk of non-hip fractures (6-12%; $p < 0.05$ at all sites).

A study by Mirchandani et al[95] examined the effect of weather and seasonality on hipfracture (femoral neck or intertrochanteric region) incidence in adults >=65 years in New York City, 1985 to 1996. They found hip fractures were more likely to occur in the winter than in any of the other seasons (p<.001), and were correlated with minimum daily temperature (r=.167, p<.001), daily wind speed (r=.166, p<.001), maximum daily temperature (r=.155, P<.001), minutes of sunshine (r=.067, P<.01), and average relative humidity (r=.033, P=.03). A greater number of hip fractures occurred in colder months, with ambient temperature rather than any adverse circumstances related to rain or snowfall associated most closely to injury.

Jacobsen et al examined the contribution of weather to the seasonality of distal forearm fractures in a population-based study in Rochester, Minnesota, 1952-89.[132] Such fractures were more frequent in the winter among men and women 35 years of age or older, which was partially explained by a greater relative risk of distal forearm fractures on days with freezing rain (1.65; 95% CI 1.28-2.13) or snow (1.42; 95% CI 1.17-1.74) among women under 65 years of age and on days with freezing rain (1.63; 95% CI 1.23-2.17) among older women. The authors concluded that the greater seasonality of forearm compared with hip fractures is explained by the fact that more of them occur out-of-doors, though factors additional to weather also play a role in the seasonal variation.

The same group also studied the association of weather factors with seasonality in hip fracture among women aged 45 years and older in Rochester, Minnesota, 1952 to 1989.[143] The risk of hip fracture was increased on days with snow (relative risk 1.41, 95% CI 1.10, 1.81) or freezing rain (RR 1.82, 95% CI 1.27, 2.62), and the elevated risk of hip fracture in winter, compared with summer (RR = 1.44, 95% CI 1.0, 2.09) was reduced after controlling for weather (RR = 1.16, 95% CI 0.81, 1.65). Among women aged 75 years and older, ice and snow were not strongly related to fracture occurrence.

In Canada, a study by Morency et al [29] based on ambulance records, reported that 72% of the outdoor falls were explicitly attributed to ice and/or snow and/or slipping. Three episodes of excess falls, representing 47% of all outdoor falls, were preceded by rain and followed by falling temperatures, or were concomitant with freezing rain.

Also in Canada a time series study by Modarres and colleagues [20] examined the association of climate variables and hip fracture (n=22855 cases of hip fracture, 75.8% female) in patients, 40-74 and 75+ years, with hip fracture in Montreal, Quebec, 1993-2004. Their models describe 50-56 % of daily variation in hip fracture rate and identify snow depth, air temperature, day length and air pressure as principal influencing variables on the time-varying mean and variance of the hip fracture rate; find that the effect of climate variables on hip fracture rate is most acute when rates are high and climate conditions at their 'worst'; and observe that the association of climate variables and hip fracture does not seem to change linearly, but to increase exponentially under harsh climate conditions. The climatic/meteorological conditions for Montreal are appreciably different from those of the UK, and the sophisticated analysis make clear interpretation difficult.

In a further Canadian study, Levy et al[135] investigated the relationship between inclement weather and the risk of hip fracture using hospitalization data on all hip fractures (n=18,455) in Montreal, 1982 to 1992, linked to weather data on the amount of snow, rain, and freezing rain and outdoor temperature. They observed a cyclical pattern, with the peak of hip fractures in mid-December among women and the first week of January among men. The pattern was less pronounced among women than men, with peak-to-trough ratios of 1.2 and 1.4, respectively. Days with lower temperatures, snow, and freezing rain were associated with increased rates of hip fracture. The relative risk (relative to days > 5 Celsius without precipitation) of days with any freezing precipitation was 1.14 (1.04, 1.24). The association between inclement weather and hip fractures was stronger among younger persons in both women and men. The authors speculate about the possible additional influence of slower reaction times in winter and winter bone loss as contributory mechanisms, or other (low) temperature effects.

Although snow and ice contribute to the risk of falls and injuries, the relationship is more complex when stratified by age and type of injury risk, and may vary by geographical setting/climate conditions. Overall, there is a steep increase in the rate of emergency hospital admissions for falls on snow and ice as temperature falls,[35] though in the UK seasonal fluctuation is generally modest. Hip fractures, at least among elderly groups, appear to have a comparatively weak relationship with cold/icy weather in the UK,[39 105 113 147] and the large majority of falls resulting in fractured hip occur indoors. Fractures of other bones (especially distal forearm) are more strongly linked to cold/icy weather,[132] but the greater increase is in younger, working-age adults than the elderly. Some effect occurs on risks in children, but children have greater overall levels of fracture risk in summer, probably because of outdoor activities. International evidence, especially from North America, suggests greater increase in risk in more extreme icy weather.[135]

ES1.7 Summary evidence statements – falls and injuries

18 studies looked at seasonal variations in falls and injuries (7 from the UK (3 ++ [16 105 113], 4 + [35 39 42 147]), 4 from the US (3 ++ [72 143 132], one + [95]), 3 from Canada (2 + [29 20], one ++ [135]) 2 from Australia (1 + [44], 1 ++ [146]) and one each from Spain[63] and Sweden[137] (both +)). Although snow and ice contribute to the risk of falls and injuries, the relationship is more complex when stratified by age and type of injury risk, and may vary by geographical setting/climate conditions. Overall, there is a steep increase in the rate of emergency hospital admissions for falls on snow and ice as temperature

falls,[35] though in the UK seasonal fluctuation is generally modest. Hip fractures, at least among elderly groups, appear to have a comparatively weak relationship with cold/icy weather in the UK[39 105 113 147] and the large majority of falls resulting in fractured hip occur indoors. Fractures of other bones (especially distal forearm) are more strongly linked to cold/icy weather, [132] but the greater increase is in younger, working-age adults rather than the elderly. Some effect occurs on risks in children, but children have greater overall levels of fracture risk in summer, probably because of outdoor activities. International evidence, especially from North America, suggests greater increase in risk in more extreme icy weather.[135]

(5) Socio-demographic factors

Rurality

Despite a common assumption that rural populations are more likely to be at risk of cold exposure and hence of cold-related mortality and morbidity, the evidence for the UK and England in particular suggests no material difference in the vulnerability to cold by urban-rural status. That was the conclusion of a 2002 study by Lawlor and colleagues,[115] rating +/+, who examined the pattern of winter mortality in the South West Region of England, using data aggregated over a five year period 1994–1998: there was no clear evidence of trend across quintile of population density (persons.km^{-2}) in terms of the 'seasonality ratio' – the ratios being 116.32, 117.02, 117.10, 115.90, and 116.42 for each of the five quintiles of increasing population density (p-value for trend =0.3).

More recent and statistically powerful time-series analyses using national (English) data linked to small-area markers of urban-rural status have also shown no clear evidence of association between rurality and cold-related mortality (Hajat et al 2013,[16] rating ++/++, Hajat et al 2007,[74], rating ++/++) or morbidity (hospital admission) (Hajat et al 2013[16]).

Morris and colleagues (2007), rating +/++, have provided indirect evidence of *potential* vulnerability for winter death in some rural areas of Northern Ireland, but the empirical evidence for this is weak.[76]

Elsewhere, in a study in New Zealand, Hales and colleagues (2012), rating ++/+, using data of record linkage from five censuses, provide evidence that *urban* dwellers are at greater risk of excess winter death than those of rural areas,[25] though it is unclear how those results would translate to England. However, in an ecological spatial analysis of data from Taiwan, Wu and colleagues (2011), rating +/+, found evidence that elevated cardiovascular mortalities after cold events were inversely associated with 'medical resources availability and the degree of urbanisation'[45] while in the US, Macey reported that "elders living in nonmetropolitan areas were disproportionately likely to suffer deaths from temperature-related causes", though the analytical basis and interpretation of this result are somewhat unclear (rating +/+).[149]

Overall, the evidence appears to be against greater vulnerability to winter- or cold-related mortality/morbidity in rural areas, especially in England which has some of the better empirical research, though the evidence base remains thin.

ES1.8 Summary evidence statement – rurality

Seven studies consider issues of rurality, including 3 UK studies (2 from England, 1 ++ [16], 1 + [115] and 1+ from Northern Ireland[76]). 4 others (all +) come from New Zealand,[25] Taiwan[45 49] and the US.[149] Overall, the evidence appears to be against greater vulnerability to winter- or cold-related mortality/morbidity in rural areas, especially in England which has some of the better empirical research, though the evidence base remains thin.

Socio-economic status

Evidence on the effect of socio-economic status in relation to excess winter mortality/morbidity is also mixed.

Studies that provide the most robust and pertinent evidence for England suggest overall no greater risk among more deprived populations. The recent time-series analysis of regional emergency hospital admissions data for England by Hajat and colleagues (2013), rating ++/++, found no evidence of effect modification of the cold-risk by area-level measures of deprivation.[16] Indeed, in this analysis the most deprived quintile was associated with the lowest point estimate of cold-related relative risk.

This finding is broadly consistent with an earlier similar analysis by Hajat and colleagues,[74], rating ++/++, of post-coded mortality data for England and Wales, 1993 and 2003, in which vulnerability to cold was found not to be modified by deprivation, except in rural populations where cold effects were slightly stronger in more deprived areas.

Lack of gradient in cold risk with socio-economic deprivation was found also in earlier studies by Lawlor and colleagues. In their 2000 analysis of data for Bradford,[129] rating +/+, no clear pattern of trend was observed in age-standardized excess winter mortality in relation to enumeration district markers of socio-economic deprivation based on 1991 census-derived 'Super Profile groups'. In a subsequent analysis based on the data for a larger regional population of South West England (Lawlor et al 2002,[115] rating +/+) no trend was observed in relation to the Townsend index of socio-economic status, with the seasonality ratio having almost identical point estimates in the first and last quintile of deprivation (115.28 and 115.87 respectively, p-value for trend across quintiles = 0.6).[115 115] An earlier study by Shah and Peacock (1999),[133] rating +/+, of deaths of Croydon residents, 1990-1995, also showed no evidence of a relation between age- and sex-standardised seasonality ratios and Townsend scores for all deaths, cardiovascular deaths or respiratory deaths, and no interaction between Townsend score and temperature in the model of ward mortality rates.

These findings are in line with those of other analyses of data in England, including of a case-control study of social factors on winter hospital admission for respiratory disease based on data from 79 general practices in central England (Jordan et al 2008,[69] rating ++/++) and an analysis of mortality, 1981 to 1999, and emergency hospital admissions, 1990 to 1999, in the South Yorkshire Coalfields Health Action Zone (Maheswaran et al 2004,[102] rating +/+) where deprivation was again classified using the enumeration district Townsend index. In a national (Great Britain) small-area analysis at electoral ward level of mortality in men and women aged 65 and over, between 1986 and 1996, Aylin and colleagues 2001,[118] rating +/++, identified little association between winter mortality and socio-economic deprivation. A similar conclusion was reached by Watkins and colleagues 2001,[123] rating -/+, who studied patterns of hospital admissions data for the Metropolitan Borough of Stockport, analysing winter and summer differences in ACORN-specific, age- and sex-standardized hospital admissions for ischaemic heart disease. In the latter study, the authors hypothesized that the lack of scoio-economic gradient may in part reflect the relatively high admission rates in the summer months for more deprived populations.

Strong evidence for lack of socio-economic gradient in excess winter death comes from a population cohort study (119,389 person years of follow up) based on 106 general practices from the Medical Research Council trial of assessment and management of older people in Britain (Wilkinson et al 2004,[104] rating ++/++). With control for individual level risk factors, there was no evidence that the winter:non-winter ratio of mortality varied in relation to socio-economic factors. Similarly, a 2001 report based on analysis of mortality data, 1986-1996, linked at postcode level to the English House Conditions Survey (Wilkinson et al 2001,[124] rating +/+), showed no evidence that the winter:non-winter mortality ratio was related to socio-economic group. Indeed, the point estimates of winter excess mortality were marginally *greater* in households where the head of household was from professional or managerial groups than they were in households where the head was a semi- or unskilled labourer, though this may in part reflect confounding by age (higher socio-economic groups have somewhat older populations).[104]

Donaldson and Keatinge 2003,[106] rating +/+, offered a more nuanced interpretation of socio-economic patterns based on their analysis of cold related mortality, 1998–2000, in England and Wales at ages 65–74 and 50–59. These authors found that in men of working age (50–59), cold related mortality was low in social class V compared with that in any other social class, but that it was high in social class V in men of the retired age group (65–74). Moreover, in social class V, but not class I, cold mortality in men of working age was also low compared with women or housewives of the same class and age group. Their interpretation of these findings is that (working) manual labourers are in part protected against the effect of daytime cold stress by their physical activity, independently of the home environment and income.

In Scotland, a tentative and limited correlation analysis based on the Scottish Index of Multiple Deprivation (SIMD), [94] rating -/-, has been used to suggest an association between excess winter death and deprivation, while a more sophisticated time-series regression analysis of seasonal variation in mortality in Scotland, 1981 and 1993 (Gemmell et al 2000,[127] rating +/+), found little evidence of link to socio-economic status. In Ireland, Callaly et al,[12] rating +/+, in an analysis of all emergency medical admissions to St James' Hospital, Dublin, 2002-2011, found that although deprivation was a univariate and multivariate predictor of overall mortality, it was not related to seasonal variation.

On the other hand, in a month by month analysis of all COPD admissions (ICD10 codes J40-J44 and J47) for 2001-2010 for all Scottish residents, McAllister and colleagues found evidence of stronger associations between low outdoor temperature and admission in the more deprived quintiles.[17] In Canada, Bayentin and colleagues found evidence that the effects of meteorological variables on the daily admissions rate for ischaemic heart disease (IHD) were more pronounced in regions with high deprivation index.[47] In the US, Curriero found that two indicators of socioeconomic status (percentage of persons without a high school education and percentage of those living in poverty) were associated with increased mortality effects of high temperature, but not cold.[114] Similarly, Madrigano and co-workers showed that persons living in areas with greater poverty were more susceptible to heat but (by implication, though not explicitly reported) not to cold,[19] while Anderson and Bell, observed no variation in risk of cold mortality in relation to community level markers of income or unemployment.[56] In a novel analysis of US individual death records, 1989 to 2006, Rau and colleagues could not detect any noteworthy differences in the seasonality of deaths from heart and respiratory disease in relation to socioeconomic group.[54]

In New Zealand, Davie et al reported no evidence to suggest that patterns of EWM differed by ethnicity, region or local-area based deprivation level,[73] though Hales and colleagues in their analysis of mortality data linked to records from five censuses, showed that after adjusting for age, sex, census year, ethnicity and tenure, those in the lowest tertile of income were at increased risk of winter death compared to those in the highest tertile (odds ratio 1.13 (95% CI 1.08 to 1.19)).[25] In a spatial analysis of data for Taiwan, Chen provided evidence that the effects of meteorological variables on the daily IHD admissions rate were more pronounced in regions with high smoking prevalence and high deprivation index.[49]

In contrast, the case crossover analysis by Wichmann and colleagues of hospital admissions for acute myocardial infarction in Copenhagen found that the highest SES group seemed to be more susceptible in the cold period.[34]

As reported briefly above, in a cross-country analysis of excess winter death in 14 European countries, Healy showed an ecological association between country-level parameters of socio-economic development (as well as of housing thermal efficiency) and (lower) risk of winter mortality.[107]

Overall, notwithstanding some reports of links to socio-economic status, the most direct and secure evidence relevant for England suggests no appreciable socio-economic gradient in winter- or cold-related risk.

ES1.9 Summary evidence statement – socio-economic status

26 studies look at socio-economic status. Of these, 15 are from the UK (12 from England/England and Wales (4 ++ [74 16 69], 7 + [128 102 124 118 115 129 133], 1 +/-[123]), 3+ from Scotland ([127 17 94])). A further 4 are from the US (3++ [114 56 19], 1 + [47]), 2 from New Zealand (1 + [25 73]) and 1 each from Ireland,[12] + Canada,[47] + Taiwan,[49] ++ Denmark,[34] ++ and Europe.[107]+).

4 studies provide evidence to suggest that deprived groups suffered greater effects of cold ([25 49 47 17]),. 2 studies suggest a higher rate of admission for MI[61] and risk of winter mortality[107] in groups with higher measures of higher socioeconomic status or development. 1 study from England and Wales found a lower rate of mortality in working age men in social class V compared to other social classes.[128]

Overall, notwithstanding some reports of links to socio-economic status, the most direct and secure evidence relevant for England [74 16 102 124 104 118 69 129 115 133 123] suggests no appreciable socio-economic gradient in winter- or cold-related risk.

(6) Housing factors including fuel poverty

There is limited robust evidence on the relationship between housing factors and winter- or cold-related mortality and morbidity in large part because of the large sample size needed to test housing as a *an effect modifier* of the winter/non-winter ratio in mortality or morbidity.

(i) Central heating

Among UK research, an early ecological study of seasonal mortality, 1986-1996, in men and women aged 65 and over by Aylin and colleagues[118] was based on ward-level data for Great Britain. Their analyses suggested that lack of central heating was associated with a higher risk of dying in winter (odds ratio = 1.016 (1.009, 1.022). These authors noted that selected housing variables derived from the English House Condition Survey showed little agreement with census-derived variables at electoral ward level. Subsequently, Wilkinson and colleagues,[124] linked data from the English House Conditions Survey to mortality statistics and observed a modest but not statistically significant difference in excess winter death in those without central heating.

In the US, Curriero et al[114] undertook time-series analyses of the association between temperature and mortality for 11 large eastern US cities, 1973–1994, and explored city-level (ecological) characteristics associated with variations in this temperature-mortality relation. Although not statistically significant, the percentage of homes with heating was associated with a reduction in the steepness of the cold slope, but this (interaction) effect was more substantially attenuated after additional controlled for latitude (since heating is strongly correlated with latitude).

ES1.10 Summary evidence statement – central heating

Three studies (1 + UK,[118 124] 1 ++ US[17]) looked at the association of heating or central heating with health. Using ward level data Aylin[118] found a higher risk of dying in winter with lack of central heating (OR 1.016, 1.009, 1.022). A small excess was also obsewrved in a study by Wilkinson et al 2001,[124] (+). Curriero[17] found a non-significant reduction in the steepness of the slope relating temperature and mortality across 11 eastern US cities. This interaction was reduced when latitude was controlled for.

(ii) House conditions, including thermal efficiency, temperature and fuel poverty

The 2001 study by Wilkinson and colleagues[124] provides relatively detailed evidence relating excess winter death to housing conditions. It examined seasonal mortality in England, 1986-1996, with death records linked by postcode of residence (14 households per postcode) to data from the 1991 English House Conditions Survey. Among its chief findings were that:

- The ratio of winter:non-winter mortality was slightly higher in properties with poorer energy efficiency as measured by the Standard Assessment Procedure (SAP) rating
- There was evidence of a clear gradient of risk of excess winter death with age of property, with people living in dwellings with a more recent build date having lower risk than those

living in older dwellings. Age of property has a strong correlation with standards of energy efficiency. A key result of the multivariable analyses is given below:

Multi-variable analyses of the risk of Excess Winter Death in relation to property age (adjusted for age, sex, socio-economic group and presence of central heating):

Property age	Relative risk for EWD
Pre 1850	1
1850-99	0.97 (0.83 – 1.12)
1900-18	0.93 (0.80 – 1.09)
1919-44	0.96 (0.83 – 1.11)
1945-64	0.96 (0.83 – 1.11)
1965-80	0.87 (0.75 – 1.01)
Post 1980	0.82 (0.68 – 0.98)
	(p=0.001 for trend)

Table 3. Extract of data from Wilkinson et al 2001.[124] Multivariable adjusted risks of excess winter death in relation to property age.

- There was evidence of a trend in the ratio of winter:non-winter mortality in relation to indoor temperature. Indoor temperature estimates (usually for only one dwelling per postcode) were based on a 'standardization' procedure of simultaneous spot indoor and outdoor measurements in which an adjusted indoor temperature was estimated through a regression approach: the mid-afternoon temperature on a day with maximum outdoor temperature of 5 degrees Celsius – referred to as the Standardized Indoor Temperature (SIT). In unadjusted analyses, the seasonal increase in mortality in homes in the quartile with lowest SITs was 1.20 (1.09, 1.32) times that of in homes in the warmest quartile of SITs (p=0.002 for trend).

In further analyses, daily time series methods were used to characterize the steepness of the (low) temperature-mortality relationship in relation to the Standardized Indoor Temperature. This showed that the relationship between outdoor temperature and mortality was steeper among residents of homes with low SITs than among those living in warmer homers, i.e. for each degree Celsius fall in *outdoor* temperature, the percentage rise in mortality was greater in those living in cold homes (low SITs) compared with those living in warm homes (high SITs).

Other evidence from this study (Tables 4, 5 & especially 6 from Wilkinson et al 2001[124]) showed that multi-variable adjusted determinants of (standardized) low indoor temperatures included: size of household (warmer in larger families, 0.5 deg C range of temperature differences between warmest and coolest in relation to household size); property age (strong effect, older properties colder: range of temperature difference 1.2 deg C); absence of central heating (strong effect: temperature difference 1.1 deg C); dissatisfaction with heating system (very strong effect: range of temperature difference 1.8 deg C (most vs least satisfied)); and minimum standardized heating costs (strong effect: range of temperature difference 1.1 deg C). Variation of temperatures in relation to household income was fairly modest – only 0.25 degree Celsius difference between the lowest and highest quartile of income.

People in social or local authority housing tend to have low standardized heating costs[124] compared with owner occupiers or those in privately rented accommodation, and comparatively high estimated Standardized Indoor Temperatures, probably because of newer more energy efficient stock and the higher frequncy of flats and dwellings sharing communal heating systems. But those in social or local authority housing (and those with low household income) showed greater decline in SITs as standardized heating costs rose.

The same group subsequently published a study based on an analysis of data from a cohort of elderly people from 106 general practices in the Medical Research Council trial of assessment and management of older people in Britain.[104] There was little evidence that the ratio of winter:non-winter mortality varied by geographical region, age, or any of the personal, socioeconomic, or clinical factors examined except for gender and self-reported history of respiratory illness (see above). More specifically, in relation to housing/indoor environment, there was no evidence that the winter:non-winter ratio of mortality was higher in those who lived alone (OR 0.94 (0.88 to 1.02)), or who reported difficulty making ends meet (OR 0.96 (0.88, 1.06)) or difficulty keeping the house warm ('sometimes:' OR 0.98 (0.87 to 1.11), 'often:' OR 1.14 (0.89 to 1.46)).

In 2002, Mitchell and colleagues presented an analysis of data from cross-sectional observational studies from 5663 participants of the Health and Lifestyle Survey (HALS) to examine the relationship between exposure to colder climate and housing quality, and second the relationship of colder climate and housing quality with risk of hypertension.[116] They reported that people in colder areas are more likely to live in poor quality housing and that the combination of colder climate plus residence in worse quality housing raises significantly the risk of diastolic hypertension (OR 1.45, 95% CI 1.18, 1.77) and, more weakly, systolic hypertension (1.25, 95% CI 1.01, 1.53).

A similar more recent study by De Vries and Blane[14] examined the inter-relationship between climate, fuel poverty and health, using individual data (n = 7160) on respiratory health, hypertension, depressive symptoms and self-rated health derived from the 2008/09 wave of the English Longitudinal Study of Ageing. These data were linked to weather data for 89 English counties and unitary authorities. In multilevel regression models they report that variation in individual risk of fuel poverty was not explained by variations in average temperature (climate), but that fuel poverty was significantly related to worse health for two of the four health outcomes studied (respiratory health and depressive symptoms). In models without terms for climate interaction, the coefficient for the difference in peak expiratory flow in people living in fuel poverty was -9.22 (-16.8, -1.61) l/min; and the odds ratio for depression 1.37 (1.17, 1.61).

In a relatred analysis, Webb et al.[23] also report a study on housing conditions and respiratory health using data from the second wave of the English Longitudinal Study of Ageing. The measure of fuel poverty was based on the proportion of the total annual net household income respondents reported spending on fuel (including electricity, gas, solid fuel and all other fuels). Multivariate regression methods were used to test the associations of housing factors with respiratory health while accounting for the potential effect of other factors, including social class, previous life-course housing conditions and childhood respiratory health. The authors found that older people who were in fuel poverty had significantly worse respiratory health as measured by peak expiratory flow rates: difference in peak expiratory flow (PEF) in the fully adjusted model −8.79* (−16.46, −1.11) l/min. But after accounting for the same covariates, fuel poverty had no association with other measures of respiratory health (forced expiratory volume in 1 second, forced vital capacity and presence of obstructive defect).

Rudge and Gilchrist reported a small area ecological study of the variation in the winter excess of emergency hospital episodes for all respiratory diagnosis codes in the London Borough of Newham.[97] This was a population-based study of 25,000 residents aged >or=65 years using on Hospital Episode Statistics data, 1993-1997, anonymized at enumeration district (ED) level (average of 220 households, or 460 persons per ED). The excess winter morbidity ratio (for emergency hospital admission) was examined in relation to an ED-level composite marker of Fuel Poverty Risk (FPR) based on the following factors:

- low income: households receiving Council Tax Benefit (LBN data), this benefit being available to householders of all tenures;
- age: households including pensioners (1991 Census*);
- poor housing: extent of homes with energy efficiency ratings below the 1991 national average;
- under-occupation (where small households occupy relatively large homes for their needs): from combined Census variables: households of one or two persons only and households with ≥5 rooms.

Using FPR as a two-level factor (high and non-high), their analysis provides odds ratios for higher winter/summer ratios in relation to the FPR binary variable for two of four years studied: 1993 OR 1.7 (1.1, 2.7) and 1996, OR 1.6 (0.9, 2.8). In a regression with grouped EDs, having allowed for FPR, no other variables contribute to the difference between winter and summer morbidity counts. This analysis did not adjust for possibly confounding modifiers, in particular age, but given the analysis is based on those aged 65+, the FPR results are probably still largely robust.

A study based on two questionnaire surveys of residents in social housing in Torbay, Devon, 2000 and 2001, investigated relationships between home characteristics and respondent health.[111] The questionnaire elicited information on both the physical conditions in the house or flat and the physical and mental health of its occupants. Although univariate associations were observed between housing characteristics reflecting aspects of energy inefficiency (cold home, dampness, mould) and selected illnesses, in multivariable analyses, none of these housing conditions were clearly associated with any of the major physical conditions or minor illnesses analysed, with the exception of the General Health Questionnaire (GHQ) score in relation to mould (but not cold).

In a study of relatively deprived households in North East England based on a survey in 2000 and a follow-up in 2001, respondent-assessed health and health behaviours and administered SF36 health questionnaire score were analysed in relation to measures of energy efficiency (SAP rating) and satisfaction with home heating among other parameters.[93] Respondent health was significantly and independently associated with lower satisfaction with home heating and worse SAP rating. In the full logistic regression model, a unit decrease (worsening) in SAP score was associated with a 1.03 (1.01-1.05) odds of having poorer respondent-assessed health.

Other research, based on the Family and Children Study, entailed the annual follow-up of a sample of English children (n=6431 followed up annually), 2001 to 2005, using caregiver interviews for children under 11-years and self-completed questionnaires for adolescents. [66] The study focused on the relationship between poor housing including 'inadequate heating,' and child health. This study found that the longer children live in 'bad housing,' the greater the frequency of a range of adverse outcomes. In relation to inadequate heating, two notable findings were: that the percentage of children with chest, breathing, asthma or bronchitis problems increased with the number of years they had lived in an inadequately heated home (3-5 years 15%, 1-2 years 11%, 0 years 7%), as did the percentage of children with four or more negative "Every Child Matters" (ECM) outcomes (3-5 years: 28%, 1-2 years: 9%, 0 years: 4%). These associations may reflect broader socio-economic associations.

A non-intervention observational study which examined mental health in relation to measures of fuel poverty was based on secondary analysis of data from the Adult Psychiatric Morbidity Survey 2006/7 (APMS).[51] A key outcome was that of common mental disorder (CMD), classified on the basis of the Clinical Interview Schedule - Revised (CIS-R), which was related to measures of fuel poverty as indicated by whether the respondent reported being thermally comfortable and of having fuel-related financial strain. Among those who said worry about cost meant that they had used less fuel than was necessary to heat the home in the past year there was increased prevalence of CMD (OR 1.77 (1.46, 2.16)); and likewise among those who reported a cold home (or unable keep their home warm enough in winter) (OR 1.85 (1.33, 2.58). (Presence of mould, though not directly a fuel poverty measure, was also associated with CMD and with physical health condition in last year.)

A cross-sectional observational study by Osman and colleagues[70] concentrated on patients with chronic obstructive pulmonary disease (COPD) living in their own homes. Living room (LR) and bedroom (BR) temperatures were measured at 30 min intervals over 1 week using electronic dataloggers, and patients' health status measured with the St George's Respiratory Questionnaire (SGRQ) and EuroQol: EQ VAS. Of the 148 patients who consented to temperature monitoring, poorer respiratory health status was significantly associated (P = 0.01) with fewer days with 9 h of warmth at 21 degrees Celsius in the living room (independently of age, lung function, smoking and outdoor temperatures). Bedroom temperatures with at least 9 h at 18C and living room total hours of warmth at 21C showed a trend to association but were not significant at the required 0.01 level. There was no clear evidence of association with measures of indoor temperature for activity limitation scores, impact score or EQ visual analogue scores.

Studies of winter death that have made multi-country comparisons within Europe have included the previously mentioned studies of the Eurowinter Group. [128] [142] Their evidence in relation to housing suggests that, especially for the oldest groups studied (those aged 65-74), high levels of protection against indoor and outdoor cold at given outdoor temperatures were found mainly in countries with cold winters, and were associated with low levels of excess mortality at a given level of outdoor cold. Regions such as London that had poor protection against cold and/or high baseline mortalities had higher levels of winter excess mortality than expected for the coldness of their winters.[128] Although indirect associations, their findings suggest various cold-exposure markers (standardized to conditions of 7 degrees Celsius mean daily temperature) are related to cold-related mortality from all causes, ischaemic heart disease, respiratory disease and, to lesser extent, cardiovascular disease. In relation to the indoor environment, bedroom heating of >= 4 hours/d and living room temperature were both associated with (lower risk of) cold-related all-cause mortality (coefficients of -0.8 ($p=0.002$) and -0.3 ($p<0.001$) respectively).

These data broadly fit with the ecological analyses of the coefficient of seasonal variation in mortality (CSVM) in 14 European countries undertaken by Healy.[107] This study reports moderate associations (in inter-country comparisons) between the CSVM and measures of thermal efficiency, including significant associations for cavity wall insulation, double glazing, and floor insulation (regression model results for CSVM on country level markers of: cavity wall β=-2.56, $p=0.02$; double glazing β=-0.31, $p=0.02$, but floor insulation β=1.01, $p=0.03$).

Other European comparative data come from the LARES Survey (Large analysis and Review of European Housing and Health Status) coordinated by the World Health Organization European Office for Environment and Health. This surveyed the condition of 3373 dwellings and the health status of their 8519 inhabitants in eight European cities: Angers (F), Bonn (D), Bratislava (SK), Budapest (HU), Ferreira do Alentejo (POR), Forli (IT), Geneva (CH), Vilnius (LT) (approximately 400 dwellings, 1000 inhabitants per city). Analyses by Croxford[58] focused on the association of cold homes with selected outcomes, with four variables used as indicators of poor hygrothermal conditions: reported cold in winter; dissatisfaction with insulation; dissatisfaction with heating system; dissatisfaction with draughts. The analyses were based on prevalence data rather than on seasonal variations in health, and the nature of confounder adjustment was not clear. However in multivariable logistic regression models associations were reported as follows: respiratory symptoms in children were 2.1 (1.0, 4.38) times more prevalent if dissatisfied with heating system and 4 times less prevalent (OR=0.25 (CI 0.13-0.49) if dissatisfied with draughts; and in seniors respiratory symptoms were 1.97 times more prevalent if house cold in winter (OR:1.97, CI:1.03-3.76) and 2.39 times more prevalent if dissatisfied with insulation (OR:2.39, CI:1.07-5.36). Arthirtis symptoms (in seniors) were 1.92 times more prevalent if the house was cold in winter (OR:1.92, CI:1.16-3.16). And belief that mental health problems are related to dwelling was less prevalent in children if dissatisfied with insulation (OR:0.13, CI:0.02-0.99), and more prevalent in adults if the house cold in winter (OR:1.79, CI:1.07-2.98), they were dissatisfied with insulation (OR:1.67, CI:1-2.81); or dissatisfied with heating system (OR:1.82, CI:1.14-2.91). There were no reported associations for cardiovascular problems.

ES1.11 Summary evidence statement – housing conditions including thermal efficiency

6 UK studies (1 + Great Britain-wide,[116] 5 England (1 ++ [104] 2+ [124 66], 2- [111 93]) and 2 comparative studies across Europe[107] (+) [58](+/-) looked at various aspects of housing conditions. Wilkinson[124] found a slightly higher ratio of winter:non-winter deaths in houses with poorer SAP ratings and a study in North East England[93] found a significant and independent association with respondent-assessed health and poorer SAP ratings and lower satisfaction with home heating. Wilkinson also found a clear gradient of risk of EWD in relation to property age ($p=0.001$ for trend). The combination of colder climate and residence in worse quality housing significantly raised the risk of diastolic (OR 1.45; 1.18, 1.77) and systolic (1.25; 1.01,1.53) hypertension.[116] In children,[66] the longer a child lives in 'bad housing' the greater the frequency of a range of adverse outcomes, notably chest, breathing, asthma or bronchitis (3-5yrs 15%, 1-2 yrs 11%, 0 years 7%) and 4 or more negative 'Every Child Matters' outcomes (3-5 yrs 28%, 1-2 yrs 9%, 0 yrs 4%). The authors note these associations may reflect broader socio-economic associations. A study in Torbay[111] found univariate

associations between housing characteristics reflecting energy inefficiency and selected illnesses but no clear associations between housing conditions and major physical conditions or minor illnesses in multivariate analyses (with the exception of GHQ in relation to mould). A study of older people in Britain[104] (++) found no evidence of higher winter:non-winter mortality in those who lived alone (OR 0.96; 0.88, 1.06), who reported difficulty in making ends meet (OR 0.98; 0.97, 1.11) or difficulty in keeping the house warm ('sometimes': OR 0.98; 0.87, 1.11; 'often': 1.14; 0.89, 1.46).

An ecological analysis of the coefficient of seasonal variation in mortality in 14 European countries[107] (+) found moderate associations with measures of thermal efficiency, including significant associations for cavity wall insulation (β=-2.56, p=0.02), double glazing (β=-0.31, p=0.02) and floor insulation (β=1.01, p=0.03). An analysis of prevalence of selected outcomes with 4 variables used as indicators of poor hygrothermal conditions[58] found respiratory symptoms 2.1 times (1.0, 4.38) more prevalent in children if dissatisfied with heating systems and 4 times (0.13, 0.49) less prevalent if dissatisfied with draughts; in seniors respiratory symptoms were 1.97 (1.03, 3.76) times more prevalent if the house was cold in winter and 2.39 (1.07, 5.36) if dissatisfied with insulation. Arthritis symptoms in seniors were 1.92 (1.16, 3.16) times more prevalent if the house was cold in winter. Belief that mental health problems were less prevalent in children if dissatisfied with insulation (OR 0.13; 0.02, 0.99) but more prevalent in adults if the house was cold in winter (1.79; 1.07, 2.98), if they were dissatisfied with insulation (1.67; 1.0, 2.81) or dissatisfied with the heating system (1.82; 1.14, 2.91).

ES1.12 Summary evidence statement – fuel poverty

4 English studies examine aspects of fuel poverty (2 ++[51 97] and 2+ [23 14]) which consider respiratory and mental health conditions. A study of emergency hospital episodes for respiratory diagnoses from Newham[97] found an association with a composite fuel poverty risk measure for 2 of 4 years studied: 1993 (OR 1.7; 1.1, 2.7) and 1996 (OR 1.6; 0.9, 2.8). Two other studies found significant differences in peak expiratory flow with measures of fuel poverty. One study, from the English Longitudinal Study of Ageing,[14] found a difference of -9.22 (-16.8, -1.61)l/min. The other, also from the English Longitudinal Study of Ageing, found that older people in fuel poverty had significantly worse peak expiratory flow (-8.79; -16.46, -1.11)l/min.[23]

For mental health outcomes, De Vries and Blane[14] found an odds ratio for depression of 1.37 (1.17, 1.61). A study using the Adult Psychiatric Morbidity Survey 2006/7[51] found increased prevalence of common mental disorder of 1.77 (1.46, 2.16) in those who said worry had meant they used less fuel than necessary to heat the home and 1.85 (1.33, 2.58) in those who reported a cold home (or unable to keep their home warm enough in winter).

ES1.13 Summary evidence statement – temperature

Four + studies (2 from England[124 70] 2 European comparisons[128 142]) provide information on home temperature and health outcomes. Indirect associations from the Eurowinter Group[128 142] suggest various cold-exposure markers (standardized to conditions of 7^{o} C mean daily temperature) are related to cold-related mortality from all causes, ischaemic heart disease, respiratory disease and, to lesser extent, cardiovascular disease. In relation to the indoor environment, bedroom heating of >= 4 hours/d and living room temperature were both associated with (lower risk of) cold-related all-cause mortality (coefficients of -0.8 (p=0.002) and -0.3 (p<0.001) respectively). Studies from England found, in unadjusted analyses, the seasonal increase in mortality in homes in the quartile with lowest SITs was 1.20 (1.09, 1.32) times that of in homes in the warmest quartile of SITs (p=0.002 for trend) and that the relationship between outdoor temperature and mortality was steeper among residents of homes with low SITs than among those living in warmer homers, i.e. for each degree Celsius fall in outdoor temperature, the percentage rise in mortality was greater in those living in cold homes (low SITs) compared with those living in warm homes (high SITs).[124] A cross sectional study of patients with COPD patients in Scotland found poor respiratory health status was significantly associated (P = 0.01) with fewer days with 9 h of warmth at 21^{0}C in the living room (independently of age, lung function, smoking and outdoor temperatures).[70] Bedroom temperatures with at least 9 h at 18^{0}C and living room total hours of warmth at 21^{0}C showed a trend to association but were not significant at the required 0.01 level. There was no clear evidence of association with measures of indoor temperature for activity limitation scores, impact score or EQ visual analogue scores. Patients who were continuing smokers were more vulnerable to reduction in warmth.

(iii) Housing tenure

Various studies have reported variations in risk in relation to housing tenure (as distinct from housing quality). The evidence has been reported above (Wilkinson et al 2001[124] (+)) about the comparison of home heating and standardized heating costs which tend to be lower in the more recent build dwellings in the social/local authority sector.

Studies from New Zealand reported greater risk of winter death in renter vs owner occupier households OR 1.05 (95% CI 1.01, 1.10),[25] a another from the UK reports poorer respiratory function in non-owner households,[23] and greater risk of common mental disorder in social renting households.[23] A study from France[31] points to higher risk of excess winter death among residents of nursing homes. In England and Wales the risk among nursing home residents for cold death appears not to be higher than among the general elderly population, though it is relatively high for heat risk.[74]

ES1.14 Summary evidence statement -- housing tenure

5 studies consider some aspect of housing tenure (3 from England, 1 ++[74 23,] 1 +[124] , from New Zealand[25] (+) and from France (+). Studies from England[124] suggest that people in social or local authority housing tend to have lower standardised heating costs (and higher standardised indoor temperatures) compared to owner occupiers or those in private rented accommodation, and another suggest poorer respiratory function.[23] They also show a greater decline in SIT as standardised heating costs rise. 2 studies provide mixed evidence on risk among residents of nursing homes. An English study[74] found no greater risk of cold related death among nursing home residents compared to other elderly populations (but a relatively high heat risk) while a study from France[31] found a higher risk among residents of nursing homes. A New Zealand study suggests greater risk of winter death (OR 1.05; 1.01, 1.1),[25] poorer respiratory function in non-owner households and greater risk of common mental disorders in social renting households.[89]

(iv) Expenditure trade-off

A further insight from the US relates to the issue of the trade-off between expenditure on heating and on food.[80] In the Children's Sentinel Nutrition Assessment Project from June 1998 to December 2004, caregivers with children 3 years of age in 2 emergency departments and 3 primary care clinics in 5 urban sites participated in cross-sectional surveys regarding household demographics, child's lifetime history of hospitalizations, and, for the past 12 months, household public assistance program participation and household food insecurity, measured by the US Food Security Scale. It examined the influence of the Low Income Home Energy Assistance Program (LIHEAP) which is aimed at providing financial support for home heating, medically necessary home cooling, and weather-related supply shortage emergencies (targeted at "vulnerable households with the highest home energy needs" defined as those including an individual with disabilities, a frail elder, or one member who is a young child). It served nearly 5 million US households in 2004 with average household income less than $8000 a year. After control for potential confounding variables, including receipt of other means-tested programs, children in households *not* receiving the Low Income Home Energy Assistance Program had greater adjusted odds of being at aggregate nutritional risk for growth problems, defined as children with weight-for-age below the 5th percentile or weight-for-height below the 10th percentile.

ES1.15 Summary evidence statement – expenditure trade-offs

One US study[80] (+) considered the issue of trade-off between expenditure on heating and on food. After control for potential confounding variables, including receipt of other means-tested programs, children in households not receiving the Low Income Home Energy Assistance Program had greater adjusted odds of being at aggregate nutritional risk for growth problems, defined as children with weight-for-age below the 5th percentile or weight-for-height below the 10th percentile.

Summary

- *Which subpopulations are more vulnerable to cold temperatures and poorly heated or expensive-to-heat homes?*

The evidence above shows that those vulnerable to the adverse health effects of cold temperatures are quite widely distributed in the population, but are predominantly the elderly population, with small additional risks in women (versus men). Anyone vulnerable to almost any underlying medical condition is at risk, but especially those with (or at risk of) respiratory and cardiovascular diseases. The risk of falls during periods of low temperature or inclement weather (especially freezing conditions) appears to increase, especially for working age groups. There is little evidence on which to base the assessment of risk in relation to ethnicity. Rural populations appear to be a little more at risk than urban populations, and socio-economic gradients appear to be shallow. There is some evidence that people living in energy inefficient and thus hard to heat homes are at greater vulnerability to cold-related impacts, including (cardiovascular) mortality, respiratory illness and common mental disorder.

People living in poorly heated or expensive to heat homes include those living in less energy-efficient older properties, commonly in the owner occupier or privately rented sector. Although there are appreciable numbers of hard to heat homes in social and local authority housing, in general such housing has better than average energy efficiency characteristics.

- *What factors contribute to vulnerability and how do these factors interact with each other?*

The factors contributing to vulnerability to winter- and cold-related mortality/morbidity are indicated above. There is insufficient evidence to make a clear quantitative assessment of the relative contributions of different personal and housing-related risk factors, but it would be reasonable to assume broadly multiplicative risks i.e. that, for example, the relative risk associated with inefficient housing would multiply the relative risks associated with individual personal characteristics such as age and sex. Where individual factors combine, therefore, a starting assumption would be that the joint risk could be represented by the product of the relative risks associated with each individual factor. Some individual factors will tend to cluster (e.g. age, sex and pre-existing illness), but there appears to be relatively weak association between personal factors and housing quality.

Quality of quantitative studies

The studies included in this review were quite varied in terms of their design, specific research focus and settings, and also in their quality. Many of the studies included were not specifically designed to test questions of vulnerability to excess winter mortality/morbidity, which adds to the difficulty of interpreting their evidence.

The nature of the question itself (vulnerability to winter-/cold-related mortality/morbidity) poses particular epidemiological challenges as it requires study of *effect modification* in the *seasonal variation* in outcomes or in cold-attributable outcomes. This places additional demands on epidemiological designs and statistical power, and it is for this reason that in many areas there is a paucity of high-quality research studies, particularly in areas with 'hard' outcomes such as mortality and hospital admission. Thus, while there are many very good quality time-series studies based on state-of-the-art methods that provide fairly robust evidence about temperature-response relationships for a range of disease outcomes, their evidence is often more limited in relation to effect modifiers that may be tested using simple ecological parameters (e.g. the use of city characteristics to test variation in the slope of temperature-mortality functions).

In relation to housing and fuel poverty, a common difficulty is the wide range of correlated potential explanatory factors and the complexity of ensuring adequate control of confounding. There are usually strong correlations between housing quality, socio-economic circumstances and a wide range of social variables all of which have potential bearing on health outcomes. Moreover, in relation to housing studies, it is seldom that studies are designed specifically to look at winter-related problems rather than the relationship between housing quality and health in general. For this review, our primary interest is in the energy efficiency of housing and the degree to which the indoor environment during cold winter months influences health, rather than the broader issue of how health may be influenced by dampness and mould for example (even though mould may in part be a function of low indoor temperatures). Few studies have the requisite data or the very specific analytical focus to answer such questions directly.

For this reason, much of the evidence base is somewhat indirect and its quality more limited than desirable.

Findings into context

The findings of this review provide evidence on the role of individual and other characteristics in determining vulnerability to winter-/cold-related mortality and morbidity. The evidence is fairly robust and clear in relation to such factors as age and sex, but rather less clear and somewhat counterintuitive (or at least against common assumption) in relation to such factors as rurality and low socio-economic status (for which the evidence is equivocal or broadly negative that they contribute to vulnerability). In other areas, the evidence is too limited or contradictory to draw firm conclusions (e.g. in relation to selected child health outcomes).

Nonetheless, the findings do support the widely held notion that England has a substantial burden of mortality and morbidity attributable to seasonal factors and/or the specific effects of low temperature. This is a burden that appears to be higher than it need be given comparisons with some other European countries and the evidence of its decline over time which presumably reflects the effect of a range of social, economic and health-related improvements.

The review's evidence therefore lends support to the wide array of initiatives at local and national level that attempt to reduce excess winter death and morbidity through different forms of intervention. However, the findings suggest that the risk of excess winter deaths and morbidity is quite widely distributed in the population and not very heavily concentrated in a relatively small population subgroup in fuel poverty or only in people with specific forms of underlying illness.

Implications of findings

The review has identified a number of demographic and other characteristics to be associated with risk of winter-/cold-related mortality and morbidity. They include age (risk is generally highest at older ages, with less clear but suggestive evidence for selected child outcomes), female gender, and risks in relation to a wide range of disease outcomes, especially cardiorespiratory illnesses (presumably reflecting the fact that vulnerability arises in relation to a wide range of underlying medical conditions).

The fact that the evidence is unclear in relation to socio-economic deprivation and to some extent even fuel poverty, means that intervention strategies that are aimed only at low income and fuel poor households will not address a substantial part of the population burden of winter- and cold-related mortality/morbidity. An absent or shallow socio-economic gradient implies that the burden of winter-/cold-related mortality morbidity is relatively widely distributed across social strata and hence is unlikely to be *mainly* a function of (fuel) poverty, even if fuel poverty is an important factor. The limited evidence about any greater risk in rural areas has evident bearing on the gepgraphical targeting of prevention strategies, given the appreciable burdens in in urban settings.

The importance of the energy efficiency of housing -- a physical determinant of average indoor temperatures during cold weather -- is a somewhat different factor from that of fuel poverty. There is limited direct and indirect evidence that it is an important determinant of vulnerability to the adverse health consequences of cold, which fits with broader understanding of likely patho-physiological pathways. Comparisons with populations elsewhere in Europe, especially Scandinavia, suggests that vulnerability to the effects of outdoor cold would likely be reduced by improvement in the thermal properties of housing. Although not a focus of this review, it is relevant to note that interventions in home energy efficiency are targets for action in pursuit of climate change mitigation (by helping to reduce energy use in dwellings) and energy security objectives.

Limitations of the evidence and gaps

As mentioned below, this review considered evidence only from quantitative studies and has excluded interventions. It therefore has not included all forms of evidence relevant to the question of vulnerability to excess winter mortality/morbidity.

In nearly all areas it would be desirable to have more and higher quality research evidence, which remains limited for most questions. In particular it would be desirable to have additional evidence on:

- the effect of housing quality as determinants of cold-related adverse health outcomes
- the interaction of socio—economic deprivation and fuel poverty with other potential determinants of vulnerability
- evidence in relation to child health
- impacts of fuel poverty/poor housing on mental well-being

Limitations of the review and potential impact on findings

This review was limited to quantitative non-intervention related observational studies. Evidence from intervention studies, including qualitative research, will be considered in a subsequent review. Such evidence from intervention studies may provide further insight into issues of vulnerability to seasonal and cold-related mortality/morbidity, in particular in relation to housing factors and their influence on disease symptoms and mental health status.

A limitation of the review was the need to apply a very restrictive interpretation of the inclusion criteria, specifically limiting the selection of papers to studies that had a very direct and specific focus on *variations* in risk (effect modification) of seasonal or temperature-related mortality/morbidity. A great many more studies than were included report research on seasonal variations in health and their relation to weather variables, and it could be argued that all such studies contribute in some measure to our understanding of vulnerability to seasonal- and cold-related outcomes. However, we applied a narrow interpretation for reasons of practicality and to help achieve relatively clear focus. It is likely that other reviewers would identify a somewhat different set of studies for inclusion from among the relatively large potential pool identified through the search strategy – because of the sometimes subtle distinction between a study which merely reports seasonal or temperature effects (which alone was not sufficient for inclusion) from ones which consider the issue of vulnerability directly. Of particular note we did not include studies of a specific cause-of-death if they did not also address an issue of vulnerability – implying variation with regard to personal characteristics etc. The two independent reviewers identified appreciably larger lists of abstracts for further consideration for inclusion but then applied a relatively narrow definition.

Limiting the review to papers from OECD countries is unlikely to have excluded much literature relevant to England given that vulnerability factors are likely to be somewhat specific to the level of economic development and climatic pattern. Factors such as housing are likely to be quite location specific, for which English or at least UK data are therefore much more important. However, data from other countries, and especially international comparison data, are likely to be informative with regard to general patterns of association (e.g. between energy efficeiincy and temperature-related impacts).

Limiting the review to publication from 1993 onwards has excluded some relevant past literature. However, the importance of particular determinants of seasonal and cold-related mortality/morbidity, for example housing quality, is almost certain to be changing over time, and it is appropriate to concentrate on literature from more recent years.

It is a limitation that the research question was itself very broad and thus the relevant literature very heterogeneous, which precluded formal meta-analysis.

4 Conclusions

- There is consistent evidence from multiple studies of substantial seasonality of mortality and morbidity in England. Time series studies provide strong consistent evidence that exposure to low ambient temperature is one of the key factors driving such seasonality, with clear low temperature-response functions for many disease outcomes, especially cardio-respiratory mortality/morbidity.
- The degree of seasonal fluctuation in mortality/morbidity and the strength of association with low outdoor temperature, appears to be greater in England than it is in Scandinavia and selected countries of the northern continental Europe. Correlation studies suggest that the seasonal and

cold-related excess of mortality/morbidity is lower in settings that have greater protection against low outdoor temperatures because of better thermal efficiency standards of housing and the thermal quality of clothing worn by the population.

- There has been a progressive reduction in vulnerability to seasonal- and cold-related mortality in England over many decades. Although the evidence is insufficient quantitatively to apportion those improvements to specific factors, they are likely to relate to a broad range of socio-economic and other improvements, including improvements in health care. The trend of decline adds evidence that seasonality in health and vulnerability to cold can be diminished, and that the level of seasonality and strength of the low temperature-mortality/morbidity relationships are markers of sub-optimal health protection.
- Age is probably the single most important determinant of vulnerability to winter- and cold-related mortality/morbidity. This is true not only in relative terms but especially in absolute terms, as the underlying death rates from most causes rise progressively with age. Thus the population burden of winter- and cold-related mortality/morbidity is dominantly a problem that affects the elderly population. Although there are some outcomes that may affect children in particular, such as respiratory symptoms and adverse effects of housing on mental well-being, younger population groups, including children, generally have lower risk of adverse mortality and morbidity outcomes than older population groups.
- There is reasonably consistent evidence from a number of studies that women have slightly greater vulnerability to winter- and cold-related mortality/morbidity than men. However, this may in part be explained by their older age (women have a longer life expectancy than men and are overrepresented among the oldest age groups in the population), though there is some evidence that they have slightly greater vulnerability even when age and other confounding factors are taken into account. However the difference in vulnerability is relatively small (properly no more than a few percent).
- There is insufficient evidence to draw conclusions about variations in vulnerability to winter- and cold-related mortality/morbidity by ethnic group in England.
- Although there are relatively few studies, the published research does not provide clear and consistent evidence that the risk of winter- and cold-related mortality/morbidity is greater in rural than in urban areas. Some rural populations may nonetheless be at particular risk because of their isolation, limited access to fuel sources or other reasons, but there is insufficient evidence to conclude that urban populations are in general any less vulnerable than rural populations.
- Many disease outcomes show seasonal increases during winter and have clear exposure-response relationships with low outdoor temperatures. Cardiorespiratory outcomes appear to have relatively strong associations with cold, but even mortality from malignancies and external causes also show association with cold. This suggests that many forms of illness and many pathophysiological pathways can be adversely affected by cold and other winter-related factors. Respiratory conditions, especially chronic obstructive pulmonary disease, appear to have a comparatively steep temperature-response functions, but because of their greater underlying prevalence, the attributable burdens of mortality and morbidity are greatest for cardiovascular outcomes despite their somewhat shallower relationships with low ambient temperature.

- Evidence in relation to the risk of falls is somewhat mixed. At younger ages the risk of injuries and fractures appears to be greatest in summer rather than winter months. However cold weather, and periods of snow and ice in particular, generally appear to be associated with an increase in risk of falls and fractures. However the increase in risk seems to be relatively modest in the elderly population (perhaps because they choose not to go outdoors in inclement conditions) and relatively greater in the working age population, presumably because they have less possibility to avoid exposure. Periods of low temperature and inclement weather appear in general to be associated with a greater increase in fractures and injuries to the forearm, and relatively modest change in the risk of hip fractures, most of which occur indoors.
- Several studies from England and elsewhere have shown surprisingly weak relationship between socio-economic status and risk of winter/cold-related mortality/morbidity. The evidence is not entirely consistent, and some apparently negative studies had relatively limited statistical power. Nonetheless the majority of studies, including some fairly large studies, suggest that there is at most only a weak or indeed a slightly negative relationship between socio-economic status and risk of winter- and cold-related mortality/morbidity (i.e. higher risks in less deprived groups). There may be various reasons for this counterintuitive observation. It is noteworthy however that a comparatively high proportion of people from lower income groups or in social or local authority housing live in dwellings that are relatively energy-efficient (more of them are flats and/or were built relatively recently to higher energy efficiency standards) and their predicted winter indoor temperatures are on average higher than those of the owner occupier population or those in privately rented accommodation. It is also worth noting that even if lower socio-economic groups do not have a greater winter-or cold-related excess of mortality/morbidity than high socio-economic groups, their higher underlying age specific death rates mean that a similar seasonal increase in risk gives rise to a greater excess number of deaths/cases of morbidity. Thus, the burden of excess winter mortality/morbidity is not heavily concentrated in socio-economically deprived populations, but is rather quite widely distributed. But targeting action on socio-economically disadvantaged populations would nonetheless contribute to reducing inequalities in health.
- Evidence about housing quality as a determinant of vulnerability to winter- and cold-related mortality/morbidity is limited and somewhat heterogeneous. Nonetheless, evidence particularly from record linkage studies in the UK suggest that energy efficiency of housing is an important determinant of vulnerability to cold-related health risks, and this is consistent with evidence from inter-country ecological comparisons that suggest lower seasonal variation and cold-related mortality in settings with high degrees of protection against cold in the indoor environment and through behavioural and other factors. This would also seem consistent with the observation that the groups most vulnerable to cold namely the elderly spend a high proportion of their time indoors at home. Evidence from cross-sectional surveys of the relationship between fuel poverty and selected health outcomes is difficult to interpret but provides useful suggest evidence that fuel poverty and cold homes have adverse impact on a range of morbidity health outcomes including mental well-being.
- The evidence of this review will need to be interpreted alongside the evidence of subsequent reviews that include evidence on intervention studies and qualitative data. Its evidence about the determinants of vulnerability to winter- and cold-related mortality/morbidity should provide useful background but the development of intervention strategies requires consideration of a

much wider range of evidence and criteria than have been considered in this part of the overall review.

- It is apparent that the scientific literature on winter- and cold-related mortality/morbidity remains limited in many areas and is quite heterogeneous. There would be considerable value in further research that helps to clarify the evidence in relation to the determinants and effect modifiers of the risk of winter- and cold-related mortality/morbidity. Prominent gaps remain on the role of thermal efficiency in housing, on fuel poverty, and on selected morbidity outcomes including mental well-being, especially in children.

Appendices

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 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)	Research 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.
Noah Scovronick (doctoral student)	Researcher with expertise in environmental epidemiology, and specifically health impacts modelling and the ancillary effects of climate mitigation strategies. Expertise: health impact and climate health studies
Health Protection Agency (Public Health England)	
Sotiris Vardoulakis	Senior researcher at Public Health England where he leads the Air Pollution and Climate Change Group at the Centre for Radiation, Chemical and Environmental Hazards (CRCE). He was the lead author of the Health Effects of Climate Change in the UK (2012) report commissioned by the Department of Health. Expertise in indoor and outdoor air pollution and temperature effects on health. Expertise: health impact and vulnerability assessment methods
Bernd Eggen	Principal Climate Change Scientist in the Air Pollution and Climate Change Group of the CRCE, at Public Health England. He has extensive experience in environmental modelling, including of climate change and climate change adaptation, in both public (Met Office Hadley Centre) and private sector (Halcrow, Schlumberger). Expertise: methods for health impact assessment and vulnerability to the consequences of adverse weather, including cold
UCL	
Mike Davies (Professor of Building Physics and the Environment)	Mike Davies extensive research experience in the monitoring and modelling of building performance and seeks to understand how buildings can optimally minimise their production of CO2 whilst maintaining healthy and comfortable conditions. He leads the team which are the UK representatives for the International Energy Agency Annex 55 work which aims to address the uncertainties associated with attempted improvements to the energy efficiency of national housing stocks. Expertise: indoor environment and the impact of interventions affecting exposures relevant to human health
Ian Hamilton (Research Associate)	Ian Hamilton is a Researcher at the UCL Energy Institute, with research focused on energy use in the urban environment, including the impact of energy efficiency interventions in the domestic stock. He is a principal researcher on the EPSRC 'New

	Empirically-Based Models of Energy Use in the Building Stock' and he is working with the London School of Hygiene and Tropical Medicine to develop a model for DECC that quantifies the health impact of introducing energy efficiency measures within the UK's housing stock. Expertise: modelling of housing-related indoor exposures, health impacts and costs of interventions
Payel Das (Research Associate)	Payel Das is a research associate in the Bartlett School of Graduate Studies at UCL. Her research focuses on determining optimal energy efficient solutions for residential dwellings through a combination of building physics models examining indoor environmental quality, assessment of health impacts resulting from stock decarbonization, and techniques to understand uncertainty in model inputs. Expertise: modelling of housing-related indoor exposures, health impacts and costs of interventions
Jonathan Taylor (Research Associate)	Jonathan Taylor is a post-doctoral research associate in the Complex Built Environment Systems Group, at the Bartlett School of Graduate Studies, UCL. His research focuses the indoor environment and impacts on health.
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

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137. Bjornstig U, Bjornstig J, Dahlgren A. Slipping on ice and snow--elderly women and young men are typical victims. *Accid Anal Prev* 1997; **29**(2): 211-5.
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142. Cold exposure and winter mortality from ischaemic heart disease, cerebrovascular disease, respiratory disease, and all causes in warm and cold regions of Europe. The Eurowinter Group. *Lancet* 1997; **349**(9062): 1341-6.
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148. Kunst AE, Looman CW, Mackenbach JP. Outdoor air temperature and mortality in The Netherlands: a time-series analysis. *Am J Epidemiol* 1993; **137**(3): 331-41.
149. Macey SM, Schneider DF. Deaths from excessive heat and excessive cold among the elderly. *Gerontologist* 1993; **33**(4): 497-500.

Appendix 4: Excluded studies

The following nine studies were excluded after review of the *full* paper – in each case because they were judged not to have direct evidence on the issue of vulnerability/effect modification in relation to cold related risks.

1. Saez M, Sunyer J, Tobias A, Ballester F, Anto JM. Ischaemic heart disease mortality and weather temperature in Barcelona, Spain. Eur J Public Health. 2000; 10(1): 58-63.
2. Ghebre MA, Wannamethee SG, Rumley A, Whincup PH, Lowe GD, Morris RW. Prospective study of seasonal patterns in hemostatic factors in older men and their relation to excess winter coronary heart disease deaths. J Thromb Haemost. 2012; 10(3): 352-8.
3. Cheng CS, Campbell M, Li Q, Li GL, Auld H, Day N, et al. Differential and combined impacts of extreme temperatures and air pollution on human mortality in south-central Canada. Part I: historical analysis. Air Qual Atmos Health. 2008; 1(4): 209-22.
4. Hong YC, Kim H, Oh SY, Lim YH, Kim SY, Yoon HJ, et al. Association of cold ambient temperature and cardiovascular markers. Sci Total Environ. 2012; 435-436: 74-9.
5. Brown G, Fearn V, Wells C. Exploratory analysis of seasonal mortality in England and Wales, 1998 to 2007. Health stat. 2010; (48): 58-80.
6. Pattenden S, Nikiforov B, Armstrong BG. Mortality and temperature in Sofia and London. J Epidemiol Community Health. 2003; 57(8): 628-33.
7. Laaidi M, Laaidi K, Besancenot JP. Temperature-related mortality in France, a comparison between regions with different climates from the perspective of global warming. Int J Biometeorol. 2006; 51(2): 145-53.
8. Goldberg MS, Gasparrini A, Armstrong B, Valois MF. The short-term influence of temperature on daily mortality in the temperate climate of Montreal, Canada. Environ Res. 2011; 111(6): 853-60.
9. Woodhouse PR, Khaw KT, Plummer M, Foley A, Meade TW. Seasonal variations of plasma fibrinogen and factor VII activity in the elderly: winter infections and death from cardiovascular disease. Lancet. 1994; 343(8895): 435-9.

Appendix 5: Evidence tables

Ref no.	Study & citation	Aim of study	Study design	Validity score Int	Validity score Ext	Population and setting	Classifying exposure	Outcomes	Methods of analysis	Results	Notes
2013											
11	Atsumi A, Ueda K, Irie F, Sairenchi T, Iimura K, Watanabe H, et al. Relationship between cold temperature and cardiovascular mortality, with assessment of effect modification by individual characteristics: Ibaraki Prefectural Health Study. Circ J. 2013; 77(7): 1854-61.[11]	To determine susceptibility to cold temperature-related cardiovascular mortality.	Case cross-over	++	+	3,593 subjects from the Ibaraki Prefectural Health Study who died of cardiovascular disease (mean follow-up 9.7+/-4.0 years)	Daily values of meteorological variables (from the Japan Meteorological Agency)	Mortality and by subgroup: cardiovascular, stroke	Time-stratified case cross-over(year-month-d.o.w. strata)., adj for RH. "V" model a priori apex at 27C (=85%ile). Lags 0,...,10 "separately". Effect modification examined by age (<80,>=80), obesity, smoking, alcohol, hypertension, hyperglycaemia.	Adjusted ORs per 1C decrease in daily maximum temperature over the day of death and the 2 days prior to this day were: Cardiovascular 1.018 (1.003-1.034) Stroke 1.025 (1.003-1.048) (Not cardiac disease) Sub-groups with significantly higher risk: age <80 CVD 1.034 (1.012-1.056) hyperglycemia stroke 1.076 (1.023-1.131) Other subgroup differences were not significant. Authors' conclusion: younger age and hyperglycemia enhance susceptibility to cold temperature-related cardiovascular death	
12	Callaly E, Mikulich O, Silke B. Increased winter mortality: The effect of season, temperature and deprivation in the acutely ill medical patient. Eur. 2013; 24(6): 546-	To examine variations in seasonal morality among all emergency medical admissions to St James' Hospital, Dublin, exploring the	Observational study	+	+	All emergency medical admissions to St James' Hospital, Dublin, 2002-2011	Seasonal classification	Emergency medical admission; 30-day mortality	Comparison of admission rates, patient characteristics, and 30-day hospital mortality	30-day in-hospital mortality was lowest in autumn (7.5%) and highest in winter (9.6%). Winter admission had 17% (p=0.009) increased unadjusted risk of a death by day 30 (OR 1.17: 95% CI 1.07, 1.28). A clinical classification system identified that chronic obstructive disease, pneumonia, epilepsy/seizures and congestive heart	Limitations relate to linear regres with temperature function. Temperature exposures and char temperature locally and air quali not accounted for. Excess winter period chosen by arbitrary winter period. 30 day in hospital deaths is somewhat arb

	51.[12]	effects of ambient temperature, deprivation markers, case-mix, co-morbidity and illness severity.								failure had more presentations in the winter. Multivariate analysis found that winter was not an independent predictor (OR 1.08: 95% CI 0.97, 1.19). Predictors including illness severity and the Charlson Index accounted for the increased risk of winter admission. The minimum daily temperature independently predicted outcome; there was a 20% increased in-hospital death rate when it was colder (OR 1.20: 95% CI 1.09, 1.33; p<0.001). Deprivation was a univariate and multivariate (OR 1.22 95%CI 1.07, 1.39; p=0.002) predictor of mortality, but did not show marked seasonal variation. Authors' conclusion: Patients admitted in the winter have an approximate 17% increased risk of an in-hospital death by 30days; this is related to cold along with increased illness severity and co-morbidity burden. The disease profile is different with winter admissions.	Generalisable to hospital admissi England.
13	de'Donato FK, Leone M, Noce D, Davoli M, Michelozzi P. The impact of the February 2012 cold spell on health in Italy using surveillance data. PLoS ONE. 2013; 8(4): e61720.	To estimate the impact of the February 2012 cold spell in Italy (characterized by extremely low temperatures and heavy snowfall) on health in Italian cities	Analysis of data from the rapid surveillance systems.	++	+	Italy: data from a national daily mortality surveillance system, operational since 2004 in 34 cities.	Days of the cold spell: defined as days when mean temperatures were below the 10(th) percentile of the February distribution for more than three days.	Mortality For Rome, a cause-specific analysis using the Regional Mortality Registry and the emergency visits (ER) surveillance system	Excess mortality was calculated as the difference between observed and expected daily values.	An overall 1578 (+25%) excess deaths among the 75+ age group was recorded in the 14 cities that registered a cold spell in February 2012. A statistically significant excess in mortality was observed in several cities ranging from +22% in Bologna to +58% in Torino. Cause-specific analyses for Rome showed a statistically significant excess in mortality among the 75+ age group for: -- respiratory disease (+64%) -- COPD (+57%) -- cardiovascular disease (+20%) -- ischemic heart disease (14%) -- other heart disease (+33%).	

										Similar results were observed for ER visits.	
14	de Vries R, Blane D. Fuel poverty and the health of older people: the role of local climate. J Public Health (Oxf). 2013; 35(3): 361-6.[14]	To investigate the association between climate and fuel poverty as it relates to the health of older people.	Semi-ecological cohort study	+	+	Analysis of data from the 2008/09 wave of the English Longitudinal Study of Ageing, a panel study of people aged 50+. ELSA is a stratified random sample designed to be representative. Of 8643 participants, 1483 excluded for missing data, leaving N=7160. Final sample seems representative.	Individuals were classified for climate using UK Met Office data for 89 English counties and unitary authorities. Climate measure based on minimum winter temperature and mean monthly rainfall. Fuel poverty was defined as individuals with total fuel expenditures in excess of 10% of household income. Included measures of age, gender, height, smoking status and net weekly	Individual data on: - respiratory health (peak expiratory flow) - hypertension (blood pressure) - depressive symptoms (questionnaire) - self-rated health	Multilevel regression models were used to test (i) the association between local climate and fuel poverty risk, and (ii) the association between local climate and the effect of fuel poverty on health (adjusted for age, gender, height, smoking status and household income).	Individual risk of fuel poverty varied across counties. However, this variation was not explained by differences in climate. Fuel poverty was significantly related to worse health for respiratory health, β = -9.22 (-16.83,-1.61) and depressive symptoms, OR = 1.37 (1.17,1.61), but not hypertension or self-rated health. No significant effect of climate on the association of fuel poverty with these outcomes. Authors' conclusion: although there is regional variation in England in both the risk of fuel poverty and its effects on health, this variation is not explained by differences in rainfall and winter temperatures.	

							household income.				
15	Gomez-Acebo I, Llorca J, Dierssen T. Cold-related mortality due to cardiovascular diseases, respiratory diseases and cancer: a case-crossover study. Public Health. 2013; 127(3): 252-8.[15]	To investigate the relationship between low winter temperatures and mortality due to cancer, cardiovascular (CVD) and respiratory diseases	Case-crossover study	++	+	Deaths (n=3948) from one of the three causes in the population of Cantabria (northern Spain), 2004-2005. Only included municipalities with at least 10,000 inhabitants (68% of the regional population). Data from National Institute of Statistics.	Minimum temperature (linkage to local monitoring station)	Cause-specific mortality: Cardiovascular Respiratory Cancer	Conditional logistic regression, stratified by age, sex, and delay of exposure to low temperatures. Three lags explored (0, 0-3, 0-6).	There was an inverse dose-response relationship between temperature and mortality in the three causes of death studied; this result was consistent across genders and age groups. For all observations, CVD had the highest odds ratio at lag 0-6 and cancer at lag 0. Effects on respiratory disease were relatively similar at all lags but also highest at lag 0. Odds ratios by subgroup (Minimum temperature <5th percentile versus > 5th percentile. Authors reported associations at all three lags, but the below reports only the lag with the greatest effect and/or most complete sub-group analysis): *Cardiovascular, lag 0-6:* Age 15-64: 12.67 (2.6,61.62) Age 65-74: 7.43 (2.45-22.59) Age ≥75: 3.8 (2.83,5.09) Male: 3.9 (2.51,6.06) Female: 4.75 (3.25,6.92) *Respiratory, lag 0-3:* Age 15-64: Not reported Age 65-74:14.34 (1.57,130.89) Age ≥ 75: 2.84 (1.74,4.62) Male: 4.11 (2.13,7.91) Female: 5.15 (2.21,12.02) *Cancer, lag 0:* Age 15-64: 2 (0.18,22.06) Age 65-74: 1.5 (0.25,8.98) Age ≥ 75: 17.9 (2.38,134.81)	

										Male: 3.9 (1.06,14.39) Female: 6.38 (1.42,28.63) Authors note: “There is a striking association between the extreme cold temperatures and mortality from cancer, not previously reported, which is more remarkable in the elderly. These results could be explained by a harvesting effect in which the cold acts as a trigger of death in terminally ill patients at high risk of dying a few days or weeks later.”	
16	Hajat S, Chalabi P, Wilkinson P, Erens B, Jones L, Mays N. Evaluation Of The Implementation And Health-Related Impacts Of The National Cold Weather Plan For England London: Department of Health; 2013.[16]	To assess the implementation of the Cold Weather Plan (CWP) in 2012/13, in parallel with analysis of weather-health relationships and trends over time.	Time-series and other analyses of routine population health data	++	++	Mortality data for England by region, 1996-2006 [to be updated to 2011]. Emergency hospital admissions data for 1997-2011, and A&E visits data for 2007-2011.	Weather data (temperature) from region-specific meteorological monitoring stations	All-cause and cause-specific mortality, hospital admissions, A&E visits due to falls	Regionally-stratified time-series analyses. Subgroups by age, cause. <u>Confounding control</u>: (time series) seasonality, day of week, [influenza – when updated]	Evidence of increase in mortality and (less marked) hospital admissions with low outdoor temperatures in all regions. Thresholds (for cold effect on mortality) vary by region, but are at around 6 deg Celsius. All large cause-of-death categories affected, especially cardiovascular disease (largest attributable burden) and respiratory death (greatest relative risk for a 1 deg Celsius decrease in temperature below the cold threshold). Rise in risk with age. Increased A&E visits from falls occur with snow and ice at all ages, but greatest relative increase in the working age population – not the elderly who show only a small increase in risk during periods of lying snow, nor the young, whose greatest risk of fracture occurs in the summer months. The large majority of cold-deaths occur on days that are NOT at the extreme of	

										the temperature distribution and therefore not on days when alerts are issued by the CWP.	
17	McAllister DA, Morling JR, Fischbacher CM, Macnee W, Wild SH. Socioeconomic deprivation increases the effect of winter on admissions to hospital with COPD: retrospective analysis of 10 years of national hospitalisation data. Prim. 2013; 22(3): 296-9.[17]	To investigate whether the relationship between season/temperature and admission to hospital with chronic obstructive pulmonary disease (COPD) differs with deprivation.	Observational study	+	++	All COPD admissions (ICD10 codes J40-J44 and J47) 2001-2010 for all Scottish residents by month of admission	Season. Temperature (meteorological data) Time-invariant classifier (effect modifier): 2009 Scottish Index of Multiple Deprivation (SIMD) quintile	Hospital admission for COPD	Calculation of rates and (absolute) rate differences and the proportion of risk during winter attributable to main effects and interactions. Monthly rates of admission by average daily minimum temperatures were plotted for each quintile of SIMD.	*Absolute* differences in admission rates between winter and summer increased with greater deprivation. In the most deprived quintile, in winter: 19.4% (95% CI 17.3% to 21.4%) of admissions were attributable to season/deprivation interaction, 61.2% (95% CI 59.5% to 63.0%) to deprivation alone, and 5.2% (95% CI 4.3% to 6.0%) to winter alone. Lower average daily minimum temperatures over a month were associated with higher admission rates, with stronger associations evident in the more deprived quintiles. Authors' conclusions: winter and socioeconomic deprivation-related factors appear to act synergistically, increasing the rate of COPD admissions to hospital more among deprived people than among affluent people in winter than in the summer months. Similar associations were observed for admission rates and temperatures. Interventions effective at reducing winter admissions for COPD may have potential for greater benefit if delivered to more deprived groups	Author noted limitations This work is limited by the use of average temperatures across the country and therefore does n account of significant regional variation or the effects o maximum/minimum temperatures.
18	McGuinn L,	To investigate	Case-	++	+	Patients with	Daily outdoor	ICD activation	Fixed stratum case-	For every 1 degrees C decrease in	

	Hajat S, Wilkinson P, Armstrong B, Anderson HR, Monk V, et al. Ambient temperature and activation of implantable cardioverter defibrillators. Int J Biometeorol. 2013; 57(5): 655-62.[18]	the degree to which weather influences the occurrence of serious cardiac arrhythmias	crossover study			implanted cardiac defibrillators (ICDs) London and the South of England, 1993-2005	temperature based on linkage of individual to data from nearest meteorological monitoring stations based on postcode of residence	Modifiers: age, sex, drug use, diagnosis, severity	crossover analysis. Distributed lag model 0-7 days. Spline and linear threshold	ambient temperature, risk of ventricular arrhythmias up to 7 days later increased by 1.2% (-0.6, 2.9%). Patients over the age of 65 exhibited the higher risk >= 65 years 3.1% (0.6-5.5) < 65years -1.5% (-3.6-1.5). p(interaction)=0.02 Other modifiers were not significant, but power was limited. Authors note: "This provides evidence about a mechanism for some cases of low-temperature cardiac death, and suggests a possible strategy for reducing risk among selected cardiac patients by encouraging behaviour modification to minimise cold exposure."	
19	Madrigano J, Mittleman MA, Baccarelli A, Goldberg R, Melly S, von Klot S, et al. Temperature, myocardial infarction, and mortality: effect modification by individual- and area-level characteristics. Epidemiology. 2013; **24**(3): 439-46.[19]	To examine the association between temperature and occurrence of acute myocardial infarction (MI), as well as subsequent mortality. Also to investigation potential individual-level and	Case-crossover	++	+	The Worcester Heart Attack Study, a community-wide investigation of acute MI in residents of the Worcester metropolitan area, Massachusetts, USA. Medical records were from 5 study years (every	Daily mean apparent temperature (derived from the Worcester airport meteorological station) Effect modifiers Socio-demographic characteristics, medical history, smoking status, clinical complications	Acute MI occurrence All-cause in-hospital and post-discharge mortality.	Conditional logistic regression models where the individual was the conditioning factor. Control days were in the same month and year. First examined acute MI and then examined subsequent mortality. Controlled for day of the week, air pollution and	A decrease in an interquartile range in apparent temperature during cold months was associated with an increased risk of acute MI on the same day (hazard ratio = 1.15 (1.01, 1.31). Extreme cold (<5th percentile) during the 2 days prior was associated with an increased risk of acute MI: HR 1.36 (1.07, 1.74). Found no association between temperature and acute MI during warm months in the population as a whole, although there were certain susceptible groups (see below). There were no associations with temperature and subsequent mortality	

		area-level effect modifiers.				other year from 1995-2003) and limited to adults 25 years and older.	, and physical environment. Also controlled for ozone and fine particulate matter.		humidity. Ran separate models for warmer and colder months.	in those who previously had an acute MI, but extreme hot temperatures in the 2-day and 4-day moving averages preceding death were associated with mortality. HRs were 1.44 (1.06, 1.96) and 1.41 (1.00,1.98), respectively). In terms of effect modification, the below showed statistical significance in tests for interaction. Susceptibility to decreases in temperature in cold months: - Those with prior acute MI: 1.46 (1.14, 1.87) - Those without a lake/reservoir within 400m: 1.20 (1.04-1.39) Susceptibility to MI from extreme heat - At least 14% of families below the poverty line: 1.30 (0.90,2.14) - Those in more urban areas: 1.48 (0.88-2.49) - Increased likelihood of dying from higher temperatures in warm months (in acute MI survivors) - Younger (<65) patients: 1.32 (0.65-2.68) - Patients with Q-wave acute MI: 1.61 (0.92-2.82) - Those in areas with >14% of families below the poverty line: 1.22 (0.74,2.01) Increased likelihood of dying from extreme heat - Previously diagnosed heart failure: 2.15 (1.41,3.26)	

										Associations were not found in many other socio-demographic and city-level characteristics or with other aspects of the built environment.	
21	Romero-Ortuno R, Tempany M, Dennis L, O'Riordan D, Silke B. Deprivation in cold weather increases the risk of hospital admission with hypothermia in older people. Ir J Med Sci. 2013; 182(3): 513-8.[21]	To investigate whether material deprivation in cold weather increases the risk of hypothermia and contributes to excess winter mortality in older Irish people.	Case-control study (comparison of characteristics of hypothermic patients with a random sample of 200 age and gender-matched non-hypothermic patients in the same setting).	+	+	Patient series from tertiary teaching hospital, St James's Hospital Dublin, Ireland (urban). Of all community-dwelling (without nursing home address) patients, those experiencing their last medical admission between 1 January 2002 to 31 December 2010, >=65 years, and with a body temperature <35 deg C at time of admission were selected.	Material deprivation as measured by the Irish National Deprivation Index (NDI). <u>Effect modifiers/ confounders</u> Year, season, mean air temperature on day of admission, comorbidity, major diagnostic categories	Hypothermia (defined as a body temperature < 35 deg C).	Chi-squared or 2-sided Fisher's exact tests used to compare dichotomous variables. Mann-Whitney U test used to compare continuous variables. Binary logistic regression model used to identify predictors of presentation with hypothermia: age, gender, mean air temperature on the day of admission, year of admission, comorbidity, major diagnostic categories, and NDI.	80 patients presented with hypothermia. No statistically significant differences in major diagnostic categories between non-hypothermic and hypothermic groups. Hypothermic patients presented in colder days (mean 8.8 vs. 10.8 C, P<0.001) were less likely to present in summer (P<0.002) and more likely to present in winter (P=0.010). They were more likely to be admitted earlier in the series (P=0.025). Patients admitted with hypothermia were more likely to be admitted to HDU or ICU (P=0.040) and more likely to have a prolonged hospital stay (P=0.036). Their mortality was higher than non-hypothermic patients (50% vs. 17%, P<0.001). The significant predictors of hypothermia were year of admission (OR=0.83, 95%CI 0.72-0.94, P=0.005) and the interaction NDI* air temperature on the day of admission (OR=1.03, 95% CI 1.01-1.06, P=0.033). Authors' conclusion: the NDI could be an adequate tool to target fuel poverty in older people.	Authors mention that they co not control for influenza in ar and that coastal air temperat data may underestimate inne temperature extremes.
22	Tseng CM, Chen YT, Ou SM, Hsiao YH, Li SY,	To determine the effect of air	Case-crossover study	+	+	Taiwan: National Health	Meteorological variables from the	COPD exacerbation	Conditional logistic regression model, with subgroup	*Odds ratios of exacerbation of chronic obstructive pulmonary disease in relation to meteorological variable*	A number of remaining confounders related to extern exposures (air quality and urb

	Wang SJ, et al. The effect of cold temperature on increased exacerbation of chronic obstructive pulmonary disease: a nationwide study. PLoS One. 2013; **8**(3): e57066.[22]	temperature and other meteorologic al factors on COPD exacerbation.				Insurance registry data (COPD admission), January 1999 to December 2009	Taiwan Central Weather Bureau		analyses by stratifying on patient characteristics, including age, sex, vaccination and use of inhaled medicine	OR 95% CI p Value For, sequentially: 3-day Average* 7-day Average** 14-day Average+ 28-day Average++ Mean temperature 1.039 1.007–1.071 0.015 1.055 1.021–1.089 0.001 1.075 1.038–1.114 <0.001 1.099 1.058–1.141 <0.001 1.106 1.063–1.152 <0.001 Temperature variation 1.009 1.001–1.017 0.040 1.014 1.003–1.025 0.016 1.016 1.002–1.031 0.029 1.011 0.993–1.030 0.218 1.011 0.987–1.035 0.365 Relative humidity,% 0.996 0.994–0.999 0.003 0.996 0.993–0.999 0.004 0.995 0.991–0.998 0.005 0.998 0.993–1.002 0.346 1.001 0.996–1.007 0.662 Barometric pressure 1.005 1.000–1.009 0.036 1.005 1.001–1.010 0.030 1.008 1.003–1.014 0.003 1.011 1.005–1.017 <0.001 1.014 1.007–1.020 <0.001 Wind speed, m/s 1.007 0.989–1.026 0.429 1.007 0.983–1.031 0.574 1.021 0.989–1.054 0.194 1.025 0.985–1.067 0.221 1.029 0.979–1.082 0.255 Sunshine, hours/day 1.007 1.001–1.012 0.012	temperatures) along with sea influenza occurrence are not adjusted for. The findings are not generaliz to the UK population but rem interest.

										1.008 1.001–1.015 0.022 1.009 1.000–1.018 0.041 1.003 0.992–1.015 0.593 0.987 0.972–1.003 0.110 Odds ratios of exacerbation of chronic obstructive pulmonary disease in relation to meteorological variables. *Mean meteorological data of the same day and 2 previous days. **Mean meteorological data of the same day and 6 previous days. +Mean meteorological data of the same day and 13 previous days. ++Mean meteorological data of the same day and 27 previous days. #Decrease per 5°C. *Odds ratios of exacerbation of chronic obstructive pulmonary disease with a 5°C decrease in mean temperature# stratified by age, sex, vaccination and inhaled medicine* OR 95% CI p Value For, sequentially: 3-day Average* 7-day Average** 14-day Average+ 28-day Average++ Modifier Age[greater, double equals]65 1.073 1.022–1.126 0.005 1.098 1.042–1.158 0.001 1.137 1.069–1.210 <0.001 1.153 1.073–1.239 <0.001 1.134 1.040–1.237 0.005 Age<65	

										1.029 0.919–1.154 0.618 1.079 0.954–1.220 0.225 1.043 0.903–1.204 0.568 1.109 0.940–1.308 0.220 1.134 1.040–1.237 0.005 Male 1.056 1.004–1.111 0.036 1.084 1.025–1.145 0.004 1.113 1.043–1.188 0.001 1.141 1.058–1.230 0.001 1.120 1.022–1.226 0.015 Female 1.110 1.009–1.221 0.033 1.143 1.030–1.268 0.012 1.161 1.028–1.310 0.016 1.169 1.017–1.344 0.028 1.075 0.910–1.271 0.395 Received vaccination+ 1.054 0.972–1.143 0.200 1.075 0.984–1.173 0.108 1.158 1.043–1.286 0.006 1.221 1.081–1.380 0.001 1.181 1.018–1.371 0.028 Without received vaccination+ 1.074 1.018–1.134 0.010 1.107 1.044–1.174 0.001 1.112 1.039–1.191 0.002 1.119 1.034–1.211 0.005 1.084 0.986–1.192 0.095 Received inhaled medicine* 0.998 0.819–1.216 0.981 1.036 0.932–1.290 0.751 1.044 0.806–1.353 0.742 1.126 0.826–1.535 0.453 1.091 0.740–1.608 0.659 Without inhaled medicine* 1.070 1.020–1.122 0.006 1.105 1.049–1.164 <0.001 1.127 1.060–1.198 <0.001 1.146 1.068–1.229 <0.001	

										1.110 1.020–1.208 0.016 Odds ratios of exacerbation of chronic obstructive pulmonary disease with a 5°C decrease in mean temperature # stratified by age, sex, vaccination and inhaled medicine. #Adjusted for relative humidity, barometric pressure, wind speed, and duration of sunshine. *Received inhaled medicine, including inhaled long-acting ß2 agonist, long-acting muscarinic antagonist or/and inhaled corticosteroid for more than 28 days within 6 months before the index day. +Received vaccination within one year before the event. In summary: a 1°C decrease in air temperature was associated with a 0.8% (1.015, 1.138) increase in the exacerbation rate on event-days. With a 5°C decrease in mean temperature, the cold temperature (28-day average temperature) had a long-term effect on the exacerbation of COPD (odds ratio (OR): 1.106 (1.063, 1.152) Elderly patients and those who did not receive inhaled medication tended to suffer an exacerbation when the mean temperature dropped 5°C. Higher barometric pressure, more hours of sunshine, and lower humidity were associated with an increase in COPD exacerbation.	

23	Webb E, Blane D, de Vries R. Housing and respiratory health at older ages. J Epidemiol Community Health. 2013; 67(3): 280-5.[23]	To examine the association between housing conditions and objectively measured respiratory health in a large general population sample of older people in England.	Population survey:	+	+	England: second wave of the English Longitudinal Study of Ageing.	Housing conditions, and relevant covariates	respiratory health	Multivariate regression methods were used to test the association between contemporary housing conditions and respiratory health while accounting for the potential effect of other factors; including social class, previous life-course housing conditions and childhood respiratory health.	Older people who were in fuel poverty or who did not live in a home they owned had significantly worse respiratory health as measured by peak expiratory flow rates. After accounting for covariates, these factors had no effect on any other measures of respiratory health. Self-reported housing problems were not consistently associated with respiratory health. Authors' conclusions: housing conditions of older people in England, particularly those associated with fuel poverty and living in rented accommodation, may be harmful to some aspects of respiratory health.	Author reported limitations -------------- Adjusting for social class is un to have entirely accounted fo influence of other aspects of deprivation. We recognise th limitation of this research, an future work using more detai measures of housing conditio and deprivation to determine relative importance as indepe predictors of respiratory heal additional limitation of the pr study was that our measure o poverty did not distinguish households that needed to sp more than 10% of their incon fuel to preserve an adequate of warmth (as defined by the WHO), from those who spent for other reasons.

Continued…

Appendix 5 table continued: 2012 studies.											
Ref	**Study**	**Aim of study**	**Study design**	**Validity**		**Pop, setting**	**Exposure**	**Outcomes**	**Analysis**	**Results**	**Notes**
				Int	**Ext**						
<u>2012</u>											
24	Barnett AG, Hajat S, Gasparrini A, Rocklov J. Cold and heat waves in the United States. Environ Res. 2012; 112: 218-24.[24]	To examine the cold and heat waves on mortality and how the risk of death depended on the temperature threshold used to define a wave, and a wave's timing, duration and intensity.	Time series	++	++	99 US cities, 1987-2000	We defined cold and heat waves using temperatures above and below cold and heat thresholds for two or more days. We tried five cold thresholds using the first to fifth percentiles of temperature, and five heat thresholds using the 95-99 percentiles.	Mortality	The extra wave effects were estimated using a two-stage model to ensure that their effects were estimated after removing the general effects of temperature.	In general there was no increased risk of death during cold waves above the known increased risk associated with cold temperatures. There was even evidence of a decreased risk during the coldest waves. Cold waves of a colder intensity or longer duration were not more dangerous. Cold waves earlier in the cool season were more dangerous, as were heat waves earlier in the warm season: for every 50 days after October 1 (i.e. from before the winter season) the increases in deaths associated with a cold wave decreased by –1.26% (95% CI – 0.03, –2.39%) Cold or heat waves earlier in the cool or warm season may be more dangerous because of a build-up in the susceptible pool or a lack of preparedness for extreme temperatures.	
25	Hales S, Blakely T, Foster RH, Baker MG, Howden-Chapman P. Seasonal patterns of mortality in relation to social factors. J Epidemiol Community	To investigate whether excess winter mortality varies with social factors in New Zealand. XXXX	Seasonal analysis of synthetic cohorts	+	+	New Zealand records from 1981, 1986, 1991, 1996 and 2001 censuses probabilistically linked to 3 years of subsequent mortality data creating five	Seasonal definition: winter (JJA) vs summer (DJF). Data for deaths in spring and autumn were discarded.	All-cause mortality as well as deaths from infections, cardiovascular disease, respiratory disease, cancer and accidents. Models also included variables	Logistic regression analysis of the risk of dying in winter compared to summer in relation to census characteristics. The model generates coefficients (and hence odds ratios)	There was an excess winter mortality of 22%. *ORs for all-cause mortality adjusted for age, sex, census year, ethnicity, tenure* <u>Age</u> 30s 0.915 (0.830, 1.009) 40s 0.948 (0.885, 1.016) 50s 1.011 (0.960, 1.064) 60s 1.067 (1.026, 1.109) 70s 1	

	Health. 2012; 66(4): 379-84.[25]					cohort studies of the New Zealand adult population (age 30-74 years at census) each with 3 years' follow-up There were 75 138 eligible mortality records, 58 683 with complete data on social variables.		for age, sex, ethnicity, census year, education status, marital status, housing tenure, income, rurality and neighbourhood deprivation.	that directly estimate variation in excess winter mortality. Only included participants with data on all covariates. Separate analyses were conducted for all causes of death and for cause subgroups.	<u>Sex</u> F 1 M 1.010 (0.976, 1.044) Tertile of income Highest 1 Middle 1.052 (1.001, 1.106) Lowest 1.13 (1.08, 1.19) Tenure Home owners 1 Renters 1.054 (1.009, 1.100) <u>Rurality</u> Rural 1 Urban 1.056 (1.015, 1.097) There were also no significant associations with census period, ethnicity, education, marital status or neighbourhood deprivation. The strongest associations were seen for infectious diseases, rather than circulatory, respiratory, cancer and injury causes, but the majority of social factor-cause-specific disease pairs had wide confidence intervals overlapping one. Authors note: “There was an increased risk of dying in winter for most New Zealanders, but more so among low-income people, those living in rented accommodation and those living in cities. Exact causal mechanisms are not known but possibly include correlated poorer health status, low indoor temperatures and household	

										crowding."	
26	Hori, A., M. Hashizume, et al. "Effects of weather variability and air pollutants on emergency admissions for cardiovascular and cerebrovascular diseases." Int J Environ Health Res 2012; 22(5): 416-430.[26]	To quantify the effect of ambient temperature, air pressure and air pollutants on daily emergency admissions for different types of stroke and cardiovascular disease.	Time series	++	+	Ina, Japan April 2006 – March 2010 Only patients transported by ambulance only and excludes non-residents.	Temperature, pressure and air pollution from local meteorologic al stations. Missing pollutant data were imputed by multiple linear regression models. Modifiers: individual-level age, cause-of-death	(Daily) emergency hospital admission (n=4355) by each type of stroke and cardiovascular disease	Generalized linear Poisson regression models allowing for overdispersion. Confounder control: season, year, day of week, public holidays, influenza and respiratory syncytial virus. Fitted natural cubic splines to create graphs of the temperature-admission relationship. When significance was <0.05 in the spline model, fit linear threshold models. Subgroups by age, cause.	RR for increase in the daily number of emergency admissions per 1 deg C decrease in temp: All-cause (lag 0-4): 3.24% (1.25, 5.18) Acute coronary syndrome and heart failure (lag 0-4): 7.83% (2.06, 13.25) Intracerebral haemorrhage (lag 0-3): 35.57% (15.59-59.02) Cerebral infarction (lag 0-4): 11.71% (4.1, 19.89) Increase of emergency admissions risk also noted in relation to decrease in air pressure. There were some pollutant-disease relationships, but for most pairs the confidence intervals were wide and were consistent with no association. In the sub-group analysis, temperature changes strongly affected males and those over 74 years old, with an increase of 4.87 (2.13, 7.53) and 3.96% (1.44, 6.42), respectively, for every 1 deg C decrease. Overall, cerebrovascular diseases tended to be more sensitive to temperature than cardiovascular diseases.	
27	Miron IJ, Montero JC, Criado-Alvarez JJ, Linares C, Diaz J. Intense cold and mortality in Castile-La Mancha (Spain):	To study the modification of the lagged effects of cold on mortality (with the novelty of also	Time series	+	+	Five towns in Castile-La Mancha, 1975 to 2003	Met station data	Daily deaths counts	Mortality residuals after application of ARIMA models to the mortality data were correlated with similarly filtered temperatures (from November to	A cold-related mortality trigger threshold of -3C was obtained for Ciudad Real for the period 1990-2003. The number of significant lags (p<0.05) in the CCFs declined every 10 years in Toledo (5-2-0), Cuenca (4-2-0), Albacete (4-3-0) and Ciudad Real (3-2-1). This meant that, while the trend in cold-related mortality trigger	Unusual analysis makes asses of robustness of results diffic

	study of mortality trigger thresholds from 1975 to 2003. Int J Biometeorol. 2012; 56(1): 145-52.[27]	approaching this aspect in terms of mortality trigger thresholds??)							March). Results for the periods 1975-1984, 1985-1994 and 1995-2003 were then compared.	thresholds in the region could not be ascertained, it was possible to establish a reduction in the lagged effects of cold on mortality, attributable to the improvement in socio-economic conditions over the study period. Evidence was shown of the effects of cold on mortality.	
20	Modarres R, Ouarda TB, Vanasse A, Orzanco MG, Gosselin P. Modeling seasonal variation of hip fracture in Montreal, Canada. *Bone* 2012;**50**(4):909-16.[20]	To study examined and modelled the seasonal variation of monthly population based hip fracture rate (HFr) time series	The seasonal ARIMA time series modelling	+	+	Female and male patients aged 40-74 and 75+ years, Montreal, Quebec province, Canada, 1993-2004.	Meteorological parameters • Max temperature • Min temperature • Mean temperature • Rainfall depth • Number of days with rain • Snow depth • Number of days with snow • Precipitation depth • Number days with precipitation • Max snow depth • Min snow depth • Mean wind speed • Hours of sunshine	Hip fracture Results separately for: • F1: females, 40-74 years • F2: females, 75+ years • M1: males, 40-74 years • M2: males, 75+ years	Complex times series methods were used to investigate trend, though association of HFr with metereology and season appeared described and tested using simple bivariate techinques	The simple Pearson correlation coefficients between meteorological variables such as temperature, snow depth, rainfall depth and day length and HFr are significant. The seasonality in HFr indicated sharp difference between winter (higher) and summer time. Younger (-74) people had more pronounced seasonality, though this difference was not quantified or tested statistically.	Weather very different to UK
28	Morabito M, Crisci A,	To evaluate current and	Time series and health			Ten main cities in	Daily average air	Non-accidental mortality and	Generalized additive and	The cumulative impact (over a lag-period of 30 days) of the effects of cold	

	Moriondo M, Profili F, Francesconi P, Trombi G, et al. Air temperature-related human health outcomes: current impact and estimations of future risks in Central Italy. Sci Total Environ. 2012; 441: 28-40.[28]	future impact of temperature on human health in different geographical areas	impact modelling study			Tuscany (Central Italy), 1999-2008	temperatures	hospitalizations	distributed lag models to characterize the relationships between temperature and health outcomes stratified by age: <65, 65-74 and >=75 Application of health impact methods using high-resolution city-specific climatologic A1B scenarios centred on 2020 and 2040	and especially heat, was mainly significant for mortality in the very elderly, with a higher impact on coastal plain than inland cities: 1 C decrease/increase in temperature below/above the threshold was associated with a 2.27% (95% CI: 0.17-4.93) and 15.97% (95% CI: 7.43-24.51) change in mortality respectively in the coastal plain cities.	
29	Morency P, Voyer C, Burrows S, Goudreau S. Outdoor falls in an urban context: winter weather impacts and geographical variations. Can J Public Health. 2012; 103(3): 218-22.[29]	To describe the demographic, spatial and temporal distribution of outdoor falls in Laval and Montreal Island (Canada) in relation to meteorological conditions.	Observational study of ambulance records	+	+	Data on falls, including location (outside or at home) and geographic coordinates, were obtained from ambulance services (December 1, 2008 to january 31, 2009). Age and gender were included in the analysis.	Meteorological conditions (temperature, precipitation levels) and land use data were used for descriptive analysis and mapping.	Falls requiring ambulance attendance, taken from pre-hospital intervention reports.	Descriptive analyses only.	During the study period, 3270 falls required ambulance interventions, of which 960 occurred outdoors. Most people injured outdoors were under 65 years of age (59%). Mapping showed a concentration of outdoor falls in central neighbourhoods and on commercial streets in Montreal. Three episodes of excess falls, representing 47% of all outdoor falls, were preceded by rain and followed by falling temperatures, or were concomitant with freezing rain. 72% of the outdoor falls were explicitly attributed to ice and/or snow and/or slipping by the ambulance attendant.	Non-severe falls not requiring ambulance attendance are no reported. Land use data not available in locations. Confidence intervals and significance not included in analysis. Potential bias in groups towa individuals able to leave their homes, and those who are m likely to require ambulance attendance should they fall. The proportion of households owning a car is higher on Mo Island than in Laval, meaning people need to walk rather th drive. A number of unmeasured environmental factors could influence falls.

30	Office for National Statistics. Excess winter mortality in England and Wales, 2011/12 (provisional) and 2010/11 (final). 2012.[30] See also: Office for National Statistics. Excess winter mortality in England and Wales, 2010/11 (provisional) and 2009/10 (final). 2011.[30]	To report provisional figures of excess winter deaths (also referred to as excess winter mortality – EWM) in England and Wales for the winter period 2011/12, and final figures for the winter period 2010/11.	Descriptive analysis of routine data	+	+	England and Wales, 20011/12 and 2010/11, and historical trend since 1950/51	Seasonal definition. Also by temperature.	Mortality	Descriptive reports and analysis of historical trends from 1950/51 onwards Figures are presented by sex, age, region and cause of death. Figures on temperature and influenza incidence are also provided to add context to the mortality figures.	• There were an estimated 24,000 excess winter deaths in England and Wales in 2011/12 – an 8 per cent reduction compared with the previous winter. • As in previous years, there were more excess winter deaths in females than in males in 2011/12. • Between 2010/11 and 2011/12 male excess winter deaths decreased from 11,270 to 10,700, and female deaths from 14,810 to 13,300. • The majority of deaths occurred among those aged 75 and over; there were 19,500 excess winter deaths in this age group in 2011/12 compared with 4,500 in the under 75-year-olds. • The excess winter mortality index was highest in London in 2011/12, whereas in 2010/11 it was highest in Wales. Wales had one of the lowest levels of excess winter mortality in the 2011/12 winter, second only to the North East of England.	Restricted to standard EWM method.
31	Phu Pin S, Golmard JL, Cotto E, Rothan-Tondeur M, Chami K, Piette F. Excess winter mortality in France: influence of temperature, influenza like illness, and residential care status. J Am Med Dir Assoc.	To examine the monthly variation in mortality in in France, 1988-2007, with particular focus on excess winter death	Observational study of monthly mortality patterns	+	-	France, 1988-2007	Month	Mortality	Coefficients of Seasonal Variations in Mortality (CSVMs) were calculated using monthly mortality data from 1998 to 2007 in France. CSVM was a percentage representing the excess death rate from December to March inclusively, against average, monthly mortality	There was an annual winter excess death of 23,836 (+/- 7951) (mean +/- 1 standard deviation) cases. On average, CSVM in France was+14.94% (13.54 [12.03; 19.70]) (mean, median, and interquartile intervals). Multivariate analysis results revealed that several factors contributed to the CSVM: sociodemographics, such as age (CSVM higher for the population older than 75) and death location (CSVM higher in nursing homes), environmental factors, such as the	Confounders related to air qu and socio-economic status m not included. Season 'winter periods not tested. The findings are only modera generalisable to the UK popu

	2012; 13(3): 309.e1-7.[31]								from the other 8 non-winter months. Univariate and multivariate analyses were performed to identify risk factors of increased winter mortality, including socio-demographic and environmental parameters	severity of the winter season (per monthly minimal temperature), and estimated number of influenza-like illnesses (ILI). Correlation between observed and predicted CSVMs was extremely consistent (R(2)= 0.91). Authors' conclusion: there was a fundamental belief that residents in nursing homes were well protected from cold spells and their consequences. Our results revealed this to be a mere misperception. Author's limitations: In data sources, the number of ILI was indeed an extrapolation from a national scale of data listed by a representative sampling of general practitioners spread across the French metropolitan areas. Meteorological data were taken from information registered in Paris; applying the data to the whole country might be considered debatable. Despite this short- fall, the statistical approaches remain the same.	
32	Turner LR, Connell D, Tong S. Exposure to hot and cold temperatures and ambulance attendances in Brisbane, Australia: a time-series study. BMJ Open. 2012; 2(4).[32]	To investigate the effect of hot and cold temperatures on ambulance attendances	Ecological time-series study	++	++	Population study: Brisbane, Australia.	Meterological observations of mean daily temperature and humidity	Total ambulance attendances; plus - cardiovascular, -respiratory - other non-traumatic attendances	Generalised additive models	There were statistically significant relationships between mean temperature and ambulance attendances for all categories. Cold effects were delayed and longer lasting than those of heat with a 1.30% (0.87% to 1.73%) increase in total attendances for a 1 degrees C decrease below the threshold (2-15 days lag). Harvesting was observed following initial acute periods of heat effects but not for cold effects.	Data on ambulance attendan for admin purposes so risk o misclassification is greater fo outcome than for others. Loc of attendance may not repre location of exposure

										Authors note: "This study shows that both hot and cold temperatures led to increases in ambulance attendances for different medical conditions. Our findings support the notion that ambulance attendance records are a valid and timely source of data for use in the development of local weather/health early warning systems."	
33	von Klot S, Zanobetti A, Schwartz J. Influenza epidemics, seasonality, and the effects of cold weather on cardiac mortality. Environ Health. 2012; 11: 74.[33]	To determine how much of the seasonal pattern in cardiac deaths could be explained by influenza epidemics, whether that allowed a more parsimonious control for season than traditional spline models, and whether such control changed the short term association with temperature.	Multi-site time series	++	+	48 US cities The authors obtained counts of daily cardiac deaths and of emergency hospital admissions of the elderly for influenza during 1992-2000.	Ambient temperature (daily mean)	Cardiac death (ICD 9 390–429, ICD 10 I01-I51) and Influenza Hospital Admissions (urgent and emergency hospital admissions with primary or secondary causes of influenza (ICD 9 487) of persons age 65 years and older)	Quasi-Poisson regression models estimating the association between daily cardiac mortality and temperature. All models included cubic regression splines of same day relative humidity and air pressure with two degrees of freedom each and of temperature with four degrees of freedom, as well as day of the week as categorical variable. Trend and seasonality were modelled in two different ways.	Controlling for influenza admissions provided a more parsimonious model with better Generalized Cross-Validation, lower residual serial correlation, and better captured Winter peaks. The temperature-response function was not greatly affected by adjusting for influenza. The pooled estimated increase in risk for a temperature decrease from 0 to -5C was 1.6% (95% confidence interval (CI) 1.1-2.1%). Influenza accounted for 2.3% of cardiac deaths over this period. Authors' conclusions: the results suggest that including epidemic data explained most of the irregular seasonal pattern (about 18% of the total seasonal variation), allowing more parsimonious models than when adjusting for seasonality only with smooth functions of time. The effect of cold temperature is not confounded by epidemics.	

34	Wichmann, J., M. Ketzel, et al. (2012). "Apparent temperature and acute myocardial infarction hospital admissions in Copenhagen, Denmark: a case-crossover study." Environ Health 11: 19.[34]	To quantify the temperature-acute myocardial infarction (AMI) relationship, [Sixteen studies reported inconsistent results and two considered confounding by air pollution. We addressed some of the methodological limitations of the previous studies in this study.]	Case cross-over	++	++	Copenhagen, 1 January 1999-31 December 2006, stratified in warm (April-September) and cold (October-March) periods.	Meteorological and air pollution data were collected at a fixed single urban background monitor for the monitored period.	acute myocardial infarction (AMI)	Case-crossover of daily 3-hour maximum apparent temperature (Tapp(max)) and AMI hospital admissions. Adjusted for public holidays, influenza; PM(10), NO(2) and CO was investigated Effect modification by age, sex and SES explored.	It was observed that an apparent protective effect of high maximum apparent temperature ($Tapp_{max}$) on AMI admissions in the cold period of -1.5% per 1°C (95% CI: -2.6% - -0.5%). The association was not statistically significant the warm period (-0.6% per 1°C (95% CI: -1.6% - 0.3%)). Model comparisons were undertaken. The GAM and GEE analyses (with and without adjusting for pollutants) confirmed the protective effect of an increase in Tappmax in the cold period, with somewhat weaker associations than those of the case-crossover analyses. Although some of the associations were weaker or stronger than in the case- crossover analysis, all warm season associations were still insignificant in the GAM analysis. In the warm period the GEE analysis indicated that all associations were significantly protective and generally stronger than those of the case-crossover analyses.	Confounders related to air pollution and adjustment for public holidays and influenza applied. Lags for temperatur were related to incidence ons Multiple modelling approache were used to confirm associa The findings are generalizable the UK population

Continued…

Ref	Study	Aim of study	Study design	Validity		Pop, setting	Exposure	Outcomes	Analysis	Results	Notes
				Int	Ext						
2011											
35	Beynon C, Wyke S, Jarman I, Robinson M, Mason J, Murphy K, et al. The cost of emergency hospital admissions for falls on snow and ice in England during winter 2009/10: a cross sectional analysis. Environmental Health. 2011; 10(1): 60.[35]	To describe the relationship between temperature and emergency hospital admissions for falls on snow and ice in England, identify the age and gender of those most likely to be admitted, and estimate the inpatient costs of these admissions during the 2009/10 winter	Correlation (regression) study	+	+	Whole population: England, 2005/06 to 2009/10	Region specific temperatures	Emergency hospital admission for falls on snow and ice. Subgroups by age, gender, region.	Regionally stratified correlation (regression) of episodes of emergency admissions for falls on snow and ice with mean winter temperature by region Calculation of inpatient costs of admissions in the 2009/10 winter for falls on snow and ice using Healthcare Resource Group costs and Admitted Patient Care 2009/10 National Tariff Information	Emergency hospital admissions due to falls on snow and ice varied considerably across years; the number was 18 times greater in 2009/10 (N = 16,064) than in 2007/08 (N = 890). There is an exponential increase [Ln(rate of admissions) = 0.456 - 0.463*(mean weekly temperature)] in the rate of emergency hospital admissions for falls on snow and ice as temperature falls. The rate of admissions in 2009/10 was highest among the elderly and particularly men aged 80 and over. The total inpatient cost of falls on snow and ice in the 2009/10 winter was 42 million GBP. Emergency hospital admissions for falls on snow and ice vary greatly across winters, and according to temperature, age and gender. The cost of these admissions in England in 2009/10 was considerable. With responsibility for health improvement moving to local councils, they will have to balance the cost of public health measures like gritting with the healthcare costs associated with falls. The economic burden of falls on snow and ice is substantial; keeping surfaces clear of snow and ice is a public health priority.	Confounders related to influe and other co-morbidities not included. 'Event' information gritting and snow manageme major factor in 2009/10 slips falls. The findings are applicable to England
36	Gallerani M, Boari B, Manfredini F, Manfredini R. Seasonal	To determine whether a seasonal variation exists for	Seasonal analysis	+/-	+/-	All cases of HF admissions to Ferrara Hospital, January 2002	Season definition	Hospital admission for heart failure: 15,954 patients with the ICD-9-	Analysis of monthly cases with categorization into four 3-month (seasonal) intervals,	Hospital admissions for HF were most frequent in winter (28.4%) and least in summer (20.4%). Significant peak in January for total	Significant elderly tourist populat included. Authors noted limitatio common to retrospective studies on ICD-9 coding. Authors also urg

	variation in heart failure hospitalization. Clin Cardiol. 2011; **34**(6): 389-94.[36]	heart failure (HF) hospitalization				to December 2009		CM codes of HF (420-429).	adjusted for number of days, and the average number of admissions per month Subgroup analyses by: gender, age, cardiovascular risk factors, patients' outcome	cases and all subgroups considered. No clear evidence of differences by gender, age, fatal cases, presence of hypertension and diabetes mellitus, patients' outcome, and order of ICD-9 codes (first diagnosis, accessory diagnosis).	caution in caution in the interpre of hospitalization data.
37	Morabito M, Crisci A, Vallorani R, Modesti PA, Gensini GF, Orlandini S. Innovative approaches helpful to enhance knowledge on weather-related stroke events over a wide geographical area and a large population. Stroke. 2011; 42(3): 593-600.[37]	To investigate weather-related stroke events through the use of an innovative source of weather data (Reanalysis) together with an original statistical approach to quantify the prompt/delayed health effects of both cold and heat exposures.	Time series	+	+	Tuscany (central Italy), 1997 to 2007. Hospitalizations stratified by age (65 years; >=65 years).	Daily average air temperature (meteorologic data from the Reanalysis 2 Archive)	Daily stroke hospitalizations (ICD 9 430 to 438)	Generalized linear and additive models and an innovative modeling approach, the constrained segmented distributed lag model, were applied.	Both daily averages and day-to-day changes of air temperature and geopotential height (a measure that approximates the mean surface pressure) were selected as independent predictors of all stroke occurrences. In particular, a 5C temperature decrease was associated with 1.9% and 16.5% increase of all stroke and primary intracerebral haemorrhage, respectively, of people >=65 years of age. A general short-term cold effect on hospitalizations limited to 1 week after exposure was observed and, for the first time, a clear harvesting effect (deficit of hospitalization) for cold-related primary intra-cerebral hemorrhage was described. Day-to-day changes of meteorologic parameters disclosed characteristic U- and J-shaped relationships with stroke occurrences.	
38	Magalhaes R, Silva MC, Correia M,	To determine whether stroke	Time series	++	++	Population of 86,023 residents in	Daily temperature, humidity and	Stroke and subtypes.	Poisson regression model, with tests for interaction	PICH incidence 11.8% (3.8, 20.4%) increase for each degree drop in the diurnal temperature range in the	

	Bailey T. Are stroke occurrence and outcome related to weather parameters? Results from a population-based study in northern Portugal. Cerebrovasc Dis. 2011; **32**(6): 542-51.[38]	occurrence and outcome are related to weather parameters, and whether the association varies by stroke type				the city of Porto, Portugal, October 1998 to September 2000. All patients with a first-ever stroke: 19.6% primary intracerebral haemorrhage (PICH), 75.3% ischaemic stroke	air pressure from local monitoring stations (National Meteorological Office data)	Primary intracerebral haemorrhage (PICH): 19.6%. Ischaemic stroke: 75.3% Ischaemic stroke* (IS): 21.6%, with the following subtypes: - total anterior circulation infarcts (TACIs): - partial anterior circulation infarcts (PACIs) - posterior circulation infarcts (POCIs) - lacunar infarcts (LACIs). *Ischaemic stroke (IS) defined according to the Oxfordshire Community Stroke Project classification and the Trial of Org 10172 in Acute Stroke Treatment (TOAST) criteria		preceding day. IS incidence 3.9% (1.6, 6.3%), and cardio-embolic IS 5.0% (0.2, 10.1%) increase for a 1°C drop in minimum temperature. Incidence of TACIs followed the IS pattern while for PACIs and POCIs there were stronger effects of longer hazard periods and no association was found for LACIs. The relative risk of a fatal versus a non-fatal stroke increased by 15.5% (95% CI: 6.1-25.4%) for a 1°C drop in maximum temperature over the previous day.	
39	Murray IR, Howie CR, Biant LC. Severe weather warnings predict fracture epidemics. *Injury* 2011;**42**(7):687-	To examine the relationship between severe weather warnings, the frequency of fractures, and	Observational study: consecutive series of A&E attendances	+	+	All patients presenting with fractures to two adult and one paediatric A&E departments and a minor	Meteorological parameters (from met team at Royal Botanic Gardens Edinburgh): • Max temperature	• Attendances for fracture • Fractures • Fracture admissions • Hip fractures	Descriptive statistics and Pearson correlations	*Pearson correlations between weather and fracture-related workload for Dec 2008/Jan 2009 and Dec2009/Jan2010* 08/09 09/10 Maximum air temperature Attendances -0.05 +0.03 Fractures -0.29* -0.52*** Fract admissions -0.24 -0.46***	Author noted limitations The relatively short study per may preclude generalisability other possible confounders contributing to fracture burd such as an increase in steroid COPD sufferers were not expl A wider multicentre study wit an increased study period tha

	90.[39]	fracture-related workload				injuries unit, Edinburgh, UK (combined population covered: 778,367), over a 2-month winter period: Dec 2008/Jan 2009 and Dec 2009/Jan 2010	• Min temperature • Ground temperature • State of ground • Icy roads warning • Heavy snow warning			Hip fractures -0.04 -0.21 <u>Minimum air temperature</u> Attendances -0.10 -0.03 Fractures -0.20 -0.51*** Fract admissions -0.08 -0.32* Hip fractures +0.12 +0.01 <u>Ground temperature</u> Attendances -0.07 -0.04 Fractures -0.17* -0.47*** Fract admissions -0.03 -0.30* Hip fractures +0.16 -0.01 <u>State of ground</u>[a] Attendances +0.30 +0.14 Fractures +0.32 +0.38** Fract admissions +0.21 +0.31* Hip fractures +0.06 +0.14 <u>Icy roads weather warning</u> Attendances +0.30* -0.15 Fractures +0.48*** +0.34** Fract admissions +0.36** +0.29* Hip fractures +0.14 +0.16 <u>Heavy snow weather warning</u> Attendances -0.02 +0.17 Fractures +0.14 +0.17 Fract admissions +0.27* +0.02 Hip fractures +0.24 +0.19 <u>Rain</u> Attendances -0.08 +0.03 Fractures +0.07 +0.01 Fract admissions +0.14 -0.04 Hip fractures +0.04 -0.09 [a]— 3 ordinal categories were compared: ice, snow but no ice, neither ice nor snow • Significant increase in fractures with cold and inclement weather, mostly low-energy fractures treated with day-case surgery or in fracture clinics; the number of patients treated as inpatients for fractures did not	specifically analyses the unde cause of each attendance is required.

										increase. • Hip fractures were not associated with weather. • Severe weather warnings for icy roads were predictive of fracture epidemics ($p<0.01$) with an associated 40% (20, 52%) increase in fractures.	
40	Nielsen J, Mazick A, Glismann S, Molbak K. Excess mortality related to seasonal influenza and extreme temperatures in Denmark, 1994-2010. BMC Infect Dis. 2011; 11: 350.[40]	To estimate mortality related to influenza and periods with extreme temperatures	Time series	++	++	Denmark over the seasons 1994/95 to 2009/10.	Ambient temperature data from Danish weather stations. Mean over daily temperatures from all weather stations was used as the overall Danish temperature for that day. Weekly temperatures were calculated as the mean over the week, as was the weekly min and max temperatures. Influenza-like illness reports as indicator of influenza activity	All-cause mortality	Multivariable time-series model with activity of influenza-like illness (ILI) and excess temperatures as explanatory variables. Controlled for: trend, season, age, and gender. Two estimates of excess mortality related to influenza were obtained: (1) ILI-attributable mortality modelled directly on ILI-activity, and (2) influenza-associated mortality based on an influenza-index, designed to mimic the influenza transmission.	The median ILI-attributable mortality per 100,000 population was 35 (range 6 to 100) per season which corresponds to findings from comparable countries. Overall, 88% of these deaths occurred among persons >= 65 years of age. The median influenza-associated mortality per 100,000 population was 26 (range 0 to 73), slightly higher than estimates based on pneumonia and influenza cause-specific mortality as estimated from other countries. There was a tendency of declining mortality over the years. The influenza A(H3N2) seasons of 1995/96 and 1998/99 stood out with a high mortality, whereas the A(H3N2) 2005/6 season and the 2009 A(H1N1) influenza pandemic had none or only modest impact on mortality. Variations in mortality were also related to extreme temperatures: cold winters periods and hot summers periods were associated with excess mortality. Authors' conclusion: it is doable to model influenza-related mortality based on data on all-cause mortality and ILI, data that are easily obtainable in many countries and less subject to	

										bias and subjective interpretation than cause-of-death data. Further work is needed to understand the variations in mortality observed across seasons and in particular the impact of vaccination against influenza	
41	Office for National Statistics. Excess winter mortality in England and Wales, 2010/11 (provisional) and 2009/10 (final). 2011.[41]	To report provisional figures of excess winter deaths (also referred to as excess winter mortality – EWM) in England and Wales for the winter period 2010/11, and final figures for the winter period 2009/10.	Descriptive analysis of routine data	+	+	England and Wales, 2010/11 and 2009/10	Seasonal definition. Also by temperature.	Mortality	Descriptive reports and analysis of historical trends from 1950/51 onwards Figures are presented by sex, age, region and cause of death. Figures on temperature and influenza incidence are also provided to add context to the mortality figures.	• There were an estimated 25,700 excess winter deaths in England and Wales in 2010/11, virtually unchanged from the previous winter. • As in previous years, there were more excess winter deaths in females than in males in 2010/11. • Between 2009/10 and 2010/11 male excess winter deaths increased to 11,200, but female deaths fell to 14,400. • The majority of deaths occurred among those aged 75 and over; however, deaths in this age group fell between 2009/10 and 2010/11, whereas deaths in persons aged under 75 increased. • The excess winter mortality index was highest in Wales in 2010/11, whereas in the two previous winters it was highest in the South East of England.	Restricted to standard EWM method.
42	Parsons N, Odumenya M, Edwards A, Lecky F, Pattison G. Modelling the effects of the weather on admissions to UK trauma units: a cross-sectional study.	To assess the relationship between daily trauma admissions and observed weather variables	Observational (cross-sectional) study.	+	++	Twenty-one accident and emergency departments (ED) located across England: data from Trauma Audit and Research Network of England and	UK Meteorological Office.	Daily counts of adult and paediatric trauma admissions. (All patients arriving at one of the selected ED, with a subsequent death, inpatient stay of greater	Multivariate regression analysis	There were strong seasonal trends in paediatric ((2) likelihood ratio test p<0.001), and adult (p=0.016) trauma admissions. For adults, each rise of 5C in the maximum daily temperature and each additional 2 h of sunshine caused increases in trauma admissions of 1.8% and 1.9%. Effects in the paediatric group were considerably larger, with similar increases in temperature and	

	Emerg Med J. 2011; 28(10): 851-5.[42]					Wales, 1 January 1996 to 31 December 2006.		than 3 days, inter-hospital transfer or requiring critical care)		hours of sunshine causing increases in trauma admissions of 10% and 6%. Each drop of 5C in the minimum daily temperature, eg, due to a severe night time frost, caused adult trauma admissions to increase by 3.2%. Also the presence of snow increased adult trauma admissions by 7.9%. Authors' conclusion: clear associations (with weather) that have direct application for planning and resource management in UK ED.	
43	Rocklov J, Ebi K, Forsberg B. Mortality related to temperature and persistent extreme temperatures: a study of cause-specific and age-stratified mortality. Occup Environ Med. 2011; 68(7): 531-6.[43]	To establish time-series models in which the effects of persistent extreme temperature and temperature in general can be disentangled.	Time series	++	+	Stockholm County (Sweden), 1990-2002	Ambient temperature from the Stockholm central monitoring station. Included multiple temperature variables as well as humidity and air pollution. Computed indexes of the maximum and minimum apparent temperature. Tested lags 0-1, 0-6, and 0-13.	Cause-specific mortality and age-stratified mortality in Stockholm county from the Swedish cause of death register. Looked at all-cause (excluding external), cardiovascular (CVD), respiratory and other causes. Conducted stratified analyses by age group.	Time-series Poisson regression models, adjusting for time trends and potential confounders, to study the effects of temperature and persistence of extreme temperature. Data were analysed separately for winter and summer. The effects of temperature and extreme persistent temperature were modelled simultaneously.	Persistent extremely high temperature was associated with additional deaths, and the risk of death increased significantly per day of extended heat exposure. Extreme exposure to heat was associated with higher death rates in adults and for cardiovascular causes of death, compared with a rise in temperature (see below). The relative risk (RR) associated with a 1 deg C increase in minimum apparent temperature in summer (lag 0-1) was significant for: All-cause mortality: 1.006 (1.001, 1.010) Non CVD/respiratory mortality: 1.007 (1.001, 1.013) Ages 80+: 1.011 (1.005, 1.017) The confidence intervals included 1 for CVD, respiratory, and ages 0-44, 45-64 and 65-79. The RR associated with day number in sequence of persistent extreme heat in	

							Also examined impact of persistent extreme temperatures, defined as a sequence of consecutive days above the 98th percentile or below the 2nd. Accumulation assumed only to start on the second day of the extreme temperatures. Adjusted for air pollution, year, month, weekday, holiday. Also evaluated adjustment for within and between year time trends. Controlled for flu in models of cold effects in winter.			summer was significant for: All-cause mortality: 1.024 (1.010, 1.038) Non CVD/respiratory mortality: 1.023 (1.003, 1.042) Ages 65-79: 1.028 (1.004, 1.052) Ages 80+: 1.021 (1.002, 1.040) In terms of cold, there was an increase in mortality for certain causes of death, but not when stratified by age group: The relative risk (RR) associated with a 1 deg C decrease in minimum apparent temperature in winter (lag 0-1) was significant for: All-cause mortality: 1.006 (1.001, 1.010) CVD mortality: 1.014 (1.008, 1.020) Persistent extreme cold did not show an additional effect on mortality. Furthermore, the impact of warm and cold temperatures decreases within the season, while the impact of persistent extremely high temperatures remains similar throughout the summer. Confounding or interaction with air pollution was not apparent. Authors' conclusions: the mortality impact of persistence of extreme high temperatures to increase proportionally to the length of the heat episode in addition to the effects of temperature based on the temperature-mortality relationship.	

										Thus, the additional effect of persistent extreme heat was found to be important to incorporate for models of mortality related to ambient temperatures to avoid negatively biased attributed risks, especially for cardiovascular mortality. Moreover, the effects associated with non-extreme temperatures may decline as the pool of fragile individuals shrink as well as due to acclimatisation/adaptation. However, a similar decline was not observed for the effects associated with extreme heat episodes.	
44	Turner RM, Hayen A, Dunsmuir WT, Finch CF. Air temperature and the incidence of fall-related hip fracture hospitalisations in older people. Osteoporos Int. 2011; 22(4): 1183-9.[44]	To investigate whether there is an association between mean daily air temperature and fall-related hip fracture hospitalisations in older people.	Cross-sectional time-series study,	+	+	Admissions between 1 July 1998 to 31 December 2004, inclusive, with a Sydney resident's address (60% of NSW population) and aged 65+.	Mean daily ambient air temperature calculated by averaging data from 22 weather stations spread across the most populated parts of Sydney. Effect modifiers Age/sex Confounders Seasonal trends, weekdays/weekends, long-term trends, time-lag	Fall-related hip fracture hospitalisations from New South Wales Admitted Patients Data Collection.	Poisson regression used to model daily fall-related hip fracture hospitalisation counts, adjusting for seasonal trend, day-of-week effects, long-term trends in fall-related hip fracture hospitalisation counts, and autocorrelation in the time series. Separate models fit by sex and age group (65-74 years, 75-84 years, 85+ years).	Lower daily air temperature was significantly associated with higher fall-related hip fracture hospitalisations in 75+-year-olds: men aged 75-84 years, rate ratio (RR) for a 1 deg C increase in temperature of 0.98 with 95% confidence interval (0.96, 0.99) men 85+ years RR = 0.98 (0.96, 1.00) women 75-84 years RR = 0.99 (0.98, 1.00) women 85+ years RR = 0.98 (0.97, 0.99). Fewer hospitalisations found across all age/sex strata on weekends compared to weekdays ranging from RR = 0.81 (0.73, 0.90) in women aged 65-74 years to RR = 0.89 (0.80, 0.98) in men aged 85+ years. Significant seasonal trend found in fall-related hip fracture hospitalisation rates for both males and females aged 75+ years ($p<0.001$).	Authors mention that admiss only included month/day not inclusion of patients via resid address not which hospital admitted to; date of admissio assumed to be date of injury. Deprivation and influenza/ot illness illness not accounted f

										Authors’ conclusions: after adjustment for season, day-of-week effects, long-term trend and autocorrelation, fall-related hip fracture hospitalisation rates are higher in both males and females aged 75+ years when there is a lower air temperature.	
45	Wu PC, Lin CY, Lung SC, Guo HR, Chou CH, Su HJ. Cardiovascular mortality during heat and cold events: determinants of regional vulnerability in Taiwan. Occup Environ Med. 2011; 68(7): 525-30.[45]	To identify vulnerable regions with underlying susceptibility and poor adaptive capability in response to cold and heat events in Taiwan	Spatial regression models	+	+	Taiwan, 1994 to 2003: island-wide analysis	Cold events (from temperature monitoring data)	Cardiovascular mortality (two weeks before and after cold events)	Spatial regression of mean cardiovascular mortality 2 weeks before and after cold events on area-based temperature, demographic and socio-economic parameters	<u>Urbanization</u> Metropolitan regions had substantially lower mortality than rural areas after cold events. Negative association between mortality after cold events and urbanisation, and the availability of medical resources. Authors note: “These data… suggest that urban areas have a greater adaptive capability than rural areas, plausibly because people in urban areas have a higher socio-economic status and more medical resources.” Also states that “Health statistics shows that the overall mortality in aborigine townships is about 70% higher than in the general population in Taiwan.”	

Continued…

Appendix 5 table continued: 2010 studies

Ref	Study	Aim of study	Study design	Validity		Pop, setting	Exposure	Outcomes	Analysis	Results	Notes
				Int	Ext						
<u>2010</u>											
46	Barnett AG, Tong S, Clements AC. What measure of temperature is the best predictor of mortality? Environ Res. 2010; **110**(6): 604-11.[46]	To examine which measure of temperature is the best predictor of mortality	Multi-site time series	++	++	Population mortality data from 107 US cities (National Morbidity and Mortality Air Pollution Study), 1987-2000	Meteorological parameters: mean, minimum and maximum temperature with and without humidity, and apparent temperature and the Humidex.	All-cause mortality	Poisson regression with over-dispersion to model a non-linear temperature effect and a non-linear lag structure	Large differences in the best temperature measure between age groups, seasons and cities, and there was no one temperature measure that was superior to the others. The strong correlation between different measures of temperature means that, on average, they have the same predictive ability. The best temperature measure for new studies can be chosen based on practical concerns, such as choosing the measure with the least amount of missing data.	
47	Bayentin L, El Adlouni S, Ouarda TB, Gosselin P, Doyon B, Chebana F. Spatial variability of climate effects on ischemic heart disease hospitalization rates for the period 1989-2006 in Quebec, Canada. Int J Health Geogr. 2010; **9**: 5.[47]	To examine the short-term effect of climate conditions on the incidence of ischemic heart disease (IHD	Time series	+	+	18 health regions of Quebec, Canada, 1989-2006	Meteorological classification (temperature) from local monitoring stations (Environment Canada's National Climate Archive)	Hospital admission with ischaemic heat disease (IHD)	GAM model to fit standardized daily hospitalization rates for IHD and their relationship with climatic conditions up to two weeks prior to the day of admission <u>Confounder control</u>: Abstract: "controlling for time trends, day of the season and gender". However no details were given .	Cold temperatures during winter months were associated with an increase of up to 12% in the daily hospital admission rate for IHD but showed decreased risks in some areas. In most regions, exposure to a continuous period of cold was more harmful than just one isolated day of extreme weather. For men, the risk was higher (1.03% to 12.32%) in the 45-64 years age group in most regions, compared to older men (0.53% to 2.98%). In most regions, the annual maximum of daily IHD admissions for 65 years old was reached earlier in the season for both genders and both seasons	<u>Author identified limitations:</u> - no data on patient history, personal characteristics, co-morbidity - limitations of smoking and deprivation data allowed only qualitative analysis - no assessment of role of air pollution

										compared to younger age groups. The effects of meteorological variables on the daily IHD admissions rate were more pronounced in regions with: -- high smoking prevalence -- high deprivation index.	
48	Bhaskaran K, Hajat S, Haines A, Herrett E, Wilkinson P, Smeeth L. Short term effects of temperature on risk of myocardial infarction in England and Wales: time series regression analysis of the Myocardial Ischaemia National Audit Project (MINAP) registry. Bmj. 2010; 341: c3823.[48]	To examine the short term relation between ambient temperature and risk of myocardial infarction.	Daily time series	++	++	15 conurbations in England and Wales: 84,010 hospital admissions for myocardial infarction recorded in the Myocardial Ischaemia National Audit Project during 2003-6 (median 57 events a day).	Ambient temperature	Change in risk of myocardial infarction associated with a 1 degrees C difference in temperature, including effects delayed by up to 28 days.	Time series regression	Smoothed graphs revealed a broadly linear relation between temperature and myocardial infarction, which was well characterised by log-linear models without a temperature threshold: each 1 degrees C reduction in daily mean temperature was associated with a 2.0% (95% confidence interval 1.1% to 2.9%) cumulative increase in risk of myocardial infarction over the current and following 28 days, the strongest effects being estimated at intermediate lags of 2-7 and 8-14 days: increase per 1 degrees C reduction 0.6% (95% confidence interval 0.2% to 1.1%) and 0.7% (0.3% to 1.1%), respectively. Adults aged 75-84 and those with previous coronary heart disease seemed more vulnerable to the effects of cold than other age groups (P for interaction 0.001 or less in each case), whereas those taking aspirin were less vulnerable (P for interaction 0.007). Authors' conclusions: increases in risk of myocardial infarction at colder ambient temperatures may be one driver of cold related increases in overall mortality, but an increased risk of myocardial infarction at higher	

										temperatures was not detected. The risk of myocardial infarction in vulnerable people might be reduced by the provision of targeted advice or other interventions, triggered by forecasts of lower temperature.	
49	Chen VY, Wu PC, Yang TC, Su HJ. Examining non-stationary effects of social determinants on cardiovascular mortality after cold surges in Taiwan. Sci Total Environ. 2010; **408**(9): 2042-9.[49]	To examine the ecological associations between various social determinants and cardiovascular mortality after cold surges	Spatial regression of responses to 'cold surges'	+	-	Townships of Taiwan, 1997 to 2003	'Cold surges' (see Yang et al, 2009, below) Modifiers Five social determinants derived from 2000 Taiwan Census data were explored: -- social disadvantage -- lack of economic opportunity -- 'stability' -- sensitive group (including age and disability) -- rurality	Cardiovascular mortality	Geographically-weighted Poisson regression. Modifiers treated as covariates.	Immediate increase in cardiovascular mortality after 'cold surges' All five determinants tested were related to cardiovascular mortality rates after cold surges. Social disadvantage (3.8% increase), stability (5.8%), sensitivity (10.9% for each quartile of sensitivity), and rurality (4.8%) all contributed to mortality. Lack of opportunity did not have a significant effect. Cardiovascular mortality varied spatially Sensitivity accounted for the largest influence on relative risk Relative Risks Sensitivity (2nd) 1.208 (1.162,1.256) Sensitivity (3rd) 1.254 (1.184-1.327) Sensitivity(4th) 1.327 (1.222-1.441) Disadvantage 1.038 (1.002, 1.075) Lack opportunity 0.996 (0.977, 1.016) Stability 1.057 (1.026, 1.088) Rurality (2nd) 1.130 (1.078, 1.184) Rurality (3rd) 1.138 (1.064, 1.216) Rurality (4th) 1.146 (1.049,	Limitations include: potential ecological bias; the modifying effect of air pollution was unaccounted for; and the stu not use age-sex adjusted mor It is possible that severe case would be transferred to a larg hospital, outside of the local township areas and that mor would be biased towards the locations. The basis behind th modifiers is not well explaine

										1.251)	
50	Gomez-Acebo I, Dierssen-Sotos T, Llorca J. Effect of cold temperatures on mortality in Cantabria (Northern Spain): a case-crossover study. Public Health. 2010; 124(7): 398-403.[50]	To determine the impact of low temperatures on mortality in a Spanish region that includes both rural and urban areas.	Case-crossover study.	+	+	Cantabria, a Spanish region which includes both rural and urban areas (total population of 572,824), in 2004-2005	Ambient temperature (cold). Several indicators were used for cold weather: maximum, minimum and mean temperature; effective temperature (ET); net effective temperature (NET); and windchill index.	Mortality (all cause?)	Conditional logistic regression, adjusting for humidity and wind speed. Odds ratios for several cold weather indicators were estimated. Zero- to 6-day lags in the temperature effect were considered.	Temperatures lower than the 5th percentile were strongly associated with mortality compared with temperatures above the 5th percentile (OR 3.40, 95% confidence interval 2.95-3.93 for 6-day lag). All temperature indices show a negative association with mortality; for instance, the maximum temperature had ORs of 0.71, 0.58, 0.32 and 0.16 for Quintiles 2-5 (reference: Quintile 1). This effect was common to all age groups. Authors' conclusions: cold weather is strongly associated with mortality in small cities and rural areas	
51	Harris J, Hall J, Meltzer H, Jenkins R, Oreszczyn T, McManus S. Health, mental health and housing conditions in England London: National Centre for Social Research / EAGA Charitable Trust; 2010.[51]	To explore to what extent various aspects of fuel related poverty are associated with poor mental health, specifically presence of common mental disorders (CMDs) such as anxiety and depression;	Population survey	++	++	England: population survey. Stratified probability sample of households in England: 7461 residents aged >=16 years (57% of eligible households)	Measures of fuel poverty as indicated by whether the respondent reported being thermally comfortable and of having fuel-related financial strain.	Common mental disorder (CMD), classified on the basis of the Clinical Interview Schedule - Revised (CIS-R)	Multivariable regressions methods	*Fuel poverty and common mental disorder* N OR (95% CI) *Used less fuel* No 6245 1 Yes 1088 1.77 (1.46, 2.16) *Cold home* No 6983 1 Yes 319 1.85 (1.33, 2.58) *Mould* No 6697 1 Yes 626 1.52 (1.19, 1.94) *Fuel poverty and physical health condition in last year* N OR (95% CI) *Mould* No 6617 1	

		and physical illness								Yes 663 1.38 (1.14, 1.67) *Fuel poverty and whether respondent had cardiovascular disease in the last year* Presence of CVD Yes No Stat Sig *Used less fuel* 20 14 * *Cold home* 5 3 NS *Fuel debt* 7 4 NS *Mould* 9 9 NS	
52	Iniguez C, Ballester F, Ferrandiz J, Perez-Hoyos S, Saez M, Lopez A, et al. Relation between temperature and mortality in thirteen Spanish cities. Int J Environ Res Public Health. 2010; 7(8): 3196-210.[52]	To examine the shape of the age-specific and cause-specific association between ambient temperature and mortality in 13 Spanish cities.	Cross-sectional time-series study.	+	+	Population in 13 Spanish cities over at least three consecutive years between 1990 and 1996.	Daily mean ambient temperature (average of daily minimum and maximum) and daily mean humidity (mean of values at 0, 7, 13 and 18 hours in current day) were obtained from airport meteorological station located closest to the city centre. <u>Effect</u>	Total mortality, cardio-respiratory mortality, and mortality among people 70 years old or over,	A Poisson generalised additive model for association between ambient temperature and each outcome for each city. Significance of temperature evaluated using likelihood ratio test. Temperature value linked with minimum mortality (MMT) and slopes before and after turning point (MMT) were estimated by linear regression. Impact of cold and heat expressed as percentage change in mortality for	The relationship between temperature and total mortality was significant in nine of the 13 cities, including the most populated (no p-value). Focusing on significant associations, the relationship between temperature and mortality was V or U-shaped, with largest effects (steeper slopes) for cardio-respiratory deaths (no p-value). MMTs were generally higher in cities with warmer climates. Cold and heat effects also depended on climate: effects were greater in hotter cities but lesser in cities with higher variability. The effect of heat was greater than the effect of cold. The effect of cold and MMT was, in general, greater for cardio-respiratory mortality than for total mortality, while the effect of heat was, in general, greater among the elderly.	Authors note that a limitatio the study may be the low po when analysing series with a number of events.

							<u>modifier</u> <70 and >70 <u>Confounders</u> PM10/black smoke/total suspended particles, daily incidence of influenza, day-of-week, holiday days, unusual events, secular trends, seasonality, lagged effects of temperature and humidity.		temperature change of 1 ºC.		
53	Montero JC, Miron IJ, Criado-Alvarez JJ, Linares C, Diaz J. Mortality from cold waves in Castile--La Mancha, Spain. Sci Total Environ. 2010; 408(23): 5768-74.[53]	To quantify the rise in mortality due to extreme cold and the factors that determine the relationship between these variables.	Time series	++	+	Five towns in Castile-La Mancha, 1975 to 2003	Met station data	Daily deaths counts	Mortality residuals after application of ARIMA models to the mortality data were correlated with similarly filtered temperatures (from November to March). Adj for Month and flu Lags with strongest cross-correlations were selected for presentation.	There were two mortality peaks: a short-term peak (with a lag of 3 to 7 days); and a longer term peak (of under two weeks). Excess mortality during cold waves was around 10% per degree centigrade below the threshold temperature for all the provinces except Guadalajara, where an increase of only 4.61% was detected. Mortality increased in response to rises in cold-wave duration and relative humidity. Cold waves that were longer or occurring at the end of the "winter" season caused the greatest mortality. Authors' conclusions: daily mortality in	Unusual analysis makes asses of robustness of results diffic

										Castile - La Mancha increases during cold waves.	
54	Rau R, Gampe J, Eilers PH, Marx BD. Socioeconomic differences in seasonal mortality in the United States. Extended abstract. Population Association of America, 2011. Washington DC 31 March - 2 April 2011: Princeton University, 2010.[54]	To analyse whether people from lower socioeconomic groups not only suffer from higher mortality but are also exposed to higher seasonal fluctuations in mortality.	Observational study: seasonal analysis of routine data	+	+	USA: analysis of individual death records, 1989 – 2006, from the National Center for Health Statistics.	Seasonality	Deaths from heart diseases and respiratory diseases (which constitute 40% of the 41.9 million deaths which occurred in the US between 1989 and 2006)	Analysis of seasonal fluctuations over age and time	Contrasting seasonality in deaths of people with “high” and “low” education in our preliminary analysis, there were no noteworthy differences in seasonality between the socioeconomic groups.	

Continued…

Appendix 5 table continued: 2009 studies											
Ref	**Study**	**Aim of study**	**Study design**	**Validity**		**Pop, setting**	**Exposure**	**Outcomes**	**Analysis**	**Results**	**Notes**
				Int	**Ext**						
2009											
55	Abrignani MG, Corrao S, Biondo GB, Renda N, Braschi A, Novo G, et al. Influence of climatic variables on acute myocardial infarction hospital admissions. Int J Cardiol. 2009; **137**(2): 123-9.[55]	To determine the influence of seasonal variations and weather on AMI hospital admissions.	Time series and tests for seasonality	-	-	Patients (2822 men and 1096 women) admitted to a single hospital for acute myocardial infarction (AMI) in western Sicily, 1987-1998.	Meteorological parameters (temperature, humidity, wind force and direction, precipitation, hours of sunshine, daily rain, and atmospheric pressure) from local monitoring station	Hospital admission for AMI	Multivariate Poisson regression of daily AMI admissions on weather conditions The final model was built controlling for multicollinearity and interaction between variables.	Significant winter peak in AMI. Seasonal variations were not consistent across age and sex groups. Significant association between AMI admissions and minimum daily temperature and maximum daily humidity. Relative risks Minimum temperature Males 0.95 (0.92, 0.98) Females 0.91 (0.86-0.95) Max relative humidity Males 0.97 (0.94-0.99) Females 0.94 (0.90-0.98) No significant association between heat and incidence of AMI, or wind or rain. Environmental temperature and humidity may play an important role in the pathogenesis of AMI.	Reviewer comment Not full methods of time-seri Same authors also provide si analysis for admission for ang pectoris to the same hospital separately reported here.
56	Anderson, B. G. and M. L. Bell (2009). "Weather-related mortality: how heat, cold, and heat waves affect mortality in the United	To examine temperature-related mortality across the USA	Time series	++	++	107 US communities Mainly urban Data for (whole) population	Met station observations	death	Times series regression analysis adjusting for seasonal and other time trends (7df/y spline) and d.o.w.	Cold-related mortality was most associated with a longer lag (average of current day up to 25 days previous), with a 4.2% (3.2%-5.3%) increase in risk comparing the first and 10th percentile temperatures for the community. This relative cold risk increment was higher in persons aged 75+ (about 6%, from Fig 4) than in 0-64 and 65-74	

	States." Epidemiology 20(2): 205-213.[56]									groups (about 2.5% in both). This relative cold risk increment was higher in warmer communities. (+27% across IQR of mean winter temp) Higher susceptibility to cold was identified for communities with a higher percentage of African Americans (+11%).	
57	Bryden C, Bird W, Titley HA, Halpin DM, Levy ML. Stratification of COPD patients by previous admission for targeting of preventative care. Respir Med. 2009; 103(4): 558-6.[57]	To examine risk stratification of COPD patients (for winter admission) and how interventions should be targeted to prevent admissions	Observational (retrospective cohort population-based) study of risk-stratified COPD patients	+	+	COPD admissions(n= 80,291), 1997-2003, in three Strategic Health Authorities, England: Cheshire & Merseyside, Birmingham and the Black Country, and Norfolk, Suffolk and Cambridgeshire SHAs	Stratified into three groups according to the number of admissions during the previous year: 0 (NIL) 1-2 (MOD) >or=3 (FRQ)	Hospital admission (COPD exacerbation)	Patients admitted during winter (1 November-31 March) were stratified into three groups according to the number of admissions during the previous year: 0 (NIL), 1-2 (MOD) or >or=3 (FRQ). Winter weeks were classified as "average", "above average", "high", or "very high" risk, compared with the long-term mean	The risk of admission during winter FRQ 40% MOD 12% NIL patients contributed to 70% of winter admissions, and 90% of the variation between "average" and "very high" weeks, versus 9% and 1% for MOD and FRQ. Author note: "Patients with no previous admissions have lower individual risk, but contribute to a high overall utilisation of health care resources and should be targeted to prevent admissions. Focusing upon high-risk patients (frequent attenders or more severe) may only reduce a small proportion of admissions, and therefore clinicians should ensure that all COPD patients receive appropriate therapy to reduce risk of exacerbations."	: Confounders such as influenz other co-morbidities is not accounted for, issues related temperature and air quality a included. Further limitations to coding of COPD in HES, and potential un-detected/ repor COPD events. The findings are applicable to study area, more adjustment needed to make generalisabl England.
58	Croxford B. The effect of cold homes on health: evidence from the LARES	To improve knowledge of the impacts of existing housing conditions on	House and household surveys	+/-	+/-	Survey of the condition of 3373 dwellings and the health status of	Four survey variables selected as indicative of 'poor hygro-thermal	Four major categories of outcome: (1) any cardio vascular illness	Logistic regression model with fixed effect control for city. Confounding	*Summary results of statistically significant associations between measures of cold homes and health. Results of multi-variable logistic regression*	Reviewer comments: -- Analyses based on overall prevalence not on seasonalit symptoms or cold-attribution

	study. In: Ormandy D, editor. Housig and health in Europe: the WHO LARES project. Oxford: Routledge; 2009. p. 142-54.[58]	health and mental and physical well-being (LARES study: Large Analysis and Review of European housing and health Status)				8519 inhabitants in eight European cities: Angers (F) Bonn (D) Bratislava (SK) Budapest (HU) Ferreira do Alentejo (POR) Forli (IT) Geneva (CH) Vilnius (LT). Broad aim: 400 dwellings, 1000 inhabitants per city. Average response rate over all cities: 44.2% of the eligible sample of households.	conditions:' - Temperature cold in winter? - Dissatisfied with Insulation? - Dissatisfied with heating system? - Dissatisfied with draughts?	(doctor-diagnosed hypertension, heart attack, strokes; (2) any respiratory health problem (doctor-diagnosed acute bronchitis, wheezing and whistling; (3) any arthritis/ rheumatic pain (self-reported) (4) belief that specific health problems affecting mental health are related to dwelling (this is related to four questions in the survey that together can be used to generate a score for mental health called the SALSA score, see the chapter on mental health for more details)	variables included: personal age, sex, height, weight, Body Mass Index (BMI), smoking status, alcohol consumption, exercise status; household socio-economic status, no. of inhabitants, SALSA mental health indicator; fuel poor; perceptions problems with cold in winter, dissatisfaction with heating, dissastisfaction with thermal insulation, dissatisfaction with draughtiness, mouldy or damp home	*Reported respiratory problems* *Child* 2.1 times MORE prevalent if dissatisfied with heating system (OR:2.1, CI:1.0-4.38); 4 times LESS prevalent if dissatisfied with draughts (OR:0.25, CI:0.13-0.49) *Adult* None *Seniors* 1.97 times MORE prevalent if house cold in winter (OR:1.97, CI:1.03-3.76); 2.39 times MORE prevalent if dissatisfied with insulation (OR:2.39, CI:1.07-5.36) Reported cardiovascular problems *Child* N/A (too few events) *Adult* None *Seniors* None *Reported arthritis problems* *Child* N/A (too few cases) *Adult* None *Seniors* 1.92 times MORE prevalent if house cold in winter (OR:1.92, CI:1.16-3.16) Belief that mental health problems are related to dwelling *Child* 7.7 times LESS prevalent if dissatisfied with insulation (OR:0.13, CI:0.02-0.99) *Adult* 1.79 times MORE prevalent if house cold in winter Cold (OR:1.79, CI:1.07-2.98); 1.67 times MORE prevalent if dissatisfied with insulation (OR:1.67, CI:1-2.81); 1.82 times MORE prevalent if dissatisfied with heating	-- Cross-sectional comparison -- Unclear which confounder variables included in final mo

										system (OR:1.82, CI:1.14-2.91) *Seniors* None	
59	Ekamper P, van Poppel F, van Duin C, Garssen J. 150 Years of temperature-related excess mortality in the Netherlands. Demogr Res. 2009; 21: 385-425.[59]	To gain insight into the nature of the temperature-mortality association (including factors indicating vulnerability) over a long period.	Daily time series	+	+	The Netherlands: individual death records, 1855-2006, for one of the 11 Dutch provinces.	Daily temperature	Mortality	Negative binomial regression analysis; Distributed lag (0-30 days) "V" model for temperature with apex (MMT) at 16.5 C.; adjustment for seasonality and trend by preliminary removal of sine-cosine wave and time spline	Pooling the 150 years data, clear cold effects were identified. Regression coefficients from several lag intervals but not overall given [making summary difficult]. Coefficients were higher in infants and older persons (especially 75+), but similar in men and women. Lag interval specific coefficients were presented by 25-year period. Authors identified a decline in cold effects in infants from about 1930, and an increasing cold effect in the 75+ group (details not shown). Inspection of the data presented did not show a clear upward or downward trend over time in cold effects overall.	Pre-adjustment for season m remove some cold effect. Changes in effects over such time may be due to many fac
60	Fearn V, Carter J. Excess winter mortality in England and Wales, 2008/09 (provisional) and 2007/08 (final). Health stat. 2009; (44): 69-79.[60] (See also subsequent annual ONS reports)	To present provisional estimated figures for excess winter mortality (EWM) for the winter period 2008/09, and final figures for the winter period 2007/08 for deaths occurring in England and Wales, and analyses of historical trends in	Observational study: seasonal analysis of routine mortality data	+	+	England and Wales	Seasonal analysis (EWD)	Mortality	Figures by sex, age, and Government Office Region of England, and Wales are presented for the five-year period 2004/05 to 2008/09, and by cause of death from 2005/06 to 2007/08.	• There were an estimated 36,700 excess winter deaths in England and Wales in 2008/09. This is an increase of 49 per cent compared with figures for 2007/08. • The estimate of excess winter deaths in 2008/09 is the highest since 1999/2000. • In 2008/09 there were 15,300 excess winter deaths in males and 21,400 excess winter deaths in females. The majority of these deaths occurred among those aged 75 and over.	Restricted to standard EWM method.

		EWM from 1950/51 to 2008/09.									
61	Kysely J, Pokorna L, Kyncl J, Kriz B. Excess cardiovascular mortality associated with cold spells in the Czech Republic. BMC Public Health. 2009; 9: 19.[61]	To assess the association between cardiovascular mortality and winter cold spells, examined in individual age groups groups (25-59, 60-69, 70-79 and 80+ years) and in both men and women	Observational study of excess cardiovascular mortality using standardised Health statistics (accounting for sociodemographic changes) and influenza epidemics removed.	+	+	Population of the Czech Republic, 1986-2006, stratified according to age and gender	Cold spells were defined as periods of days on which air temperature does not exceed -3.5 degrees C. Excess cardiovascular mortality was determined after the influenza epidemics, long-term changes and the seasonal cycle in mortality had been removed.	Mean relative excess CVD mortality for all age groups and both genders.	Excess mortality was calculated as the difference between observed and expected daily values. For cases less than 100, excess mortality was calculated using the lower and upper limit factors for a Poisson-distributed variable; for cases greater than 100, the normal approximation was used. Confounding influence of influenza epidemics, long-term changes and the seasonal cycle in mortality controlled for.	Cold spells were associated with relative mean excess cardiovascular mortality in all age groups in men (6.3%, 4.2-8.3) and women (6.3%, 4.4-8.2). The relative mortality effects were most pronounced in middle-aged men (25-59 years)(13.8%, 8.4-19.1), which contrasts with majority of studies on cold-related mortality in other regions, potentially due to occupational exposure. The rate of excess mortality was significantly higher in men aged 25-59, and in both men and women aged 70 and above (2-tailed t-test, $p<0.001$) during cold episodes. The estimated excess mortality during the severe cold spells in January 1987 (+274 cardiovascular deaths) is comparable to that attributed to the most severe heat wave in this region in 1994. <u>Relative mean excess mortality (%)</u> 25-59yrs, M 6.3 (4.2; 8.3) 25–59 yrs, F 6.9 (-2.5; 17.4) 60–69 yrs, M 3.8 (-0.6; 8.3) 60–69 yrs, F 7.5 (1.9; 13.6) 70–79 yrs, M 6.4 (3.1; 9.9) 70–79 yrs, F 7.5 (4.1; 10.8) 80+ yrs, M 8.5 (5.0; 12.2) 80+ yrs, F 7.3 (4.9; 9.7)	Occupational exposure to col considered, and may contribu the increased risk in young m not seen in other studies. Removal of mortality during epidemics of influenza may re the mortality rate of those in brackets most susceptible to influenza. Income or disability was not considered. Study supported by the Czech Science Foundation
62	Makinen TM,	To examine	Cohort	+	+	A population	outdoor	Diagnosed RTI	Analysis of	The mean average daily temperature	

	Juvonen R, Jokelainen J, Harju TH, Peitso A, Bloigu A, et al. Cold temperature and low humidity are associated with increased occurrence of respiratory tract infections. Respir Med. 2009; 103(3): 456-62.[62]	whether the development of RTIs is potentiated by cold exposure and lowered humidity in a northern population.				study: 892 military recruits, 224 asthmatic and 668 non-asthmatic men, from two intake groups enrolled in military service in July 2004 and in January 2005 in the Kajaani garrison in northern Finland	temperature and humidity	(Total of 643 RTI episodes were diagnosed during the follow-up period, 595 upper and 87 lower RTIs.)	occurrence of RTI in relation to (preceding) ambient temperature	preceding any RTIs was -3.7+/-10.6; for URTI and LRTI they were -4.1+/-10.6 degrees C and -1.1+/-10.0 degrees C, respectively. Temperature was associated with common cold (p=0.017), pharyngitis (p=0.011) and LRTI (p=0.048). Absolute humidity was associated with URTI (p<0.001). A 1 degrees C decrease in temperature increased the estimated risk for URTI by 4.3% (p<0.0001), for common cold by 2.1% (p=0.004), for pharyngitis by 2.8% (p=0.019) and for LRTI by 2.1% (p=0.039). A decrease of 1g/m(-3) in absolute humidity increased the estimated risk for URTI by 10.0% (p<0.001) and for pharyngitis by 10.8% (p=0.023). The average outdoor temperature decreased during the preceding three days of the onset of any RTIs, URTI, LRTI or common cold. The temperature for the preceding 14 days also showed a linear decrease for any RTI, URTI or common cold. Absolute humidity decreased linearly during the preceding three days before the onset of common cold, and during the preceding 14 days for all RTIs, common cold and LRTI. Authors' conclusions: cold temperature and low humidity were associated with increased occurrence of RTIs, and a decrease in temperature and humidity preceded the onset of the infections.	Author noted limitations: Pot confounding by crowding and annually occurring respirator infection epidemics. The military environment is optimal for examining the association between cold temperatures and RTIs becau conscripts are exposed to col frequently and for prolonged periods. In Finland where mil service is mandatory they represent a normal populatio young men, and the effects o indoor crowding are similar t those observed in schools in winter.
63	Tenias JM, Estarlich M, Fuentes-Leonarte V,	To examine the short-term relationship	Case-crossover	+	+	Hip fracture cases admitted to two reference	Meteorologica l variables • temperature • relative	Hip fracture: -cervical -pertrochanteric	Case-crossover analyses to study the relationship between the	In the case-crossover analysis, the frequency of periods of calm wind on the day prior to the event was the only variable associated in a	Author noted limitations Due in part to its retrospectiv nature and the use of administrative data, the study

	Iniguez C, Ballester F. Short-term relationship between meteorological variables and hip fractures: an analysis carried out in a health area of the Autonomous Region of Valencia, Spain (1996-2005). *Bone* 2009; 45(4): 794-8.[63]	between meteorological conditions and the incidence of hip fracture HF in people >=45 years in a Mediterranean climate zone				hospitals, Valencia, Spain (n=2121, 75.3% women)	humidity • rain • wind • other (obtained from a centrally located weather station)		incidence of a hip fracture and the meteorological conditions, both on the same day and on the day previous to the patient's admission <u>Subgroups</u> by age (older or younger than 75 years of age), sex and type of fracture (cervical or pertrochanteric).	significant fashion to the incidence of hip fractures. ------- Frequency of periods of calm wind Symmetric Delay 0 1.0002 (0.999–1.002) Delay 1 0.998 (0.997–0.999) Semi metric Delay 0 0.999 (0.998–1.001) Delay 1 0.998 (0.996–0.999) Results expressed as Odds Ratio (Confidence Interval: 95%). Wind (OR by increase in tenths of an hour of periods of calm wind). ------- Using this variable, the authors were able to classify the days from calmest to windiest. The analysis by quartiles showed a dose–response relationship in which the risk increased with greater frequency of wind, with similar results for both the symmetric and semi-metric methods Greater occurrence of cases in the autumn and winter months. Windiest days (quartile 4) were associated with an increased risk of HF (OR 1.32 (1.10, 1.58)) *vs* quartile 1, especially in patients under 75: OR 1.53 (1.02, 2.29). The remaining meteorological variables were not associated with the incidence of HFs. The results were comparable across different subgroups classified by age,	should be viewed as a hypoth generating study.

										sex, and type of fracture. The incidence of HFs varies seasonally and presents a significant association with the coldest times of the year.	
64	Yang TC, Wu PC, Chen VYJ, Su HJ. Cold surge: a sudden and spatially varying threat to health? Sci Total Environ. 2009; **407**(10): 3421-4.[64]	To analyse spatial variation in before-after changes in cardiovascular mortality in relation to four identified 'cold surges'. Specifically: 1) whether cold surges impose an immediate, adverse effect on CVD mortality; 2) whether people living in temperate zones have a higher tolerance of extreme temperature drop.	Spatial analysis	-	-	Population in townships of Taiwan in relation to four 'cold surges', 2000-2003	'Cold surges' defined (Taiwan Central Weather Bureau) as: (1) surface temperature drop within 24 hours > 8 deg C, or (2) lowest temperature in the Taipei metropolitan area <10 deg C. <u>Effect modifiers</u> Region (north, middle, south, east) <u>Confounders not treated.</u>	Cardiovascular mortality	Paired-samples' t-test to investigate whether the CVD mortality rates are significantly different before and after the cold surge. ANOVA tests used to compare mean mortality ratios between regions.	*Results of before-after ratio in cardiovascular mortality in relation to cold surges, by geographical region of Taiwan* Mean CVD mortality ratio (Min, Max, S.D.) North Taiwan 1.083(1.033 1.107 0.018) (N=95) Middle Taiwan 1.173 (1.003 1.263 0.056) (N=108) South Taiwan 1.136 (1.047 1.363 0.059) (N=107) East Taiwan 0.991 (0.783 1.248 0.129) (N=39) Cardiovascular disease mortality rates increased significantly after cold surges, and varied spatially, with 'greater tolerance' to cold surges in regions (e.g. eastern) with more 'severe winter temperatures'.	<u>Author noted limitations</u> - Ecological analysis, therefor ecological bias; -Exploratory study <u>Reviewer comments</u> Simple analysis, no analysis o potential specific determinan (modifiers) of risk, e.g. popul characteristics. See Chen *et al* 2010 above.

Continued…

Appendix 5 table continued: 2008 studies											
Ref	Study	Aim of study	Study design	Validity		Pop, setting	Exposure	Outcomes	Analysis	Results	Notes
				Int	Ext						
2008											
65	Analitis, A, Katsouyanni K, et al. "Effects of cold weather on mortality: results from 15 European cities within the PHEWE project." Am J Epidemiol 2008; 168(12): 1397-1408.[65]	To assess the effects of temperature on (cold season) cause- and age-specific daily mortality in 15 European cities.	Cross-sectional, time series, and spatial study.	++	+/++	Population in 15 European cities during the cold season (October-March) between the years 1990-2000 inclusive	Minimum apparent temperature from meteorological stations (ecological classifier), defined as minimum daily value of 3-hour apparent temperature values, which were adjusted for wind speed and barometric pressure. Effect modifiers Age, weather variables) Confounders Air pollution index, temporal correlation, holidays, day of the week, calendar month, long-term trends,	Daily mortality All-cause Cause-specific: Cardiovasc. Resp. Cerebrovasc.	The Poisson distribution was used to model each outcome for each age group at the city-level and for all cities pooled together.	*RR for a 1 deg C decrease in temp* All (natural) deaths: 1.35% (1.16, 1.53) Cardiovascular: 1.72% (1.44, 2.01) Respiratory: 3.30% (2.61, 3.99) Cerebrovascular: 1.25% (0.77, 1.73) The increase was greater for the older age groups. Cold effect greater in warmer (southern) cities. Persisted up to 23 days, with no evidence of mortality displacement.	Authors mention possible fut separation of 'apparent temperature' into air temper and humidity.

							influenza epidemics.				
66	Barnes M, Butt S, Tomaszewski W. The dynamics of bad housing: the impact of bad housing on the living standards of children. London: National Centre for Social Research, EAGA partnership, Shelter, 2008.[66]	To examine the relationship between poor housing and outcome in children	Longitudinal panel study	+	+	Longitudinal annual follow-up of a sample of English children (n=6431 followed up annually), 2001 and 2005, using caregiver interviews for under 11-year olds, and self-completed questionnaires for adolescents	Overcrowded accommodation, accommodation in a poor state of repair and inadequately-heated accommodation	Multiple outcomes including: Illness/illness behaviours, economic well-being Specific outcomes include: -- asthma or bronchitis symptoms -- multiple negative outcomes	Descriptive analyses and multivariable logistic regression	Percentage of children with problems with chest, breathing, asthma or bronchitis, according to the number of years they have lived in *an inadequately hearted home* *3*-5 years 15% 1-2 years 11% 0 7% 'Mental well-being' *Percentage of children that have four or more negative "Every Child Matters"*(ECM) outcomes, according to the number of years they have lived in an inadequately heated home* *3*-5 years 28% 1-2 years 9% 0 4% Base: Secondary school age children in Britain in 2005 Association is statistically significant for 4+ ECM outcomes (odds ratio 1.89, CI not quoted) but NOT for respiratory symptoms. *The ten outcomes are i) A long-standing illness or disability, ii) to go without regular physical exercise, iii) in trouble for smoking, drinking or taking drugs, iv) bullied in or out of school, v) expelled or suspended from school, vi) does not see friends and does not attend organised activities, vii) has been in trouble with the police, viii) below average in key academic subjects, ix) family cannot afford an	A number of explanatory vari were considered to examine relationship of children living 'bad housing'. Some confoun variables such as tenure, pov and inadequate housing need controlled for further. Limitations relate to potentia response bias and follow-up l The outcome measures are d from secondary classification inadequate heating and fuel p Associations are found for numerous poor housing facto responses of bad health and negative child outcome. Generalisable to England.

										annual holiday, and, x) family in income poverty.	
67	Brock A. Excess winter mortality in England and Wales, 2007/08 (provisional) and 2006/07 (final). Health stat. 2008; (40): 66-76.[67] (See also later annual ONS reports)	To report excess winter mortality (EWM) for the winter period 2007/08, and final figures for the winter period 2006/07 for deaths occurring in England and Wales, as well as historical trends in EWM from 1950/51 to 2007/08.	Observational study: seasonal analysis of routine mortality data	+	+	England and Wales	Seasonal analysis (EWD)	Mortality	Figures by sex and age for the Government Office Regions of England, and Wales are presented for the five-year period 2003/04 to 2007/08, and by cause of death from 2004/05 to 2006/07	In the four months of winter 2007/08 there were an estimated 25,300 more deaths in England and Wales than in the non-winter period. This was more than in the previous winter, and similar to the winter of 2005/06, but not as many as in the winter of 2004/05. There were just over 1,500 more excess winter deaths in 2007/08 than in 2006/07, an increase of 7 per cent.	Restricted to standard EWM method.
68	Jimenez-Conde J, Ois A, Gomis M, Rodriguez-Campello A, Cuadrado-Godia E, Subirana I, et al. Weather as a trigger of stroke. Daily meteorological factors and incidence of stroke subtypes. Cerebrovasc Dis. 2008; **26**(4): 348-54.[68]	To investigate relationship between daily meteorologic al conditions and daily as well as seasonal stroke incidence	Time series	+	+	1,286 consecutive strokes from the referral area of the Hospital del Mar, Barcelona, 2001-2003	Daily meteorologic al data from local monitoring station: - atmospheric pressure (AP) relative humidity (RH) - maximum, minimum, and mean temperatures - the variation of all these measures compared with the	Intra-cerebral haemorrhage (ICH) (n = 243) or ischaemic stroke (IS) (n = 1,043) IS was further divided into non-lacunar stroke (NLS) (n = 732) and lacunar stroke (LS) (n = 311)	Time series analysis	The daily incidences of NLS and ICH were higher in autumn and in winter, but depended strongly on the daily variations of AP Total stroke (TS) incidence showed little association with AP but was higher with the AP variations (CC: 0.127; $p < 0.001$). NLS were related to AP falls (OR: 2.41; $p < 0.001$) whilst ICHs were associated with AP rises (OR: 2.07; $p = 0.01$). NLS inversely related to temperature but not significant after adjusting for AP variations.	

							previous day.				
69	Jordan RE, Hawker JI, Ayres JG, Adab P, Tunnicliffe W, Olowokure B, et al. Effect of social factors on winter hospital admission for respiratory disease: a case-control study of older people in the UK. Br J Gen Pract. 2008; **58**(551): 400-2.[69]	To establish the most important (especially social) factors associated with winter hospital admissions among older people presenting with acute respiratory disease	case-control study	++	++	Seventy-nine general practices in central England.	Of a cohort of patients consulting medical services with lower respiratory tract infection or exacerbation of chronic respiratory disease, 157 hospitalised cases were compared to 639 controls. Social, medical, and other factors were examined by interview and GP records	Winter hospital admission with acute respiratory disease (excluding upper respiratory tract infection only)	Conditional logistic regression Confounder control: multivariable models including age, chronic conditions, smoking status, hospitalizations in previous year, functional score, ethnicity, rural-urban index, oral steroids, regular contact with family/friends	Risk factors (ORs) Social isolation: 4.5 (1.3, 15.8) COPD 4.0 (1.4, 11.4) Other chronic dis 2.9 (1.2, 7.0) Both 6.7 (2.4, 18.4) Being housebound 2.2 (1.0, 4.8) Measures of material deprivation were not significant risk factors for admission at either individual or area level. Authors note: "Socioeconomic factors had little relative effect compared with medical and functional factors. The most important was the presence of long-term medical conditions (especially COPD), being housebound, and having received two or more courses of oral steroid treatment in the previous year. This combination of factors could be used by primary medical services to identify older patients most vulnerable to winter admissions."	Author acknowledged limitat The study had a low uptake, p because nearly one-third of t hospitalised patients died wit three months of being admitt and therefore could not take in the questionnaire. This res in reduced power for many outcome measures. Insufficie power to test effect of indoor temperature.
70	Osman LM, Ayres JG, Garden C, Reglitz K, Lyon J, Douglas JG. Home warmth and health status of COPD patients. Eur J Public Health. 2008; **18**(4): 399-405.[70]	To determine if the health status of patients with Chronic Obstructive Pulmonary Disease (COPD) is associated with maintaining recommend domestic	Cross-sectional observational study.	+	+	Study of 148 COPD patients (67 M, mean age 69 (SD 8.5)), living in their own homes	Living room (LR) and bedroom (BR) temperatures were measured at 30 min intervals over 1 week using electronic dataloggers. (Outdoor temperatures	Health status was measured using the St George's Respiratory Questionnaire (SGRQ) and EuroQol: EQ VAS	Descriptive statistics were collated for temperature monitoring results. Parametric and non- parametric statistics were used. Unadjusted associations between demographic, clinical and temperature	Independent of age, lung function, smoking and outdoor temperatures, poorer respiratory health status was significantly associated (P = 0.01) with fewer days with 9 h of warmth at 21 degrees C in the LR. A sub analysis showed that patients who smoked experienced more health effects than non-smokers (P < 0.01). Conclusion: maintaining the warmth guideline of 21 degrees C in living areas	Confounders of underlying dw efficiency to maintain 9h/21C controlled for, bias of hospita admitted cases noted, exposu outdoor cold not accounted f arbitrary selection of 'recommended' 9h/21C temperature not 'experience 'comfort' temperature. The findings are of limited generalisability to non hospit admitted COPD patients

		indoor temperatures of 21 deg C for at least 9 h per day in living areas					were provided by Met Office.)		measures were calculated for SGRQ symptom, activity limitation and disease impact scores and EQ VAS scores. The demographic and clinical variables in analyses included: age, validated smoking status, marital status, Carstairs deprivation score, number of prior admissions for COPD and percentage of predicted FEV1 and FVC. As FEV1 and FVC were highly correlated (r = 0.61, P < 0.001) only predicted FEV1 was used. Variables with P-values of at least 0.10 in the unadjusted analyses were entered into an ordinary least squared multivariate regression analysis. Using Bonferroni correction for multiple testing of intercorrelated outcomes a P-value of <0.01 was	for at least 9 h per day was associated with better health status for COPD patients. Patients who were continuing smokers were more vulnerable to reduction in warmth.	

									required for significance. Data were analysed separately for continuing smokers and for non-smokers.		
71	Rocklov J, Forsberg B. The effect of temperature on mortality in Stockholm 1998--2003: a study of lag structures and heatwave effects. Scand J Public Health. 2008; 36(5): 516-23.[71]	To describe seasonal patterns of natural mortality and temperature-mortality relationship for high and low temperatures	Time series	++	++	Population of Stockholm, Sweden, 1998-2003	Temperature derived from local meteorological monitoring stations for Stockholm	Mortality, by cause <u>Modifiers</u> Age Cause: cardiovascular, respiratory	Generalized additive Poisson regression models <u>Confounding control</u> influenza, season, time trends, week day, and holidays	Optimal (+minimum mortality) temperature' was around 11-12 deg C. Below this temperature the cumulative RR corresponded to a 0.7% (95% CI=0.5-0.9) decrease per degrees C. <u>Age</u> <65 years 0.5% (not significant) 65-74 years 1.5% (not significant) >74 years 1.6% (0.9, 2.3) <u>Cause</u> Cardiovascular 1.1% (95% CI=0.3-2.0) Respiratory 4.3% (95% CI=2.2-6.5) Lag structures from moving averages and polynomial distributed lag models suggested a prolonged effect during winter, covering about a week.	<u>Reviewer comment</u> Although not fully clear, the a and cause-specific results presented seem to be heat ef No equivalent results are pro for cold risk

Continued…

Ref	Study	Aim of study	Study design	Validity		Pop, setting	Exposure	Outcomes	Analysis	Results	Notes
				Int	Ext						
2007											
	Bischoff-Ferrari HA, Orav JE, Barrett JA, Baron JA. Effect of seasonality and weather on fracture risk in individuals 65 years and older. *Osteoporosis international* 2007; **18**(9): 1225-33.[72]	To investigate seasonal variation in the incidence of four common fractures, and explore the association of weather with risk	Population-based observational study (analysis of Medicare data): semi-ecological comparisons	++	++	Individuals >= 65 years from 5% sample of the US Medicare population, residing in 50 US states 1 July 1986 to 30 June 1990 Cases with evidence of bone cancer of prior fracture were excluded.	• Season (winter was DJF, summer JJA etc) • Weather (monthly data): - snowfall - sunny days - mean daily temperature (data from US National Oceanic and Atmospheric Administration)	• Fractures: - hip - distal forearm - proximal humerus - ankle.	Descriptive statistics and rate comparisons Poisson regression to study associations of season and weather variables with fracture risk with 95% confidence intervals. Fractures also evaluated in subgroups of populations.	For all fractures, rates were highest in winter and lowest in summer ($p < 0.05$ at all sites). The winter/summer elative risk for was significant for hip fractures (1.08, 1.05-1.12), distal forearm (1.19, 1.14-1.24), proximal humerus (1.20,1.14-1.27), and ankles (1.22, 1.15-1.29). *Winter* Higher winter temperatures were inversely related to risk for the distal forearm fractures (RR per 10 degrees Fahrenheit = 0.95, 0.92-0.99) and ankle fractures (0.87, 0.83-0.92). Winter peaks were more pronounced in warm climate states, in men, and in those younger than 80 years old. Total snowfall was associated with a reduced relative risk of hip fracture (0.95 (0.91-0.99) per 20 inches) but an increased risk of non-hip fractures (6-12%; $p < 0.05$ at all sites). *Summer* Hip fracture risk tended to be lower during sunny weather (- 3% per 2 weeks of sunny days; $p = 0.13$), while other fractures were increased (15%-20%; $p < 0.05$) in sunny weather. Significant differences in the winter-summer relative risk for hip and distal forearm fractures were seen between genders, and in distal forearm and proximal humerus according to age	Case definitions depended on validity of Medicare claims da Misclassification of exposure may have occurred when generalising weather from no local weather stations. The majority of cases were white female.

Appendix 5 table continued: 2007 studies

										bracket. Fractures contribute considerably to winter morbidity in older individuals. Younger age between 65 and 80, living in warmer states and male gender are risk factors for increased winter morbidity due to fractures. Weather affects hip fracture risk differently than the other fractures studied.	
73	Davie GS, Baker MG, Hales S, Carlin JB. Trends and determinants of excess winter mortality in New Zealand: 1980 to 2000. BMC Public Health. 2007; 7: 263.[73]	To investigate the role of gender, region and deprivation on the magnitude of excess winter mortality (EWM) in New Zealand (NZ) countries. Also of interest was identifying causes of death with high EWM.	Cross-sectional seasonal analysis	+	+	New Zealand, between 1st January 1980 until 31st January 2001 inclusive	Seasonal definition: winter (June-September) *vs* warmer months (October-May). <u>Effect modifiers</u> Age, gender, ethnicity, geographical region, material/social deprivation <u>Confounders not treated.</u>	Cause-specific monthly mortality rates per 100,000 population calculated from routinely collected national mortality data by the New Zealand Health Information Service, Ministry of Health	Generalised negative binomial regression (selected through goodness-of-fit tests) were used to model all-cause and cause-specific mortality rates between winter (June-September) and the warmer months (October–May). No tests used for comparisons between winter and non-winter.	<u>Age</u> Young and the elderly particularly vulnerable <u>Sex</u> (adjusted for all major covariates) M 1 F 1.09 <u>Cause</u> (adjusted for all major covariates) % of all EWDs Circulatory system 47% Respiratory system 31% No evidence that EWM differed by ethnicity, region or local-area based deprivation level. Author note: “EWM in NZ is substantial and at the upper end of the range observed internationally. …the surprising lack of variation in EWM by ethnicity, region and deprivation, provides little guidance for how such mortality can be reduced.”	Authors note that the work w benefit from a time-series an exploration of the role of clim influenza, behaviour, crowdin winter, levels of home heatin thermal performance of houses.
74	Hajat S, Kovats RS, Lachowycz K. Heat-related and cold-related deaths	To determine the subgroups of the population that are most	Ecological time-series .	++	++	All regions of England and Wales, 1993 and 2003	Maximum, minimum and mean temperature based on: (i)	Mortality	Poisson generalised linear models allowing for over-dispersion	For all regions combined, a mean relative risk of 1.06 (1.05, 1.06) per deg C decrease below the cold threshold (set at the 5th centile). Cold effects were strongest in the East	

	in England and Wales: who is at risk? Occup Environ Med. 2007; **64**(2): 93-100.[74]	vulnerable to heat- and cold-related mortality					Central England temperature plus (ii) one monitoring station per region for regional analyses <u>Modifiers</u> - classified from postcode linkage of individual death records to a UK database of all care and nursing homes, and 2001 UK census small-area indicators		<u>Control of confounding</u> cubic smoothing splines of date	England region. Elderly people, particularly those in nursing and care homes, were most vulnerable. Vulnerability to either heat or cold was not modified by area-based measures of deprivation, except in rural populations where cold effects were slightly stronger in more deprived areas.	
75	Medina-Ramon M, Schwartz J. Temperature, temperature extremes, and mortality: a study of acclimatisation and effect modification in 50 US cities. Occup Environ Med. 2007;	To examine the increase in mortality associated with hot and cold temperature in different locations, the determinants of the variability in effect	Case-crossover & meta-analysis	++	++	Daily mortality data for 6,513,330 deaths in 50 US cities, 1989-2000	Exposure was assessed using two approaches: (i) exposure to extreme temperatures using city-specific indicator variables based on the local	All-cause mortality; Myocardial infarction mortality; Cardiac arrest mortality	The effect of hot and cold temperature was examined in season-specific models. Meta-analysis city-specific results, to examine several city characteristics as effect modifiers: - mean of cold	*Percent change in total and cause-specific mortality associated with (cold) temperature. Results from the meta-analysis of 42 US cities, 1989–2000* Cold exposure Sequential results as follows Lag 0 ⌉ Lag 1 Extreme temp* Lag 2-day ⌋ Lag 0 ⌉ Lag 1 Piecewise linear Lag 2-day ⌋	

	64(12): 827-33.[75]	estimates, and its implications for adaptation					temperature distribution; (ii) piecewise linear variables to assess exposure to temperature on a continuous scale above/below a threshold.		months' temp (deg C) - variance of cold months temp (deg C) - central heating (%) - population density (pop/km^{-2}) Confounder control: fixed stratum case-crossover	<u>Total mortality</u> *Extreme* 0.03 (21.09 to 1.16) 1.79 (0.87 to 2.72) 1.59 (0.56 to 2.63) *Piecewise* -0.19 (-0.22 to -0.15) 0.23 (0.18 to 0.27) 0.04 (0.01 to 0.08) <u>Myocardial infarction</u> *Extreme* 2.43 (20.79 to 5.75) 1.51 (21.56 to 4.67) 3.90 (0.18 to 7.76) *Piecewise* 0.00 (20.11 to 0.11) 0.25 (0.14 to 0.36) 0.26 (0.15 to 0.36) <u>Cardiac arrest</u> *Extreme* 7.29 (21.92 to 17.4) 11.9 (2.32 to 22.4) 16.2 (5.12 to 28.4) *Piecewise* -0.25 (-0.61 to 0.12) 0.62 (0.25 to 1.00) 0.39 (0.07 to 0.71) * Per cent change in mortality on extreme temperature days relative to all other days † Per cent change in mortality per each degree of maximum daily temperature below 17 deg C Modification by city characteristics of the two-day cumulative effect of extreme cold on mortality. Comparison of the predicted change in mortality at the 25th and 75th percentile of the effect modifier distribution.	

										Sequential results as follows Mean of cold months' temp (deg C) Variance of cold months temp (deg C) Central heating (%) Population density (pop/km^{-2}) Change in total mortality at the: 25th percentile 1.31 (0.04 to 2.60) 1.88 (0.75 to 3.03) 1.79 (0.28 to 3.32) 1.87 (0.50 to 3.26) 75th percentile 1.81 (0.62 to 3.02) 1.13 (20.14 to 2.41) 1.22 (20.11 to 2.57) 1.70 (0.60 to 2.82) Change in MI mortality at the: 25th percentile 3.10 (21.36 to 7.77) 4.65 (0.27 to 9.22) 4.38 (21.61 to 10.7) 4.66 (20.43 to 10.0) 75th percentile 4.71 (0.17 to 9.46) 3.13 (21.42 to 7.89) 3.92 (21.05 to 9.14) 4.26 (0.17 to 8.51) Change in CA mortality at the: 25th percentile 11.9 (21.65 to 27.4) 18.00 (4.71 to 32.9) 18.0 (2.28 to 36.2) 17.8 (3.96 to 33.5) 75th percentile 19.0 (6.29 to 33.3) 14.00 (0.19 to 29.7) 14.2 (0.90 to 29.2) 16.7 (5.29 to 29.3)	

										Mortality increases associated with extreme cold (2-day cumulative increase 1.59% (0.56, 2.63)) , the former being especially marked for myocardial infarction and cardiac arrest deaths. The effect of extreme cold (defined as a percentile) was homogeneous across cities with different climates, suggesting that only the unusualness of the cold temperature (and not its absolute value) had a substantial impact on mortality (that is, acclimatisation to cold).	
76	Morris C. Fuel poverty, climate and mortality in Northern Ireland 1980-2006 (NISRA Occasional Paper 25): Statistics and Research Branch, Department for Social Development, Ormeau Road, Belfast BT7 2JA; 2007.[76]	To examine temperature and changes in mortality rates in Northern Ireland, focusing on circulatory and respiratory deaths.	Observational study	+	++	Northern Ireland, 1980-2006	Ambient temperature. Housing as an effect modifier	Mortality from circulatory and respiratory diseases	Descriptive analyses of relationship between housing conditions, cause of death and temperature	During the period 1980-2006, deaths from circulatory and respiratory causes have declined by about 30%. In terms of death rates, there is some variability by age and cause in the decline, but all groups show a decline. Little decline in respiratory death rates for those 65 and over. It was possible to construct a robust model to explain the variation in death rates. Temperature shortfall was the most common significant explanatory variable, but there was evidence to suggest that seasonality and economic factors, as well as the underlying general improvement, also had an impact. The relationships broadly hold up for shorter time periods. From 1980-1999, the proportion of deaths that could be linked to temperature shortfall was 16-21%, dependent on age group, falling to 5-	The authors conclude that th a considerable improvement cold-related mortality , may b linked to measures addressin poverty though this is not investigated

										12% in the period 2000-2006. The circulatory death rate among those aged 65 or over was affected by temperature shortfall in each of the successive five year periods from 1980-2004. The impact of one degree of shortfall in the 1980s, however, was about three times as great as in the period 2000-2004, and even in the 1990's, the impact was more than double. Strong relationship found between type of central heating and cause of death (see Table 13)	
77	Myint PK, Vowler SL, Woodhouse PR, Redmayne O, Fulcher RA. Winter excess in hospital admissions, in-patient mortality and length of acute hospital stay in stroke: a hospital database study over six seasonal years in Norfolk, UK. Neuroepidemiology. 2007; 28(2): 79-85.[77]	To examine the hypothesis that age, sex and type of stroke are major determinants of the presence or absence of winter excess in morbidity and mortality associated with stroke.	Register-based observational study	+	++	Hospital-based stroke register from Norfolk, UK (n=5,481 patients, men=45%, age range 17 to 105 years, median=78 years).	Seasonal definition of excess winter death (Curwen)	Mortality	Calculation of winter excess for the number of admissions, in-patient deaths and length of acute hospital stay -- sex-specific analyses by (1) seasonal year and (2) quartiles of patients' age and stroke subtype.	There appeared to be winter excess in hospital admissions, deaths and length of acute hospital stay overall accounting for 3/100,000 extra admissions (winter excess index of 3.4% in men and 7.6% in women) and 1/100,000 deaths (winter excess index of 4.7 and 8.6% in women) due to stroke in winter compared to non-winter periods. Older patients with non-haemorrhagic stroke mainly contribute to this excess. If our findings are replicated throughout England and Wales, it is estimated that there are 1,700 excess admissions, 600 excess in-patient deaths and 24,500 extra acute hospital bed days each winter, related to stroke within the current population of approximately 60 million.	Potential confounders relatec environment factors not dire accounted for. Exposed temperature, smoking, influe risks were not accounted for winter period is abritrary and based on temperatures. Win excess controlled for age and but no estimates of associaito provided.

Continued…

Ref	Study	Aim of study	Study design	Validity		Pop, setting	Exposure	Outcomes	Analysis	Results	Notes
				Int	Ext						
2006											
78	Carson C, Hajat S, Armstrong B, Wilkinson P. Declining vulnerability to temperature-related mortality in London over the 20th century. Am J Epidemiol. 2006; 164(1): 77-84.[78]	To examine the degree to which population vulnerability to outdoor temperature changed over the 20th century, as an indication of the possible effect of improvement in infrastructure, technology, and general health.	Time series study (weekly data)	+	++	London, UK during four periods of the 20th century: 1900-1910, 1927-1937, 1954-1964, and 1986-1996	Seasonal definition (winter (DJFM) to non-winter (AMJJASON) ratio) and use of temperature data for London (meteorological monitoring stations) for cold-mortality relationship <u>Confounding</u> Time-series for temperature-mortality relationship adjusted for season but not influenza	All cause, CVD and respiratory mortality	(for temperature) Autoregressive Poisson models	*The ratio of winter deaths to nonwinter deaths* 1900-1910 1.24 (1.16, 1.34) 1927-1937 1.54 (1.42, 1.68) 1954-1964 1.48 (1.35, 1.64) 1986-1996 1.22 (1.13, 1.31) *Temperature-mortality gradient for cold deaths (*the increase in mortality per 1 degree C drop below 15 degrees C) 1900-1910 2.52% (2.00, 3.03) 1927-1937 2.34% (1.72, 2.96) 1954-1964 1.64% (1.10, 2.19) 1986-1996 1.17% (0.88, 1.45) Corresponding population attributable fractions were 12.5%, 11.2%, 8.7%, and 5.4%. Reductions in cold risk were most pronounced for CVD mortality. Authors note that "there was a progressive reduction in temperature-related deaths over the 20th century, despite an aging population. This trend is likely to reflect improvements in social, environmental, behavioural, and health-care factors…"	
79	Diaz J, Linares C, Tobias A. Impact of extreme temperatures	To analyse the relationship between extreme temperatures	Time series study of one age group	++	+	Madrid, Spain, January 1986 to December 1997.	Meteorological variables from Madrid-Retiro Observatory	Cause-specific daily mortality as provided by the Madrid Regional	Generalised additive models fit separately for males, females and both sexes, for	Mortality impact was limited for temperatures in the 5th to the 95th percentiles range, but increased sharply thereafter.	

Appendix 5 table continued: 2006 studies

	on daily mortality in Madrid (Spain) among the 45-64 age-group. Int J Biometeorol. 2006; 50(6): 342-8.[79]	and sex- and cause-specific mortality among persons aged 45-64 years.					located in the Madrid metropolitan area: maximum daily temperature (Tmax); minimum daily temperature (Tmin); relative humidity (RH) observed at 7.00 a.m. <u>Effect modifiers</u> Season, gender <u>Confounders</u> Air pollution (nitrogen ocides, sulphur dioxide, total suspended particulate matter, ozone), influenza epidemics, time lags, time trends, seasonalities	Department of Statistics. All except accidental deaths were included and labelled as due to organic causes, circulatory diseases, and respiratory diseases.	winter, and for summer.	When both sexes were analysed jointly, effect of heat proved relevant for organic- and circulatory-cause mortality, with ARs of 11.5% and 12.0%, respectively. When sexes were analysed separately, results for males were similar for organic (AR=12.3%) and circulatory causes (13.3%), but no relationship observed for females. Ozone effect noticeable on organic-cause mortality in both sexes (AR=6.4%). Further appreciable effects were registered for: TSP in the case of males (AR=4.2%) and organic causes; and NO2, which proved statistically significant in the case of both sexes for both organic and circulatory causes, particularly the latter (AR=15.0%). Impact of extreme cold was solely evident in female organic-cause mortality AR=7.7%). Influenza epidemics ("g") explained most of variance in these models.	
80	Frank DA, Neault NB, Skalicky A, Cook	To evaluate the association	Cross-sectional surveys	+	+	USA: 2 emergency departments		Survey of caregivers with children < 3 years		Families participating in the Low Income Home Energy Assistance Program reported more household	<u>Author acknowledged limitat</u> Do not know why those eligib LIHEAP benefits did not recei

	JT, Wilson JD, Levenson S, et al. Heat or eat: the Low Income Home Energy Assistance Program and nutritional and health risks among children less than 3 years of age. Pediatrics. 2006; **118**(5): e1293-302.[80]	between a family's participation in the Low Income Home Energy Assistance Program and the anthropometric status and health of their young children. (Children's Sentinel Nutrition Assessment Project)				and 3 primary care clinics in 5 urban sites, June 1998 to December 2004. Surveyed population included only Low Income Home Energy Assistance Program income-eligible renter households without private insurance who also participated in > or = 1 other means-tested program.		of age regarding household demographics, child's lifetime history of hospitalizations, and, for the past 12 months, household public assistance program participation and household food insecurity, measured by the US Food Security Scale, which classifies households as food insecure if they report that they cannot afford enough nutritious food for all of the members to lead active, healthy live		food insecurity (24% vs 20%) There were no significant group differences between recipients and nonrecipients in caregiver's education or child's gender. After controlling for these potentially confounding variables, including receipt of other means-tested programs, compared with children in recipient households, those in nonrecipient households had greater adjusted odds of being at aggregate nutritional risk for growth problems, defined as children with weight-for-age below the 5th percentile or weight-for-height below the 10th percentile (Adjusted odds ratio 1.23;95%CI 1.00-1.52, p=0.5). Nonreceipients households had a significantly lower mean weight-for-age z scores calculated from age- and gender-specific values from the Centers for Disease Control and Prevention 2000 reference data (z score -0.033 v 0.076, p=0.01). However, in adjusted analyses, children aged 2 to 3 years in recipient households were not more likely to be overweight (BMI > 95th percentile) than those in nonrecipient households. Rates of age-adjusted lifetime hospitalization excluding birth and the day of the interview did not differ between Low Income Home Energy Assistance Program recipient groups.	them. Although attempt mad control for covariates throug multivariate analysis possible there was unobserved differe between the two groups.

											Among the 4445 of 7074 children evaluated in the 2 emergency departments, children from eligible households not receiving the Low Income Home Energy Assistance Program had greater adjusted odds than those in recipient households of acute hospital admission on the day of the interview (adjusted odds ratio 1.32, 95% CI:1.00-1.74; p=0.05)	
81	Gerber Y, Jacobsen SJ, Killian JM, Weston SA, Roger VL. Seasonality and daily weather conditions in relation to myocardial infarction and sudden cardiac death in Olmsted County, Minnesota, 1979 to 2002. J Am Coll Cardiol. 2006; **48**(2): 287-92.[81]	To assess the relationship of season and weather types with myocardial infarction (MI) and sudden cardiac death (SCD) in a geographically defined population, and test the hypothesis that increased risk in winter is related to weather.	Temporal association study	+	+	The population of Olmsted County, Minnesota, USA, 1979 to 2002	Temperature and meteorological data from local airport monitoring station (National Weather Service)	Incident myocardial infarction Sudden cardiac death (SCD) - with antecedent coronary heart disease (CHD) - without antecedent CHD (unexpected SCD).	Age-, gender- and year-specific event rates were calculated for each season, weather and precipitation category. Poisson regression was used to assess the association of MI/SCD on season and meteorological variables. Two-way interaction terms were used to test effect modification by outcome, prior CHD status, age, gender and calendar year.	Age-, gender-, and year-adjusted RR of SCD, but not of MI, was increased: - in winter (vs summer): 1.17 (1.03, 1.32) - by low temperatures (<0 deg C vs. 18-30 deg C): 1.20 (1.07, 1.35) Associations were stronger for unexpected SCD than for SCD with prior CHD. There was significant effect modification by prior CHD status in the relationship between temperature and SCD. Compared with the 18-30 deg C category, the RR below 0 deg C for unexpected SCD was 1.35 (1.17, 1.56) and with prior CHD was 0.95 (0.77, 1.17). After adjustment for all meteorological variables, low temperature was associated with a large increase in the risk of unexpected SCD (RR = 1.38 (1.10, 1.73)), while the RR declined substantially in fall and winter (RR = 1.06, (0.83 to 1.35) for the latter). Neither rain nor snow was significantly	

										related to either outcome. No age or gender interactions were found. Conclusion: the winter peak in SCD can be accounted for by daily weather.	
82	Medina-Ramon M, Zanobetti A, Cavanagh DP, Schwartz J. Extreme temperatures and mortality: assessing effect modification by personal characteristics and specific cause of death in a multi-city case-only analysis. Environ Health Perspect. 2006; **114**(9): 1331-6.[82]	To identify subpopulations and mortality causes with increased susceptibility to temperature extreme	Case-only analysis	++	+	7,789,655 deaths from 50 U.S. cities, 1989-2000.	<u>Meteorological parameters</u> Distributions of daily minimum and maximum temperature in each city defined extremely cold days (</= 1st percentile). Modifiers: individual death records including primary and secondary causes of death, place of death, and age, sex, race and educational attainment.	Mortality,	For each hypothesized effect modifier, a city-specific logistic regression model was fitted and an overall estimate calculated in a subsequent meta-analysis. <u>Confounder control</u> Case-only analysis requires control only of (a) other modifiers of the temperature effect and (b) of risk factors modified by the putative modifiers of the temperature effect, not primary risk factors. Here just season (b) was controlled. Putative modifiers were not mutually controlled so identified factors may not be independent.	*Modification by subject characteristics of the effect of extreme temperatures on mortality** <u>Extreme cold</u> Characteristic OR (95% CI) Age ≥ 65 years 1.018 (0.998, 1.039) Female 0.998 (0.983, 1.013) Black race 1.009 (0.990, 1.029) Low education† 1.006 (0.983–1.030) Out-of-hospl death 1.020 (0.995–1.046) Presenting chronic condition: Diabetes 0.979 (0.951–1.008) COPD 0.995 (0.968–1.023)a *Cause of death* Pneumonia 1.028 (0.979–1.079) Stroke 0.987 (0.956–1.020) CVD 1.053 (1.036–1.070) Myocardial infarct 1.030 (0.999–1.062) Cardiac arrest 1.137 (1.051–1.230) Contributing cause of death	Considering only same-day la extreme cold will have deplet power.

										Congest heart fail 0.976 (0.947–1.005) Atrial fibrillation 1.052 (0.993–1.115) *Results from the meta-analysis of 50 U.S. cities during the period 1989–2000. Estimates represent the relative odds of dying on an extreme cold day for persons who had the condition (e.g., being female) compared with persons who did not have the condition. † High school (=university) graduate or less. Cardiovascular deaths and especially cardiac arrest deaths showed a greater relative increase on extremely cold days.	
83	Misailidou M, Pitsavos C, Panagiotakos DB, Chrysohoou C, Stefanadis C. Short-term effects of atmospheric temperature and humidity on morbidity from acute coronary syndromes in free of air pollution rural Greece. Eur J Cardiovasc Prev Rehabil. 2006; 13(5): 846-8.[83]	To evaluate effect of ambient temperature on morbidity from acute coronary syndromes (ACS) while avoiding confounding by air pollution.	Observational (ecological) study	+	+	Rural Greece, for 1 year.	Ambient temperature	Hospital admission (daily) for acute coronary syndrome	Daily admissions to hospital because of ACS were recorded for 1 year and analysed versus daily temperature and humidity.	For a 1 degrees C decrease in temperature there was a 1.6% (95% confidence interval 0.9-2.2%) increase in admissions. This effect was more prominent in the elderly. No difference was detected according to sex or type of ACS.	Air quality only assumed to b good in rural areas, this may strictly be true (e.g. high grou level ozone on sunny days)
84	Morabito M, Crisci A, Grifoni	To investigate the	Cross-sectional time	+	+	Florence, Italy: the	An objective daily synoptic	Computerized inpatient hospital	Calculation of a daily MI admission	Hospital admissions for MI showed a significant linear increase	Authors note that: health complications may bias

	D, Orlandini S, Cecchi L, Bacci L, et al. Winter air-mass-based synoptic climatological approach and hospital admissions for myocardial infarction in Florence, Italy. Environ Res. 2006; **102**(1): 52-60.[84]	winter risk of hospitalization for myocardial infarction (MI) by means of daily weather conditions, classified by an air-mass-based synoptic climatological approach.	series study.			winters of 1998-2003	air-mass classification calculated using seven meteorological variables. These are measured at 0900 and 1500 h at a weather station located in Florence, by the Institute of Biometeorology of the National Research Council, between the months of December to February, from 1998 to 2003. Effect modifiers Age (>=65, <65) Confounders Temporal, day-of-the-week, year, time lag	discharge data for MI (808 hospitalizations) over five-winter survey provided by Administration of Careggi Hospital, main hospital in Tuscany. Only data of people resident in Florence considered.	index (MIAI), taking into consideration the average admission value, characteristic of each winter. Time lag in disease onset also considered. Days of the week and air mass types were tested for MIAI differences using the Mann-Whitney U test. Two-day sequences of air mass types tested for MIAI differences using ANOVA and Bonferroni tests.	from winter of 1998–1999 to winter of 2002–2003 ($P<0.001$). Significant differences found between MIAI values on Saturday (lowest MIAI values) and those observed on Tuesday ($P<0.05$), Wednesday ($P<0.01$), and Thursday ($P<0.01$). Significant MIAI differences found between air masses over short and long periods. MIAI values occurring 24 h after a day characterized by anticyclonic continental air mass were statistically higher than MIAI values occurring the day after a mixed air mass ($P<0.05$). MIAI values occurring 6 days after a cyclonic air mass were significantly higher than MIAI values occurring 6 days after an anticyclonic polar continental ($P<0.05$) or after a mixed ($P<0.05$) air mass. Significant variations found ($P<0.001$) of mean MIAI values among all possible 2-day sequences of air masses.	associations; age/sex effect modifiers not considered; oth environmental variables such pollution/pollen not consider
85	Reinikainen M,	To determine	Observational	++	+	Finland: data	Month and	Hospital mortality	Logistic regression	The crude hospital mortality rate was	

	Uusaro A, Ruokonen E, Niskanen M. Excess mortality in winter in Finnish intensive care. Acta Anaesthesiol Scand. 2006; 50(6): 706-11.[85]	whether there are seasonal variations in mortality rates in Finnish intensive care units (ICUs)	study			on 31,040 patients treated in 18 Finnish ICUs.	season ('winter' defined as the period from December to February inclusive). Severity of illness with acute physiology and chronic health evaluation II (APACHE II) scores and intensity of care with therapeutic intervention scoring system (TISS) scores. Only included patients admitted for the first time, and those with a known outcome.	(among ICU patients). APACHE II severity of illness was also examined.	analysis with chi-squared. Age, severity of illness, intensity of treatment, and diagnosis were controlled for.	17.9% in winter and 16.4% in non-winter, P = 0.003. Even after adjustment for case mix, winter season was an independent risk factor for increased hospital mortality (adjusted odds ratio 1.13, 95% confidence interval 1.04-1.22, P = 0.005). In particular, the risk of respiratory failure was increased in winter (0.7% increase, p<0.001). Crude hospital mortality was increased during the main holiday season in July, although not significantly when confounding factors adjusted for. The APACHE II severity of illness in July was higher in July (18.3) than other months (17.6),p=0.004. An increase in the mean daily TISS score was an independent predictor of increased hospital mortality (adjusted odds ratio 1.04 for one additional point (1.04-1.05, p<0.001). Authors' conclusions: severity of illness-adjusted hospital mortality for Finnish ICU patients is higher in winter than in other seasons.	The study did not adjust for hospital unit occupancy or characteristic of patients in surrounding beds. Population studied was largely patients o than 75. The definition of 'winter' and 'summer' periods ignores the that cold periods can occur o of the defined winter period. The severity of the Finnish wi much greater than that in the
86	Southern DA, Knudtson ML, Ghali WA, Investigators A. Myocardial infarction on snow days: incidence,	To compare 'snow days' with 'non-snow days' with respect to the incidence of myocardial	Observation study	+	+/-	Alberta, Canada	These data were merged with data from Environment Canada to determine the amount of	Hospital admission and outcome in myocardial infarction. The use of acute procedures,	The average incidence of MIs on snow days versus nonsnow days was then determined. Risk-adjusted odds ratios for the use of direct percutaneous	There were 61 snow days and 575 non-snow days. The incidence of MI (incidence density ratio of 1.08, 95% CI 0.82 to 3.10) and the use of direct percutaneous coronary intervention (adjusted OR=1.07, 95% CI 0.74 to 1.54) were	Exposed temperature not accounted for in modelling, t morbidities were, influenza a not accounted for. Setting is not generalisable to populations, snow events are

	procedure, use and outcomes. Can J Cardiol. 2006; 22(1): 59-61.[86]	infarction (MI), the use of acute procedures and in-hospital mortality					snowfall that occurred on any given day. Snow days were defined as days when at least 5 cm of snow fell, and the two subsequent days were included because of the lingering effect of 'urban chaos' that can ensue after significant snowfall	determined by linking to data from the Alberta Provincial PRoject for Outcomes Assessment in Coronary Heart disease (APPROACH).	coronary intervention and in-hospital mortality were also determined.	slightly higher on snow days. In-hospital mortality trended toward being lower (adjusted OR=0.54, 95% CI 0.28 to 1.04) for patients admitted on snow days, although none of these differences were statistically significant. Authors' conclusions: despite the potential for the significant adverse effects of snow days on the incidence of MI, the use of acute procedures and outcomes, these findings suggest only minor effects, if any	frequent and temperature exposure more extreme.
87	Wang H, Matsumura M, Kakehashi M, Eboshida A. Effects of atmospheric temperature and pressure on the occurrence of acute myocardial infarction in Hiroshima City, Japan. Hiroshima J Med Sci. 2006; 55(2): 45-51.[87]	To examine the main effects and the interaction of atmospheric temperature and pressure on AMI	Observational study	+	+	Hiroshima City, Japan. 1993-2002: ambulance data for cases of acute myocardial infarction (AMI) (n=3755).	In the analysis, thermo-hydrological-index (THI), or humidity adjusted temperature, was calculated to involve the effect of relative humidity.	Acute myocardial infarction	Poisson regression	Daily events of AMI decreased as temperature increased. Daily events in the low, moderate, and high temperature groups were 1.16, 1.07 and 0.90, respectively (average=1.03/day). Atmospheric pressure showed a weaker effect in the presence of temperature. A more profound interaction was found between temperature and pressure. The highest daily events 1.38 were observed in the low temperature and low pressure group, while this meteorological type was always accompanied by rain and/or snow. It	

										was significant (p=0.047) and 37% higher than that of the high temperature and moderate pressure group. The lowest daily events 0.87 were observed in the high temperature and low pressure group. These associations were reinforced when temperature adjusted by relative humidity was used. Atmospheric temperature and the interaction of temperature and pressure had significant influences on the occurrence of AMI. The highest risk was found on days with low temperature and low pressure. Days with high risk were characterized by winter rain and/or snow.	

Continued…

Appendix 5 table continued: 2005 studies											
Ref	**Study**	**Aim of study**	**Study design**	**Validity**		**Pop, setting**	**Exposure**	**Outcomes**	**Analysis**	**Results**	**Notes**
				Int	**Ext**						
2005											
88	Barnett AG, Dobson AJ, McElduff P, Salomaa V, Kuulasmaa K, Sans S. Cold periods and coronary events: an analysis of populations worldwide. J Epidemiol Community Health. 2005; **59**(7): 551-7.[88]	To investigate the association between cold periods and coronary events, and the extent to which climate, sex, age, and previous cardiac history increase risk during cold weather	Time-series regression	+	+	Twenty four populations from around the world (including Belfast, NI but none in England) from the WHO's MONICA project, a 21 country register, 1980-1995.	Daily temperature from one weather station in each location. Also, daily humidity for 18 of the 24 sites.	People aged 35-64 years who had a coronary event.	A hierarchical analyses of populations from the World Health Organisation's MONICA project.	Daily rates of coronary events were correlated with the average temperature over the current and previous three days. In cold periods, coronary event rates increased more in populations living in warm climates than in populations living in cold climates, where the increases were slight. The increase was greater in women than in men, especially in warm climates. On average, the odds for women having an event in the cold periods were 1.07 higher than the odds for men (95% posterior interval: 1.03 to 1.11). The effects of cold periods were similar in those with and without a history of a previous myocardial infarction. Conlcusions: rates of coronary events increased during comparatively cold periods, especially in warm climates. The smaller increases in colder climates suggest that some events in warmer climates are preventable. It is suggested that people living in warm climates, particularly women, should keep warm on cold days.	

89	Basu R, Dominici F, Samet JM. Temperature and mortality among the elderly in the United States: a comparison of epidemiologic methods. Epidemiology. 2005; 16(1): 58-66.[89]	To compare time-series and case-crossover analyses using varying referent periods (ie, unidirectional, ambidirectional, and time-stratified) for studies of temperature and cardiorespiratory mortality	Time series and case cross-over designs	+	+	Elderly population (>65 years) who died of cardiovascular or respiratory disesases in 1992, in the 20 largest metropolitan areas of the United States	Daily mean temperature and daily dew-point temperature (measure of relative humidity) in 1992 provided by the National Climatic Data Center Earthinfo CD2 database for each metropolitan area. <u>Effect modifiers</u> Age, season, region, heterogeneity within region, <u>Confounders</u> Relative humidity, air pollution, time lag, day-of-week,	Cardiorespiratory mortality data from the US Division of Vital Statistics	Conditional logistic regression models (case-crossover) and overdispersed Poisson regression model (time-series) used to estimate risk by metropolitan area and season. Odds ratios (case-crossover) and relative risks (time-series) calculated for cardiorespiratory mortality associated with 10°F increase in mean daily temperature, adjusted for mean daily dew-point temperature and day-of-week effects.	<u>*Regional analyses with time-stratefied case-crossover method (similar results with ambidirectional and time-series analyses, but not unidirectional)*</u> Greatest risk for temperature-related cardiorespiratory mortality occurred in summer. Strongest in Southwest (OR=1.15, 95% CI 1.07–1.24). In winter, all regional estimates showed no effect. Null or negative associations also found in spring and fall seasons, except for: Northwest in fall (1.04, 0.92–1.17), Southwest in spring (1.04; 0.98 –1.09), and Midwest in spring (1.03; 0.98 –1.08). Lag-zero and lag-1 day exposures had similar estimates, and both had stronger associations between temperature and cardiorespiratory mortality than lag-2 or -3 days. Stratifying by age group gave no consistent evidence for effect modification by age for all regions. PM_{10} only confounder in summer months (Fig. 5), which slightly increased effects for some regions (Northeast and Southwest) and slightly lowered for other regions (Southeast and Midwest). Ozone not confounder in summer or winter months.	Authors note lack of treatme some modifiers such as microenvironment characteri use of AC; only one year of da county-averaged temperatur
90	Cagle A, Hubbard R.	To examine the	Observational study	+	+	People aged 55 years or	Daily average temperature	Out of hospital cardiac death:	Poisson regression to examine the	Identified a significant negative association between daily average	Limitations include limited in analysis of age (all individuals

	Cold-related cardiac mortality in King County, Washington, USA 1980-2001. Ann Hum Biol. 2005; 32(4): 525-37.[90]	relationship between temperature and cardiac death rates in King County, Washington, USA and suggest possible public health measures that can decrease the number of cardiac deaths associated with cold exposure.	Health statistics (mortality from cardiac causes) from Washington State Department of Health			older with out-of-hospital cardiac deaths, King County, Washington State, USA, 1980 to 2001 (n=62,125)		data from State death records	association between same-day daily average temperature and death rate. Adjustment for season Confounding factors investigated included season, year, precipitation, and barometric pressure.	temperature and cardiac mortality among persons over 55 years of age. A 5 degrees C increase in temperature was associated with a decrease in death rate by a factor of 0.971 (95% CI: 0.961, 0.982). <u>Relative risk for 5C temperature change</u> Total 0.971 (0.961, 0.982) Males 0.976 (0.961, 0.991) Females 0.968 (0.953, 0.983) Temperature on rate ratio (change in death rate per 5 degrees C change in temperature) continued to have a significant influence, even with a five-day time lag: <u>Relativerisk for 5C temperature change</u> 1 day (0.969,0.958-0.979) 2-day lag (0.961,0.951-0.972) 3-day lag (0.960,0.950-0.971) 4-day lag (0.959,0.949-0.970) 5-day lag (0.959,0.948-0.969) Authors' conclusions: cold temperatures may be an important triggering factor in bringing on the onset of life-threatening cardiac events, even in regions with relatively mild winters. Public health efforts stressing cold exposure while out of doors may play a prominent role in encouraging a reduction in cold stress, especially among seniors and those already at higher risk of cardiac death.	55), and does not investigate vulnerability. Seasonal variati influenza, are not investigate potential confounding factor, was ambient levels of air poll investigated. There is a risk o misclassifying the cause of de
91	Carder M, McNamee R,	To investigate the lagged	Time series	++	++	Three largest Scottish cities	Dry bulb and wind chill	Cardio-respiratory mortality	Generalised linear Poisson regression	Non-linear association between mortality and temperature: steeper at	

	Beverland I, Elton R, Cohen GR, Boyd J, et al. The lagged effect of cold temperature and wind chill on cardiorespiratory mortality in Scotland. Occup Environ Med. 2005; 62(10): 702-10.[91]	effects of cold temperature on cardiorespiratory mortality and to determine whether "wind chill" is a better predictor of these effects than "dry bulb" temperature.				(Glasgow, Edinburgh, Aberdeen), January 1981 to December 2001.	temperature		models, with lags up to one month Effects of temperature on mortality (lags up to one month) were quantified. Analyses were conducted for the whole year and by cool and warm season	temperatures below 11 degrees C. The association between temperature and mortality persisted at lag periods beyond two weeks but the effect size generally decreased with increasing lag. *Table. Estimated % increase (and 95% confidence intervals) in mortality over the ensuing one month period associated with a 1˚C drop in the daytime mean temperature (when temperature <11˚C) on any given day* <u>Cause of death</u> <u>Estimate (95% CI)</u> All cause mortality, all ages 2.93 (2.46, 3.39) All cause mortality, >65 years 3.34 (2.81, 3.87) All cause mortality, <65 years 1.40 (0.38, 2.41) Cardiovascular, all ages 3.35 (2.64, 4.06) Cardiovascular, >65 years 3.65 (2.87, 4.42) Cardiovascular, <65 years 1.90 (0.10, 3.67) Respiratory mortality, all ages 4.81 (3.45, 6.16) Respiratory mortality, >65 years 4.65 (3.18, 6.10) Respiratory mortality, <65 years 5.90 (2.60, 9.08) ''Other'' cause mortality, all ages 1.71 (0.99, 2.41) ''Other'' cause mortality, >65 years 2.06 (1.19, 2.93) ''Other'' cause mortality, <65 years 0.46 (-0.86, 1.77)	

										The effect of temperature on mortality was not observed to be significantly modified by season. There was little indication that "wind chill" temperature was a better predictor of mortality than "dry bulb" temperature.	
92	Diaz J, Garcia R, Lopez C, Linares C, Tobias A, Prieto L. Mortality impact of extreme winter temperatures. Int J Biometeorol. 2005; **49**(3): 179-83.[92]	To examine the effect of extreme winter temperature on mortality	Time series	+	+	Madrid, people older than 65 years (two different age groups: from 65 to 74, and older than 75). Data correspond to 1,815 winter days (November to March) over the period 1986-1997, during which time a total of 133,000 deaths occurred	Maximum, minimum and average daily temperatures, together with the relative humidity at 7 am and 3 pm. Air pollution variables were computed as daily average values.	Mortality (ICD9 codes 1–799) excluding accidental causes	ARIMA and Generalised Additive Models (GAM) time-series models	The daily maximum temperature (T(max)) was shown to be the best thermal indicator of the impact of climate on mortality. When total mortality was considered, the maximum impact occurred 7-8 days after a temperature extreme; for circulatory diseases the lag was between 7 and 14 days. When respiratory causes were considered, two mortality peaks were evident at 4-5 and 11 days. When the impact of winter extreme temperatures was compared with that associated with summer extremes, it was found to occur over a longer term, and appeared to be more indirect.	
93	Heyman B, Harrington BE, Merleau-Ponty N, Stockton H, Ritchie N, Allan TF. Keeping Warm and Staying Well: Does Home	To investigate relationships between home energy efficiency, socio-economic status and respondent	Cross-sectional (mainly) and longitudinal surveys.	-	-	Two surveys of relatively deprived households in North East England . One in 2000 and a follow-up in 2001.	Measured: (i) socio-economic status (ii) objective measure of energy	Respondent-assessed overall health. Also asked about health behaviours and administered SF36 health questionnaire.	Tabulation and logistic regression analysis. Self-assessed health was dichotomized (“Excellent” or “very good” in one group, “good”,	The main health measure used in the analysis, respondent-assessed overall health, was statistically significantly related to other health indicators, including SF36 scores, the reported presence of limiting conditions and health care behaviours such as visiting the GP.	

	Energy Efficiency Mediate the Relationship between Socio-economic Status and the Risk of Poorer Health? Housing Studies. 2005; 20(4): 649-64.[93]	health.				Sampling in 2000 occurred in two "waves". In the first, 6500 households contacted by phone, 2199 agreed to participate, 540 met criteria for fuel poverty and 301 were interviewed. In Wave 2, 234 of 538 household approached in person were recruited. Some differences were found between the two waves. There was 13-15% loss to follow up for the 2001 survey.	efficiency (SAP rating) (ii) Satisfaction with home heating (iv) Mastery scale score (v) Home tenure (vi) Other individual characteristics (age, gender, smoking…)		"fair" or "poor" in the other). The 2000 survey was basis of most results. Conducted path analysis on patterns of relationships between predictors and self-assessed health.	Worse respondent self-assessed health was statistically significantly related to occupational, wealth and income measures of poorer socio-economic status. However, measures of heating satisfaction and sense of mastery displaced the socio-economic measures when they were included in the predictive logistic regression model for self-assessed respondent health. Respondent health was significantly and independently associated with lower satisfaction with home heating and worse SAP rating. In the full logistic regression model, a unit decrease (worsening) in SAP score was associated with a 1.03 (1.01-1.05) odds of having poorer respondent-assessed health. Results suggest that objective energy efficiency, as measured by SAP ratings, may play a double role, affecting satisfaction with home fuel Inefficiency, which in turn influences health, as well as directly impacting on health. Authors' conclusions: the findings support other evidence that home energy efficiency makes an important contribution to the relationship between lower socio-economic status and poorer health, and document the combined relationship between objective and subjectively measured home energy efficiency and health.
94	Howieson SG,	To examine	Ecological	-	-	Scotland,	Seasonal	Mortality (EWD)	Correlation analysis	The SIMD is positively correlated with

	Hogan M. Multiple deprivation and excess winter deaths in Scotland. J R Soc Promot Health. 2005; 125(1): 18-22.[94]	the relation between socio-economic deprivation and excess winter death	correlation study			1989-2001:	definition: excess winter death (Dec-Mar vs other months) Modifer: Scottish Index of Multiple Deprivation (SIMD) with five criteria by region: income; employment; health and disability; education, skills and training; and geographical access to services		of EWD ratio with SIMD	EWD by region (0.35 at the 5% confidence level). Author interpretation: “This correlation appears to go against the influence of climatic variations, house type, energy efficiency and access to the gas network which favours urban areas.”	A fairly crude analysis
95	Mirchandani S, Aharonoff GB, Hiebert R, Capla EL, Zuckerman JD, Koval KJ. The effects of weather and seasonality on hip fracture incidence in older adults. Orthopedics 2005;28(2):149-55.[95]	This study examined the effect of weather and seasonality on hip fracture incidence in older (>65) adults	Observational study: analysis of routine hospital discharge records	+	+	Patients > 65 years with fracture of the femoral neck or inter-trochanteric region, New York City, USA, admission during 1985 to 1996 (n=66,346 patients)	Season (winter was DJF, summer JJA etc) Weather variables averaged by month: Min temperature Max temperature Ave daily windspeed Ave RH Precipitation Snowfall	Hip fracture by type: - neck - inter-trochanteric (sub-trochanteric and pathological fractures excluded)	Cross-tabulation and chi-squared statistics; correlation analysis Rates of admission were adjusted to a ‘season’ length of 91.25 days. Sample 79% women but average monthly fracture rates were adjusted for age/sex/fracture type	Temperature found to be positively correlated with hip fracture incidence. Adjusted number of fractures Winter 17507 Spring 16503 Summer 15600 Autumn 16758 Comparison of the characteristics of hip fracture patients: December-January vs June-July DJ JJ No (%) 12124 (53.9%) 10,374* (46.1%) Mean age 81.7 81.6 F:M ratio 3.6 3.9 Neck-to- 1.13 1.12	Reviewer comment: - relatively simple analysis wi adjustment for season in ana effect of weather variables - data on weather conditions averaged for each of the 144 months of analysis and correl with the adjusted number of fractures

							Percent of possible sunshine Depth of snow			Intertrochanteric ratio Length of stay (days) 21.7 20.8* Place of injuries: Indoors 86.1 90.6* Home 62 62.6 *p<0.001 Linear correlation of average monthly weather conditions and monthly adjusted number of hips fractures Weather parameter r p-value Min temperature 0.167 <0.001 Max temperature 0.155 <0.001 Ave daily windspeed 0.166 <0.001 Ave RH 0.033 0.03 Amount of preciptn 0.16 NS Amount of snowfall 0.021 NS Percent of possible sunshine 0.005 NS Depth of snow 0.008 NS Note that most hip fractures occur indoors	
96	Morabito M, Modesti PA, Cecchi L, Crisci A, Orlandini S, Maracchi G, et al. Relationships between weather and myocardial infarction: a biometeorological approach.	To calculate threshold values of weather discomfort which increase the risk of hospital admissions for myocardial	Time series/ temporal association cross-sectional study	+	+	Hospital admissions for myocardial infarction for the period 1998-2002 in Florence, Italy.	Classification of temperature exposure based on: (i) daily mean air temperature (ii) Apparent Temperature Index (ATI) in summer, and	Computerized inpatient hospital discharge data for MI provided by the Administration of Careggi Hospital the biggest and the main regional hospital. Only data of people residents in	Preliminary statistical analysis regressed daily event rates and mean daily air temperatures and assessed differences between age groups, sex and seasonal fluctuations used	Daily event rates were significantly related with daily mean air temperature in patients >65 (P <0.001): 19% increase in daily event rates for a 10 degrees C decrease. Highly significant seasonal fluctuation (chi2=69.9, P <0.001). Male/female ratio of admissions was significantly different from 1 (chi2=286.7, P<0.001) and higher for patients >65 than for =<65, in all seasons. Statistically	

	Int J Cardiol. 2005; **105**(3): 288-93.[96]	infarction in winter and summer.					the New U.S./ Canada Wind Chill Temperature Index (NWCTI) in winter, which combine air temperature, relative humidity and wind velocity. Uses meteorological data from the urban weather station located in the centre of Florence. Effect modifiers Age, sex, and season. Confounders Potential weather confounders , time-lags controlled, but several potentially important confounders (e.g. pollution, deprivation	Florence considered.	chi-squared tests. Second statistical analysis regressed admission rates and 'potential discomfort days' for different groups: summer/winter only, age, and sex. Correlation between severe discomfort conditions and hospitalization investigated on same day and up to three following days.	significant fluctuation for different age groups also found (chi2=430.7, P<0.001). *Cold-specific results* Significant relationships between severe discomfort caused by cold conditions and hospitalization on same day when considering everyone together (r =0.74, P<0.05) and patients >=65 (without difference of sex) (r =0.84, P<0.01). Males showed no significant associations, but females showed highest correlation coefficients in both total sample of females (without difference of age) (r =0.85, P <0.01) and females >=65 (r =0.84, P <0.01). Statistically significant relationships found correlating hospitalizations occurring two days after day with severe discomfort conditions. Found for everyone together (r =0.84, P <0.01) and males =>65 (r =0.97, P<0.001). Apparent temperature approach important of heat impacts.	

							status, influenza/illness) not considered.				
97	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 (Oxf). 2005; 27(4): 353-8.[97]	To examine the demonstrability of a relationship between older people's health and fuel poverty risk, using morbidity data.	Observational population-based study	++	++	25,000 residents, >=65 years, in the London Borough of Newham (LBN). Using Hospital Episode Statistics (HES) data over 1993-1997, anonymized at enumeration district (ED) level, we calculated excess winter morbidity, based on emergency hospital episodes for all respiratory diagnosis codes.	Effect modifier: EDs were classified by a Fuel Poverty Risk Index (FPR), including factors of energy inefficient housing, low income, householder age and under occupation.	Excess winter morbidity (hospital admission for respiratory diagnosis)	Poisson regression of respiratory admissions focussing on interactions of FPR with season (no covariates).	FPR is a predictor of excess winter morbidity. In particular, FPR was observed showing a significant relationship with high winter morbidity counts for 2 of 4 years studied. Using FPR as a two-level factor (high and non-high), the model provides odds ratios: for 1993, winter/summer morbidity ratio for high FPR is 1.7 higher than the corresponding ratio for non-high FPR [95% confidence interval (CI)=1.1-2.7], and for 1996, the odds ratio is 1.6 (95% CI=0.9-2.8). In a regression with grouped EDs, having allowed for FPR, no other variables in our set contribute to the difference between winter and summer morbidity counts. Authors' conclusions: 'supporting evidence' of a relationship between energy inefficient housing and winter respiratory disease among older people, with public health implications for increasing health-driven energy efficiency housing interventions.	No adjustment for possibly confounding modifiers, in particular age. But given all a 65+, FPR still largely robust if assumes poverty does not als cause cold deaths by other ro
98	Schwartz J. Who is sensitive to extremes of temperature?: A case-only	To investigate the characteristics of persons that put them	Case only analysis	++	++	160,062 deaths in Wayne County, Michigan,	Ambient temperature from the Detroit airport	Mortality in subjects who had one of the following conditions but	Case only analysis. Fit a logistic regression model with the indicators for extreme	All of the below are for the 1-day relative odds, as these showed the higher effects than the 3-day. Persons older than 84 years showed	

	analysis. Epidemiology. 2005; 16(1): 67-72.[98]	at higher risk of mortality during temperature extremes, focusing on the role of medical conditions.				among persons >= 65 years, covered by Medicare, and who had a previous hospital admission for heart and lung disease.	station. Hot days defined as >99th percentile of minimum daily temperature. Also looked at days >99th percentile of the 3-day moving average of minimum temperature (same day and two previous days). Similarly, cold days defined as those <1st percentile and also looked at days <1st percentile of the 3-day moving average.	were then discharged: myocardial infarction (MI), diabetes, COPD, congestive heart failure (CHD) and pneumonia. Subjects identified from Medicare records.	weather conditions as predictors and the presence or absence of the hypothesized modifying condition as the dependent variable. Potential modifiers: sex, age (85 years of age and older), nonwhite race, as well as the lung and heart diseases. Also included seasonal sine and cosine terms and linear and quadratic terms for apparent temperature.	greater effects of extreme cold but not extreme heat with an OR of 1.16 (1.03, 1.31). Women were at greater risk of dying from extreme cold (1.14; 1.02-1.26). Nonwhites showed the greatest evidence of effect modification with ORs of 1.22 (1.09-1.37) on hot days and (1.25; 1.12-1.40) on cold days. Persons with diabetes showed increased susceptibility to very hot days with OR of 1.17 (1.04, 1.32) whereas persons with COPD had elevated risks of dying on cold days (1.19; 1.07-1.33). Persons who survived MIs were less susceptible than patients who were hospitalized for other conditions on cold days (0.83; 0.69-0.99). Note that these are relative odds and do not mean that the absolute risk for these subjects is not elevated, just that it is elevated less. The other conditions conveyed no higher risks than average. Overall, the results for extreme temperatures were stable when interactions with season and continuous temperature were included. However, although control for these interactions did not affect the differential susceptibilities to extreme temperatures, there was some	

										evidence for an independent effect of the additional variables. Author’s conclusion: socio-demographic characteristics and medical conditions can increase the likelihood of death associated with temperature extremes.	

Continued…

Appendix 5 table continued: 2004 studies											
Ref	Study	Aim of study	Study design	Validity Int	Validity Ext	Pop, setting	Exposure	Outcomes	Analysis	Results	Notes
2004											
99	Aronow WS, Ahn C. Elderly nursing home patients with congestive heart failure after myocardial infarction living in New York City have a higher prevalence of mortality in cold weather and warm weather months. J Gerontol A Biol Sci Med Sci. 2004; 59(2): 146-7.[99]	To investigate whether there was a seasonal variation in mortality from CHF.	Prospective observational study	-	+	New York city, USA: 517 patients, mean age 81 +/- 8 years, with congestive heart failure (CHF) after prior myocardial infarction who died in a nursing home in New York City with 24-hour on-site physician coverage	Cold and warm-weather months (December, January, February, March, July, and August) compared to Spring and Fall.	All-cause mortality	The exact binomial test was used to see if the number of deaths from CHF in the cold weather and warm weather months was significantly different from those in the spring and fall	321 of the 517 deaths (62%) occurred during the months of December, January, February, March, July, and August, and 196 deaths (38%) occurred during the other 6 months (p <.0001). Authors' conclusions: the number of deaths in patients with CHF after prior myocardial infarction in cold weather and warm weather months is significantly higher than those in spring and fall months (p <.0001).	Limitations include a small sa size; examining all-cause mor which may include non-CHF r deaths; no adjustment for the degree of 'cold'.
100	Goodman P, Dockery D, Clancy L. Cause-specific mortality and the extended effects of particulate pollution and temperature exposure. Environ Health Perspect. 2004; 112(2): 179-85.[100]	To assess the associations of medium-term exposure to particulate pollution (black smoke) and temperature with age-standardized daily mortality	Cross-sectional time-series study	++	+	City of Dublin (Dublin County Borough), 1st April 1980 until 31st December 1996.	Daily black smoke (BS) air pollution concentration given by average of measurements at six residential monitoring stations in Dublin. Daily minimum temperatures	Cause-specific daily mortality: ICD-9 codes - total non-trauma deaths < 800 -- cardio-vascular death 390–448 -- respiratory death 460–496, 507	*Temperature-relevant analysis* Apolynomial (six order) distributed lag model of both temperature (and RH) and BSfor 0-40 days after exposure was constructed for each cause- and age-specific mortality stratum. Day-specific log odds ratios and 95% confidence intervals	*Cold temperature-relevant results* Each decrease of 1 degree C was associated with a 2.6% increase in mortality in the following 40 days. Most of excess mortality associated with cold temperatures observed in first three weeks after exposure. <u>Age</u> (40-day cumulative cold effect) Age-group — % increase in mortality for a 1 deg C decrease in mean temperature (95% CI) 0-64 — 1.4 (0.7, 2.2) 65-74 — 2.8 (2.2, 3.5) 75+ — 3.0 (2.6, 3.5)	

							(deg Celsius) and daily mean relative humidity (percent) measured at Dublin airport. <u>Effect modifier</u> Age <u>Confounders</u> Relative humidity controlled, changes in age distribution of Dublin Population adjusted for by constructing age-standardized daily, death rate. *r*espiratory epidemic indicator, temporal, day-of-week, seasonal, and long-term trend factors.		(CIs) calculated	<u>Cause</u> (40-day cumulative cold effect) Cause-group % increase in mortality for a 1 deg C decrease in mean temperature (95% CI) Cardiovascular 2.5 (2.0, 3.0) Respiratory 6.7 (5.8, 7.6) Other 1.5 (0.90, 2.0) The largest effects on cardiovascular mortality were observed immediately, whereas respiratory mortality was delayed and distributed over several weeks.	
101	Hajat S, Bird W, Haines A. Cold weather and GP	To determine the magnitude	Time series	+	++	UK: elderly people (65+ years) in	Ambient temperature	Lower and upper respiratory tract infections (LRTI,	Time series analysis of short-term effects of	An association between low temperatures and an increase in LRTI consultations was observed in all 16	

	consultations for respiratory conditions by elderly people in 16 locations in the UK. Eur J Epidemiol. 2004; 19(10): 959-68.[101]	and consistency of associations between cold temperature and consultations for respiratory conditions in primary care settings at different sites in the UK.				general practices in 16 urban locations across the UK where a Met Office monitoring station was in operation. Data for a 10-year period, 1992-2001		URTI)	temperature on daily general practitioner (GP) consultations	locations studied. The biggest increase was estimated for the Norwich practices for which a 19.0% increase in LRTI consultations (95% CI 13.6, 24.7) was associated with every 1degreesC drop in mean temperature below 5degreesC observed 0-20 days before the day of consultation. Slightly weaker relationships were observed in the case of URTI consultations. A north/south gradient, with larger temperature effects in the north, was in evidence for both LRTI and URTI consultations. Authors' conclusions: an effect that was consistent and generally strongest in populations in the north was observed between cold temperature and respiratory consultations.	
102	Maheswaran R, Chan D, Fryers PT, McManus C, McCabe H. Socio-economic deprivation and excess winter mortality and emergency hospital admissions in the South Yorkshire Coalfields Health Action Zone, UK. Public Health. 2004;	To describe the pattern of excess winter mortality and emergency hospital admissions, and the relationship between excess winter mortality and emergency hospital admissions and socio-economic	Ecological analysis of seasonal data	+	+	England: the South Yorkshire Coalfields Health Action Zone: 1981 to 1999 (deaths), 1990-1999 (emergency hospital admissions)	Seasonal definition: excess winter mortality ratio.	Deaths (aged 45 years and above): - all - cardiovascular - respiratory - all other Emergency hospital admissions <u>Modifiers</u> Age Cause Enumeration district-level	Analysis of excess winter mortality ratios (observed/expected)	*Mortality* (sex, cause) Respiratory F 1.70 M 1.58 Cardiovascular F 1.25 M 1.20 All other causes F 1.09 M 1.07 *Hospital admission ratio* Respiratory F 1.80 M 1.58	

	118(3): 167-76.[102]	deprivation at the enumeration district level.						Townsend socio-economic deprivation score (quintile)		No excess was evident for the other two groups of conditions. No significant increase in excess winter mortality ratios or excess winter respiratory admission ratio with increasing socio-economic deprivation. With regard to age, we found P<0.0001 and for all other diseases P>0.001 and also in the excess winter hospital admission ratio for respiratory disease P<0.0001 With regard to sex, the excess ratios were lower in men than in women for both respiratory mortality P<0.05 and respiratory hospital admissions P<0.0001 We also observed that excess winter mortality ratios decreased significantly over the 18-year period for cardiovascular disease P<0.05 and for all other diseases P<0.05. Authors note: "Our results suggest that measures to reduce excess winter mortality should be implemented on a population-wide basis and not limited to socio-economically deprived areas. There may also be a case for tailoring interventions to specifically meet the needs of older people."	
103	Panagiotakos DB, Chrysohoou C, Pitsavos C, Nastos P, Anadiotis A, Tentolouris C,	To examine the association between climatologic parameters	Cross-sectional time-series study	+	+	Cardiology emergency units of hospitals in the greater Athens area,	Daily mean, maximum and minimum temperatures, relative humidity,	Daily number of admissions for acute myocardial infarction (electrocardiographic changes,	Generalized additive models (GAM) with loess smoothers applied to regress-time-series of daily	Negative correlation between hospital admissions and mean daily temperature (MDT): 1 deg C decrease in mean air temperature yielding a 5% increase in hospital admissions due to an acute coronary event (β =0.05, risk	Authors note: data consisted of people admitted alive, therefore do n cover all major coronary events; air pollution investigated; relatively short

	et al. Climatological variations in daily hospital admissions for acute coronary syndromes. Int J Cardiol. 2004; **94**(2-3): 229-33.[103]	and daily admissions for non-fatal acute coronary syndromes (ACS)				1st January 2001 to 31st August 2002 (5458 patients, 75% male)	wind speed, barometric pressure and a thermo-hydrological index (T.H.I.) were measured at the meteorological station of the Laboratory of Climatology of the Geology Department of the University of Athens <u>Effect modifiers</u> Gender and age in one of three groups: <=35yrs,36–64yrs, and >= 65yrs. <u>Confounders</u> Overdispersion, serial correlation, seasonal patterns, day-of-week, and holiday days.	compatible clinical symptoms, and/or specific diagnostic enzyme elevations), or unstable angina (occurrence of one/more angina episodes, at rest, within preceding 48 h, corresponding to class III of Braunwald classification) (ACS) in five major general hospitals in greater Athens area recorded. Partly subjective.	numbers of outpatients with acute cardiac events against climatological variables and a thermo-hydrological index. Contribution of each potential confounder was evaluated by the use of the F-test. Goodness-of-fit assessed from residuals against time. Partial auto-correlation function applied to determine degree of remaining serial-correlation	ratio=1.05, P < 0.05). Association stronger in females (β=0.08, risk ratio=1.08, P=0.058 for females vs. β=0.04, risk ratio=1.04, P= 0.15 for males) and in elderly (β = 0.09, risk ratio=1.10, P= 0.032 for >65-years-old vs. β=0.02, risk ratio=1.02, P = 0.23 for < 65-years-old). For relative humidity, positive correlation found with hospital admissions (β=+0.02, risk ratio per 10% change=1.24, P= 0.04). Negative correlation found between T.H.I. and hospital admissions, in both genders. 1 deg C decrease in T.H.I. yielded 6% (β=0.06, risk ratio=1.06, P= 0.039) increase in hospital admissions for ACS. Correlation slightly stronger in elderly (β=0.09, risk ratio=1.09, P < 0.001). No differences found when analysis stratified according to outcome and no significant interactions between mean temperature and humidity or with day-of-the-week, holidays and strikes. Wind speed negatively correlated with hospital admissions, but not statistically significant (β=0.10+/-0.15, risk ratio =1.11,P=0.479). Similar results found regarding mean barometric pressure.	duration of study period.
104	Wilkinson P, Pattenden S, Armstrong B,	To examine the determinants	Population based cohort study	++	++	People aged > or = 75 years from 106	Seasonal definition: winter:non-	(All-cause) mortality	Analysis of seasonal ratio and its variation by	Little evidence of variation in winter:non-winter ratio by: - geographical region	The strength of this study is t uses individual level data unli some of the other cruder eco

	Fletcher A, Kovats RS, Mangtani P, et al. Vulnerability to winter mortality in elderly people in Britain: population based study. BMJ. 2004; 329(7467): 647.[104]	of vulnerability to winter mortality in elderly British people	(119,389 person years, 10,123 deaths) followed up for death through the Office for National Statistics			general practices in the Medical Research Council trial of assessment and management of older people in Britain	winter ratio.		personal and linked area characteristics	- age - any of the personal, socioeconomic, or clinical factor examined except: Relative risks Sex (adjusted for all major covariates) M 1 F 1.11 (1.00 to 1.23) Only self reported history of respiratory illness associated with winter death (adjusted for all major covariates) No 1 Yes RR=1.20 (1.08 to 1.34) There was no evidence that socioeconomic deprivation or self-reported financial worries or reported difficulty in keeping house warm were predictive of winter death. Authors note that “The lack of socioeconomic gradient suggests that policies aimed at relief of fuel poverty may need to be supplemented by additional measures to tackle the burden of excess winter deaths in elderly people” [more generally].	analyses and presumably the is representative

Continued…

Ref	Study	Aim of study	Study design	Validity		Pop, setting	Exposure	Outcomes	Analysis	Results	Notes
				Int	Ext						
2003											
105	Crawford JR, Parker MJ. Seasonal variation of proximal femoral fractures in the United Kingdom. *Injury* 2003;**34**(3):223-5.[105]	To determine seasonal variation in the incidence of hip fractures by season and in relation to weather conditions	Prospective observational study: consecutive case series with 1-year follow-up	++	++	3034 consecutive hip fracture patients admitted to a single unit (Peterborough DGH) in the UK, 13 Jan 1989 to 12 Jan 2001	Month, season and temperature	• Hip fracture by type: - extracapsular - intracapsular • Length of hospital stay • Mortality (case fatality)	Descriptive analyses	*Comparison of number of admitted patients, their characteristics and outcome in winter and summer months* Winter (NDJ) / Summer (MJJ) No. of # 867 / 693 - intracap % 53.6% / 57.0% - extracap 46.4% / 43.0% % Male 20.4% / 19.5% Mean age 81.8 / 81.3 From home 69.7% / 65.5% Mean MTS* 5.4 / 5.5 Mean mobility score† 5.2 / 5.0 Days in hospital 23.2 / 23.4 Mortality - 30 d 9.7% / 8.2% - 120 d 21.1% / 16.7% - 365 d 31.5% / 27.3% **MTS – mental test score (range 0-10)* *†Mobility score: range 0-9* • More hip fractures in winter than summer (p=0.002) • Increase in extracapsular fractures (p=0.006) and tendency to a higher mortality for those patients admitted in winter. • No statistically significant difference in patient characteristics between the winter and summer seasons.	Reviewer comment: - winter unusually defined as which accentuates winter ex
106	Donaldson GC, Keatinge WR.	To assess cold related	Cross sectional	+	+	England and Wales	Central England	Daily deaths from Office of National	Poisson regression of mortality	Cold related mortality in the retired (65–74) age group was generally higher	Authors note: possible (‘simp

	Cold related mortality in England and Wales; influence of social class in working and retired age groups. J Epidemiol Community Health. 2003; **57**(10): 790-1.[106]	mortality among social classes in England and Wales and in working and retired age groups	study with time lags accounted for			between 1998-2000	temperatures from Meteorological Office, were daily means of Squire's Gate Lancashire, Manchester Airport, Malvern, Rothamstead. <u>Effect modifiers</u> Social class, gender, age group, and whether housewife. <u>Confounders</u> Mean influenza deaths 10 days before to 10 days after, and single three-day time lag on temperature	Statistics, for men and women in England and Wales aged 65–74 years and 50–59 years, by social class: 1 (professional) 2 (managerial and technical) 3N (nonmanual skilled) 3M (manual skilled) 4 (partly skilled) 5 (unskilled)	on temperature in subgroups by social class, age, sex. Statistical comparisons assessed using the t test between social classes 1 and 5 only (the extremes).	in men of class 5 (unskilled) than class 1 (professional), or other classes, with little difference between men and women or housewives, of any class. In the working age group (50–59), women in class 5 had significantly higher cold related mortality than those in class 1, but in men in class 5 cold related mortality was on average lower than in men of any other class. It was also significantly lower in class 5 among men than women, or housewives, both in direct comparison and in relation to comparisons of men and women in class 1.	explanation is that manual w protected class 5 men agains daytime cold stress. International surveys also po important role of out of hom factors. [especially] heating a insulation…, but less attentio to these.
107	Healy JD. Excess winter mortality in Europe: a cross country analysis identifying key risk factors. J Epidemiol Community	To investigate potential causative factors explaining why certain countries experience dramatically	Ecological (country-level) analysis of EWM and potential causative factors	+	+	Excess winter deaths (all causes), 1988–97, EU-14 countries	Seasonal (winter) definition: DJFM vs other months	All-cause mortality	Multiple time series data on a variety of risk factors analysed against seasonal-mortality patterns to identify key relations	Substantial country-to-country variation in EWM. Highest rates in western edge countries: Portugal highest: 28% (25%, 31%) Spain 21%, (19%, 23%) Ireland 21% (18%, 24%). UK 18%, France 13%, Denmark 12%, Finland 10%, Germany 11%.	<u>Reviewer comment</u> A calendar month-based defi of winter may represent diffe seasonal effects in different countries (more months are c northern than southern clima so a common DJFM period ha different meaning.

	Health. 2003; **57**(10): 784-9.[107]	higher winter mortality.								<u>Cross country variations in mean winter environmental temperature</u> Coef P-value Mean winter environ temp 0.2 0.001 Mean winter precipitation 0.23 0.017 Mean winter RH 0.54 0.001 PPP-adjusted per capita GDP 1.08 0.001 Primary education spend* 0.12 0.070 Second education spend* 20.27 0.061 Total health spend* 0.63 0.069 Public health spend* 0.60 0.001 Private health spend* 0.90 0.011 PPP-adjusted health spend 21.19 0.001 GPs per 1000 population 0.59 20.437 Hospital beds per 1000 20.23 0.067 Smoking rate 0.40 0.344 Obesity rate 0.30 0.512 Income poverty rate† 20.47 0.008 Income inequality (Gini) 0.97 0.020 Deprivation rate (composite) 0.11 0.048 Fuel poverty rate (composite) 0.44 0.005 % of housing, cavity insul 22.56 0.022 % of housing, roof insul 1.36 0.110 % of housing, fFloor insul 1.01 0.029 % of housing, double glazed 20.31 0.024 * As a % of per capita GNP † 60% median equivalised income Author notes: "The strong, positive relation with environmental temperature and strong negative relation with thermal efficiency indicate that housing standards in southern and western Europe play strong parts in such seasonality."	

										Conclusion: high seasonal mortality in southern and western Europe could be reduced through improved protection from the cold indoors, increased public spending on health care, and improved socioeconomic circumstances resulting in more equitable income distribution.	
108	Hong YC, Rha JH, Lee JT, Ha EH, Kwon HJ, Kim H. Ischemic stroke associated with decrease in temperature. Epidemiology. 2003; 14(4): 473-8.[108]	To investigate the association between ischemic stroke onset and decrease in temperature	Case-crossover	+	+	Incheon, Korea: 545 patients of the Inha University Hospital. Conducted over a 3-year period (January 1998 to December 2000)	Ambient temperature from the National Meteorological Office	Ischemic stroke. Diagnosed with brain imaging.	For each subject, the case period was matched to 2 control periods exactly 1 week before and after onset of the ischemic stroke. Used conditional logistic regression. In addition to temperature, relative humidity, barometric pressure and air pollution were included as continuous variables. Also evaluated the effect of 24-hr and 3-hr average temperature on stroke onset. Conducted stratified analyses by: age, sex, history of hypertension or	Decreased ambient temperature was associated with risk of acute ischemic stroke. The strongest effect was seen on day after exposure to cold weather. The odds ratio (OR) for an interquartile range decrease in temperature was 2.9 (95% confidence interval [CI] = 1.5-5.3). There was a decreasing effect with time. The risk period was 24-54 hours after cold exposure. Risk estimates associated with decreased temperature were greater in the winter than in the summer. Air pollutants were not associated with stroke onset. The following subgroups were more susceptible to cold-induced ischemic stroke (ORs for one interquartile range decrease in temperature, lag of 1 day, controlled for humidity and pressure): Women: 3.74 (1.37,10.19) People aged over 65: (4.04 (1.48,11.04) Previous hypertension: 3.33 (1.53, 7.26) Previous hypercholesterolemia: 9.37 (1.51, 58)	

									hypercholesterolemia and obesity.	Not obese: 3.66 (1.73, 7.73) Authors' conclusions: stroke occurrence rises with decreasing temperature; even a moderate decrease in temperature can increase the risk of ischemic stroke.	
109	Johnson H, Griffiths C. Estimating excess winter mortality in England Wales. Health stat. 2003; 20: 19-24.[109]	To examine the method of calculating an excess winter mortality (EWM)	Analysis of routine mortality data	+	++	England and Wales	Season	Mortality	Descriptive analyses of seasonal excess	Over the last 50 years, in December to March, mortality levels have remained above average, and in May to October mortality has been consistently below average. Although year-on-year variability - which is most pronounced in the winter months - remains, there has been a steady log-linear decline in EWM. In general, the current method used by the Office for National Statistics (ONS) of estimating the EWM gives similar results to those of other methods of calculating EWM over the last 50 years. However, due to the year-on-year variability seen in seasonal mortality, mortality can also be above average in the autumn or spring. Where these periods are included in the comparison period for EWM calculations - as with the current ONS method - this has the effect of decreasing the EWM estimate. As well as examining EWM trends in England and Wales, the authors look at cause-specific patterns for deaths over the period 1993-2001	Methods for calculating EWM not given error or confidence intervals. Comparison of diffe analytical methods only. Study results reflect observed trends for different diseases a different methods of estimati EWM, no confounding effects as influenza are considered. Highly applicable to England a Wales
110	O'Neill MS, Zanobetti A,	To examine effect	Time series	++	++	Seven US cities 1986-	Mean daily apparent	Mortality (ICD9 codes 1–799)	City-specific Poisson regression analyses	Percentage change in mortality was calculated at 29 degrees C apparent	

	Schwartz J. Modifiers of the temperature and mortality association in seven US cities. Am J Epidemiol. 2003; 157(12): 1074-82.[110]	modification of heat- and cold-related mortality				1993.	temperature (a construct reflecting physiologic effects of temperature and humidity) calculated from data from local meteorological monitoring stations	excluding accidental causes	of daily non-injury mortality were fit with predictors of mean daily apparent temperature <u>Confounder control</u> Time, barometric pressure, day of the week, and PM_{10}	temperature (lag 0) and at -5C (mean of lags 1, 2, and 3) relative to 15C. Percentage change in total daily mortality associated with a –5°C apparent temperature: 10.1 (CI 95%, 7.0, 13.3), and with a 29°C apparent temperature: 5.0 (CI 95% 3.1, 7.0). Separate models were fit to death counts stratified by age, race, gender, education, and place of death. Effect estimates were combined across cities, treating city as a random effect. Deaths among Blacks compared with Whites, deaths among the less educated, and deaths outside a hospital were more strongly associated with hot and cold temperatures, but gender made no difference. Stronger cold associations were found for those less than age 65 years, but heat effects did not vary by age. The strongest effect modifier was place of death for heat, with out-of-hospital effects more than five times greater than in-hospital deaths, supporting the biologic plausibility of the associations. Place of death, race, and educational attainment indicate vulnerability to temperature-related mortality, reflecting inequities in health impacts related to climate change.	
111	Sullivan S, Somerville M, Hyland M, Barton A, on behalf of the Torbay Healthy Housing Group. The Riviera Housing and	To examine the extent of the relationship between physical and emotional health and housing	(Postal) survey of housing residents	-	+	All households owned by the Riviera Housing Trust, Torbay, South Devon Responses	Questionnaire elicited information on both the physical conditions in dwelling and the physical and mental	Illnesses, GHQ12 score, EuroQol score and symptom score.	ANOVA	Poor housing conditions were associated with poor mental health and well-being, but not with minor illnesses or physical conditions. 27% of residents said they lived in a dwelling that was often or always too cold.	The symptoms of individuals conditions of the housing and household characteristic were reported, and so may be misclassified or under or overreported. The study popu is much sicker and poorer tha wider population, and the ho studied has often been alloca

	Health Survey. Kendall: EAGA Charitable Trust; 2003.[111]	conditions				from 1053 (38%) household and 2219 individuals (total population of individuals within the housing is unknown)	health of its occupants. Questions for residences were used to determine usual temperature, visible mould, and damp. Questions for households were used to determine number in household, age, health, employment status, and benefits. Questions for individuals were used to determine smoking, drinking, overall health (EuroQoL), and emotional health (GHQ12). The three housing conditions alongside			Significant relationships were observed between cold homes and asthma (p=0.003), angina (p<0.001), diabetes (p<0.001), stroke (p=0.012), high blood pressure (p<0.001), anxiety/depression (p<0.001), headache (p<0.001), arthritis/rheumatism (p<0.001), and GHQ score (p<0.001). However, when other interactions were accounted for, there was no significance.	on a medical priority basis. Th elderly in the study are less li live in substandard housing. T behaviour of individuals with dwellings is not accounted fo such as indoor cold due to sm opening windows while smok There were a large number o respondents, and a small sam size.

							smoking and drinking were treated as confounding factors in the relationship between housing and health.				

Continued…

Appendix 5 table continued: 2002 studies											
Ref	Study	Aim of study	Study design	Validity		Pop, setting	Exposure	Outcomes	Analysis	Results	Notes
				Int	Ext						
2002											
112	Braga AL, Zanobetti A, Schwartz J. The effect of weather on respiratory and cardiovascular deaths in 12 U.S. cities. Environ Health Perspect. 2002; 110(9): 859-63.[112]	To estimate the acute effects and the lagged influence of weather (temperature and humidity) on respiratory and cardiovascular disease (CVD) deaths.	Time series	++	++	Population of 12 U.S. cities from 1986-1993.	Daily average ambient temperature and humidity from the nearest airport station. Also included the role of other possible "predictors": prevalence of air conditioning, variance of summer and winter temperature, background mortality rate, percentage of the population with a college degree, percentage non-white, percentage unemployed, percentage below the poverty line, city size, mean	Daily counts of deaths from pneumonia, chronic obstructive pulmonary disease (COPD), all cardiovascular diseases (CVD) and myocardial infarction(MI). Data from the National Center for Health Statistics.	Generalized additive Poisson regressions for each city using nonparametric smooth functions to control for long-term time trend, season and barometric pressure. Also controlled for day of the week. Distributed lag model to estimate the effect and the lag structure of both temperature and humidity. The other predictors were included as a second stage analysis with an ecological regression.	In cold cities, heat and cold were associated with increased CVD deaths. In general, cold effects persisted for days, while heat effects were restricted to the day of death or the day before. For myocardial infarctions (MI), the effect of hot days was twice as large as the cold-day effect (6% and 3% increases in daily deaths), whereas for all CVD deaths the hot-day effect was five times smaller than the cold-day effect (1% and 5%, respectively). The effect of hot days included some harvesting. In terms of respiratory diseases, only heat increased COPD deaths (by 25%), whereas both affected pneumonia. In hot cities, neither hot nor cold temperatures had much effect on CVD or pneumonia deaths. However, for MI and COPD, there were lagged effects of heat. No consistent pattern for humidity. None of the predictors significantly modified the effects of hot or cold days on CVD deaths, except that for both COPD and pneumonia, variance in summer temperature was associated with increased heat effects (estimated at 30°C). The increases were 42.76% (4.54,94.94) for COPD and 28.01% (3.96,57.63) for pneumonia. The	

							population age. Data taken from survey and census data.			variance of winter temperature was similarly associated with cold deaths (estimated at -10°C). Increases were 25.86% (-1.12,60.20) and 12.57% (2.87,23.19) respectively in COPD and pneumonia. Authors suggest that increased temperature variability is the most relevant change in climate for the direc effects of weather on respiratory mortality. Analysis of climate change impacts should take into account regional weather differences	
113	Chesser TJ, Howlett I, Ward AJ, Pounsford JC. The influence of outside temperature and season on the incidence of hip fractures in patients over the age of 65. *Age Ageing* 2002;**31**(5):343-8.[113]	To determine whether the incidence of fractures altered with the daily temperature, seasons or months of the year	Observational study: consecutive case series	++	++	818 patients, >= 65 years, who presented to one district general hospital (Frenchay), Bristol, with fracture of the proximal femur. Over a five-year period we studied	Month of year; location-specific max and min daily temperature grouped into 5 deg C bands	• Fracture of the proximal femur • Length of hospital stay	Descriptive analysis: presentation rates and length of stay in relation to month, season, temperature	(1) No statistically significant differences in the daily rate of fractures across temperature ranges for either max or min temperature, or by month of year. *Mean fractures per season:* Winter (DJF): 39.6 Spring (MAM): 40 Summer (JJA): 44.2 Autumn (SON): 39.6 (2) No statistically significant difference in the characteristics of patients (age, sex, pre-injury mobility, residence, functional and mental scores) presenting in different seasons or temperature ranges. (3) Patients presenting in winter months had a significantly longer inpatient stay	<u>Reviewer comment:</u> No denominator shown to calculate rates for temp band non-parametric tests of assoc Author suggests winter lengt stay may have been due to th strain on the social services ir winter.
114	Curriero FC,	To investigate	Time-series	++	++	11 large	Daily mean	All-cause and	For each city, a	Current and recent days' temperatures	

	Heiner KS, Samet JM, Zeger SL, Strug L, Patz JA. Temperature and mortality in 11 cities of the eastern United States. Am J Epidemiol. 2002; 155(1): 80-7.[114]	the association between temperature and mortality across a range of less extreme temperatures in 11 US cities, and to explore city-specific factors that might explain variations in the association.				eastern US cities in 1973-1994	temperature and dew point Explored impact of city-specific characteristics, in addition to latitude, including the percentage of: 1 elderly 2 elderly and disabled 3 adults without a high school degree 4 living in poverty 5 homes with air conditioning 6 homes with heating Also looked at associations stratified by age.	cause-specific (cardiovascular, respiratory and other) mortality. External causes excluded.	Poisson regression general additive model was fit to estimate the weather-mortality relation. Nonparametric functions used to describe non-linear relations. Explored multiple lags and degrees of freedom to control for calendar time. In the second stage of analysis, used a random effects linear regression model to summarize each city's weather - mortality relation; determined the minimum mortality temperature and the average cold and hot slope while exploring variation due to city-specific characteristics.	were the weather components most strongly predictive of mortality, and mortality risk generally decreased as temperature increased from the coldest days to a certain threshold temperature, which varied by latitude, above which mortality risk increased as temperature increased. The same day dew point provided an additional explanation for mortality. As in the models for all-cause mortality, mortality risk for cardiovascular and respiratory diseases decreased as temperature increased, but cold slopes were steeper. Death from other causes (mainly cancer) did not show this association. There was a qualitatively similar relation between weather and mortality for each age group, although the temperature effect was smallest for the youngest age group (<65) and largest for those >75 years. There was a strong association of the temperature-mortality relation with latitude, with a greater effect of colder temperatures on mortality risk in more-southern cities and of warmer temperatures in more-northern cities. Percentage of households with air conditioners in the south and heaters in the north, which serve as indicators of socioeconomic status of the city population, also predicted weather-related mortality.	

										Summary results from regressing the cold slopes, hot slopes, and minimum mortality temperatures on city-specific predictor variables with and without adjusting for latitude, United States, 1973–1994† Predictor‡ Cold slope§ (SE) MMT %65+ Unadjusted -3.97* (1.27) 1.66 Adjusted -3.96* (1.17) 5.34 %NoHS Unadjusted 0.10 (0.83) -5.95 Adjusted -0.46 (0.71) -3.46 %Poverty Unadjusted 0.03 (0.10) 6.05 Adjusted -0.39 (0.83) -2.56 %65+ Disability Unadjusted 1.20 (1.70) 0.41 Adjusted 0.85 (1.48) 6.78 %Air Cond Unadjusted -0.22 (0.22) 2.54* Adjusted 0.44 (0.35) 0.46 %Heating Unadjusted 2.38 (1.60) -9.08 Adjusted 0.74 (1.96) 5.33 * Statistically significant at the p = 0.05 level. † Expressed as log-relative rates (― 1,000), which are approximately the percentage change in mortality per 10°F (°C = 5/9 ― (°F – 32)) per 10-unit change in the predictor variable The regressions for each predictor	

										were performed both without including latitude (unadjusted) and including latitude (adjusted) as a second predictor. ‡ Percentage of the population aged 65 years or more, not completing high school, living in poverty, aged 65 years or more and disabled, living in homes with air-conditioning, and living in homes with heating, respectively. § Cold slope = average slope of the estimated relative risk curves at temperatures lower than MMT. Effects of weather on mortality remained qualitatively consistent over the total period of 1973-1994.	
115	Lawlor DA, Maxwell R, Wheeler BW. Rurality, deprivation, and excess winter mortality: an ecological study. J Epidemiol Community Health. 2002; 56(5): 373-4.[115]	To assess the association between both rurality, and area deprivation, and excess winter mortality	Area (ecological) analysis of seasonal ratio in mortality	+	+	Population of the S West region of England, 1994-1998. Both urban and rural areas	Seasonal definition (seasonality ratio). Modifiers: population density (urban/rural) and Townsend index (s-e deprivation) both calculated from 1991 census small area data.	All-cause mortality	Analysis of age-sex standardized seasonality ratio. Examination of modification of ratio by area characteristics (urban/rural, deprivation)	Neither rurality nor area deprivation were found to be associated with EWD Urban-rural (population density) Quintile Standardized seasonality ratio 1 116.3 (112.4, 120.4) 2 117.0 (113.8, 120.3) 3 117.1 (114.5, 119.7) 4 115.9 (113.7, 118.1) 5 116.4 (114.5, 118.4) (p=0.3 for trend) Deprivation (Townsend) Quintile Standardized seasonality ratio 1 115.3 (112.5, 118.2) 2 116.7 (113.8, 119.6) 3 118.0 (115.3, 120.8) 4 116.5 (114.1, 119.0) 5 115.9 (113.8, 118.0) (p=0.6 for trend)	Authors note that Townsend used here may be a weak me of area deprivation

										Authors conclude that: “neither rurality nor area deprivation are importantly associated with excess winter mortality. [But that] these results cannot be used to suggest that policy aimed at reducing fuel poverty and improving housing energy efficiency might not be appropriately targeted at more deprived groups and rural populations.”	
116	Mitchell R, Blane D, Bartley M. Elevated risk of high blood pressure: climate and the inverse housing law. Int J Epidemiol. 2002; 31(4): 831-8.[116]	To investigate whether an individual's risk of hypertension is associated with (a 'mismatch' between) the quality of their housing and the climate to which they have been exposed.	Cross-sectional observational study	+	+	Britain: data from the 5663 Health and Lifestyle Survey (HALS) participants for whom all relevant items were available. A two-stage study design: (1) the relationship between exposure to colder climate and housing quality was established; (2) the impact on risk of hypertension was determined for level of exposure to colder climate and housing	(1) Climatic exposure to cold (based on 10 km^2 grid climate model linked to place of residence) (2) A dichotomous housing quality variable based on combination of: access to an inside WC and sharing basic amenities; carbon monoxide in the (indoor) air; heating efficiency. (Heating was recorded as inefficient	Systolic hypertension; diastolic hypertension (based on dichotomous classification of	Multivariable logistic regression	Survey respondents with greater exposure to colder climate are more likely (1.32, 95% CI: 1.18-1.42) to live in poor quality housing than those with lower exposure to colder climate. Risks of systolic and diastolic hypertension in relation to climate and housing quality are summarized as follows: *Relationship between climate, housing and risk of being hypertensive. Odds ratios (ORs) for (i) systolic and (ii) diastolic hypertension adjusted for: age, sex, body mass index (BMI), units of alcohol in the previous week, room temperature, smoking, whether taking anti-hypertensive medication.* *Systolic hypertension* Lower exposure to colder climate, in better housing OR 1.00 Higher exposure to colder climate, in better housing OR 1.16 (0.98, 1.36) Lower exposure to colder climate, in worse housing OR 1.15 (0.94, 1.40) Higher exposure to colder climate, in worse housing OR 1.25 (1.01, 1.53)	

						quality.	when the heating system was on but room temperature was below 15˚C).			*Diastolic hypertension* Lower exposure to colder climate, in better housing OR 1.00 Higher exposure to colder climate, in better housing OR 1.17 (0.99, 1.38) Lower exposure to colder climate, in worse housing OR 1.15 (0.94, 1.40) Higher exposure to colder climate, in worse housing OR 1.45 (1.18, 1.77) Authors' conclusions: there appears to be an 'inverse housing law' in Britain, whereby longer term residents of relatively cold areas are also more likely to live in worse quality housing and this combination of circumstances is associated with significantly higher risk of diastolic hypertension. The findings provide an example of how long term exposure to an adverse environment, which may stem from material disadvantage, can damage health.	
117	Stewart S, McIntyre K, Capewell S, McMurray JJ. Heart failure in a cold climate. Seasonal variation in heart failure-related morbidity and mortality. J Am Coll Cardiol. 2002; 39(5): 760-[117]	To examine seasonal variation in hospitalizations and deaths due to heart failure (HF) and possible contributors to such variability	Analysis of seasonal trends in admissions and deaths	+	++	Scotland, population study (using individualized morbidity and mortality from the linked Scottish Morbidity Record scheme), 1990 and 1996	Seasonal (month) definition	Hospitalization and death due to acute or congestive heart failure; other discharge diagnose also analysed (respiratory disease, AMI, other)	Analysis of seasonal (month) variation, by age, sex, cause	Admission rate July Dec F 7% below year ave 12% above year ave OR 1.14, p<0.001 M 8% below Year ave 6% above year ave OR 1.16, p<0.001 Greatest seasonal (monthly) variation occurred in those aged >75 years---peak winter rates being 15% to 18% higher than average. Winter peak in concomitantly coded	<u>Authors note:</u> "There is substantial seasona variation in HF hospitalizatior deaths, particularly in the eld Approximately one-fifth of th winter excess in admissions is attributable to respiratory dis Extra vigilance in patients wit is advisable in winter, as is immunization against pneumococcus and influenza

										respiratory disease; this seasonal excess accounted for approximately one-fifth of the winter increment in HF hospitalizations. Seasonal variation in mortality was also seen in these patients. The number of male deaths in December was 16% higher, and in July 7% lower, than average (OR 1.25, $p < 0.001$). In women, the equivalent figures were 21% higher (January) and 14% lower (July) (OR 1.21, $p < 0.001$). Again, the greatest variation occurred in those aged >75 years---peak rates being 23% to 35% higher than average.	

Continued…

Appendix 5 table continued: 2001 studies											
Ref	**Study**	**Aim of study**	**Study design**	**Validity**		**Pop, setting**	**Exposure**	**Outcomes**	**Analysis**	**Results**	**Notes**
				Int	**Ext**						
2001											
118	Aylin P, Morris S, Wakefield J, Grossinho A, Jarup L, Elliott P. Temperature, housing, deprivation and their relationship to excess winter mortality in Great Britain, 1986-1996. Int J Epidemiol. 2001; 30(5): 1100-8.[118]	To examine the associations between temperature, housing, deprivation and excess winter mortality using census variables as proxies for housing conditions.	Small area ecological study at electoral ward level.	+	++	Men and women aged 65 and over: Great Britain, 1986-1996.	Winter season: defined by month (Dec – Mar).	Deaths from all causes ([ICD-9] codes 0-999), coronary heart disease (ICD-9 410-414), stroke (ICD-9 430-438) and respiratory diseases (ICD-9 460-519). Odds of death occurring in December to March compared to the rest of the year.	Analysis of the ratio of deaths in winter/non-winter months, and its variation with age, mean winter temperature, and area-based (electoral ward) markers of deprivation and central heating.	A trend of higher excess winter mortality with age was apparent across all disease categories (P < 0.01). 1.5% higher odds of dying in winter for every 1 degrees C reduction in 24-h mean winter temperature. The amount of rain, wind and hours of sunshine were inversely associated with excess winter mortality. Selected housing variables derived from the English House Condition Survey showed little agreement with census-derived variables at electoral ward level. For all-cause mortality there was little association between deprivation and excess winter mortality (e.g. all cause mortality by Carstairs index OR=0.99; similar findings for CHD, stroke, respiratory disease). Lack of central heating was associated with a higher risk of dying in winter (odds ratio [OR] = 1.016 (1.009-1.022).	Ecological study Reviewers disagreed on exter validity score: changed from
119	Donaldson GC, Rintamaki H, Nayha S. Outdoor clothing: its relationship to geography, climate,	To examine (a) what are the determinants of regional variation in clothing worn outdoors	Inter-country (ecological) comparison of survey data	+	+	Survey data (of 6583 people) from eight regions of Europe: Samples divided by sex and age (50-	From survey and routine sources: (a) cold, wind, less physical activity and longer periods	(a) clothing (b) Indices of cold-related mortality	(a) ANCOVA of clothing Vs (b) Correlation of patterns of clothing with indices of cold-related mortality	Across Europe, the total clothing worn (as assessed by dry thermal insulation and numbers of items or layers) increased significantly with cold, wind, less physical activity and longer periods outdoors. Men wore 0.14 clo (1 clo = 0.115 m2 K	

	behaviour and cold-related mortality in Europe. Int J Biometeorol. 2001; 45(1): 45-51.[119]	and (b) whether wearing more clothing is associated with lower cold-related mortality				59 and 65-74 years).	outdoors. (b) Clothing parameters: thermal insulation properties, number of layers and type			W-1) more than women and the older people wore 0.05 clo more than the younger group (both P < 0.001). Regional differences in clothing after allowance for these factors were correlated (r = -0.74, P = 0.037; r = -0.74, P = 0.036 respectively), but not those in clothing layers (r = -0.21; P = 0.61), with indices of cold-related mortality. Cold weather most increased the wearing of gloves, scarves and hats. The geographical variation in the wearing of these three together items more closely matched that in cold-related mortality (r = -0.89, P = 0.003).	
120	Huynen MM, Martens P, Schram D, Weijenberg MP, Kunst AE. The impact of heat waves and cold spells on mortality rates in the Dutch population. Environ Health Perspect. 2001; 109(5): 463-70.[120]	To investigate the impact of ambient temperature on mortality, specifically the impact of heat waves and cold spells, and the possibility of forward displacement of mortality.	Time series	++	++	The Netherlands, 1979-1997,	Ambient temperature (daily mean)	Mortality: total and by cause – malignant neoplasm, cardiovascular, respiratory	Poisson log-linear regression controlling for time trend and season.	There was a V-like relationship between mortality and temperature, with a lowest mortality rate at 16.5 degrees C for total mortality, cardiovascular mortality, respiratory mortality, and mortality among those >=65 years. For mortality due to malignant neoplasms and mortality in the youngest age group, the optimum temperatures were 15.5 degrees C and 14.5 degrees C, respectively. The increase in mortality for each degree Celsius decrease below the optimum (lowest mortality) temperature in the preceding month was: malignant neoplasms 0.22% cardiovascular disease 1.69% respiratory diseases 5.15%	

										total mortality 1.37%, The average excess mortality during the cold spells was 12.8%, mostly attributable to the increase in cardiovascular mortality and mortality among the elderly. No clear evidence of cold-induced forward displacement of deaths.	
121	Nafstad P, Skrondal A, Bjertness E. Mortality and temperature in Oslo, Norway, 1990-1995. Eur J Epidemiol. 2001; 17(7): 621-7.[121]	To determine the associations between temperature and daily mortality	Time series	+	+	Oslo, Norway, 1990-1995	Ambient (outdoor) temperature, relative humidity, wind velocity and air pollution (NO_2). Averaged over several days and lags were also considered.	Mortality from all diseases; mortality from respiratory diseases; mortality from cardiovascular diseases; mortality from gastrointestinal diseases as a control	Time series counts performed using generalized additive models with log link and Poisson error. Frequency distributions of dose-response curves were used to estimate relative risk using Poisson regression. Influenza was included as a dummy variable. Confounding effects of air pollution considered.	At temperatures below 10 degrees C, a 1 degrees C fall in the last 7 days average temperature increased the daily mortality from all diseases by 1.4%, respiratory diseases 2.1%, and cardiovascular diseases 1.7%. Above 10 degrees C, there was no statistically significant increase in daily mortality, except for respiratory mortality, which increased by 4.7% per 1 degrees C increase in the last 7 days average temperature. <u>Relative risk (total)</u> T <10 C (7 day lag) (0.986, 0.981–0.991) Respiratory diseases T <10 C (7 day lag) (0.979, 0.966–0.992) Cardiovascular diseases T <10 C (7 day lag) (0.983, 0.976–0.990) Daily mortality in Oslo increases with temperatures falling below 10 degrees C. The increase starts at lower temperatures than shown in warmer regions of the world, but at higher temperatures than in regions with even colder climates.	Majority of mortality was in t elderly population. Location o mortality (in homes, outside, hospital) was not taken into account. Confounding effects seasonal mortality not includ

										As well insulated and heated dwellings are standard in Norway today, more adequate clothing during outdoor visits is probably the most important preventive measure for temperature related mortality.	
122	van Rossum CT, Shipley MJ, Hemingway H, Grobbee DE, Mackenbach JP, Marmot MG. Seasonal variation in cause-specific mortality: are there high-risk groups? 25-year follow-up of civil servants from the first Whitehall study. Int J Epidemiol. 2001; 30(5): 1109-16X.[122]	To determine the seasonal effect on all-cause and cause-specific mortality and to identify high-risk groups.	Cohort follow-up study	+	++	London, England: 25-year follow-up of 19,019 male civil servants aged 40-69 years.	Seasonal definition Potential effect modifiers age, employment grade, blood pressure, cholesterol, forced expiratory volume, smoking, diabetes, pre-existing disease status	Mortality	Regression analysis	Participants at high risk based on age, employment grade, blood pressure, cholesterol, forced expiratory volume, smoking and diabetes did not have higher seasonal mortality. Participants with ischaemic heart disease at baseline did have a higher seasonality effect Baseline IHD status Rel risk (95% CI) With IHD 1.38 (1.2, 1.6) Wiithout IHD 1.18 (1.1, 1.3) (P = 0.03) Authors' conclusions: seasonal mortality differences were greater among those with prevalent ischaemic heart disease and at older ages, but were not greater in individuals of lower socioeconomic status or with a high multivariate risk score. Since seasonal differences showed no evidence of declining over time, elucidating their causes and preventive strategies remains a public health challenge.	
123	Watkins SJ, Byrne D, McDevitt M. Winter excess morbidity: is it a summer phenomenon?	To test the prediction that winter excess morbidity would be observable	Analysis of routine health services hospital admissions data	-	+	Metropolitan Borough of Stockport, England: routine health services hospital	Winter and summer differences (ratios). Data classified by ACORN	Age and sex-standardized hospital admission rates for ischaemic heart disease	Calculation of standardized mortality ratios and winter/summer ratios by ACCORN group	*Comparison of the winter summer ratio in standard mortality ratio (%)* G Council estates III 98 F Council estates II 113 E Council estates I 83 D Older terraced housing 79	Author noted limitations ------------ Our present study is not capa doing more than suggest this serendipitous hypothesis. It deserves testing in a study designed for the purpose. Th

	Journal of Public Health Medicine 2001;23(3):237-41.[123]	and would show a social class gradient with greater excesses in less affluent groups, who are less able to heat their houses or whose lack of a car exposes them more frequently to outdoor cold exposure				admissions data,	group for area of residence The authors speculative that winter excess morbidity is a feature of health benefits derived in the summer and differentially available to the more affluent, such as opportunities for outdoor leisure.			C Older intermediate housing 88 B Higher income family housing 108 I High-status non-family areas 108 K Better off retirement areas 202 J Affluent suburban housing 99 *Winter excess* Standardized rate G Council estates III -0.07 F Council estates II +0.82 E Council estates I -0.38 D Older terraced housing -0.63 C Older intermediate housing -0.11 B Higher income family housing +0.59 I High-status non-family areas +0.57 K Better off retirement areas +3.65 J Affluent suburban housing +0.16 Affluent groups showed winter excess morbidity, less affluent groups showed "summer excess morbidity."	serendipitous hypothesis is n entirely satisfactory as an explanation of existing data.
124	Wilkinson P, Landon M, Armstrong B, Stevenson S, Pattenden S, McKee M, et al. Cold Comfort: The social and environmental determinants of excess winter deaths in England, 1986-96: Policy press Bristol; 2001.[124]	To examine whether vulnerability to winter death is related to housing quality and home heating	Seasonal analysis (winter: non-winter) and its variation by area characteristics	+	+	Population mortality data, England, 1986-1996: 80,331 deaths from cardiovascular disease linked by postcode of residence to data from the 1991 English House Conditions Survey	Season (winter (Dec-Mar) vs non-winter months); <u>Modifiers</u>: individual level age, sex, cause-of-death; area-level classifiers of socio-economic status and	All-cause mortality; deaths from cardiovascular, respiratory and other (non cardio-respiratory) disease.	(1) Analysis of seasonal pattern of deaths and its variation with personal and area characteristics; (2) Daily time-series analysis, and test of modification of cold-mortality function by housing quality	<u>Seasonal analyses</u> *Relative risks (relative to baseline) all-cause deaths: unadjusted analyses* <u>Age</u> (unadjusted) 0-44 1 45-64 1.17 (1.03 – 1.34) 65-74 1.20 (1.05 – 1.36) 75-84 1.21 (1.07 – 1.38) 85+ 1.28 (1.13 – 1.46) (p<0.001 for trend) <u>Sex</u> (unadjusted) M 1 F 1.03 (1.02 – 1.05) (p=0.09)	Cross sectional study linking E dwellings and postcode mort data. Confounders included I dwelling characteristics and s economic factors. Confoundi seasonal influenza was not accounted for, but a good association with indoor temperatures and dwelling er efficiency was found.

							housing quality			<u>Socio-economic groups of head of household</u> (unadjusted) Professional 1 Managerial 0.96 (0.85 – 1.07) Intermed non-manl 0.93 (0.82 – 1.05) Junior non-manual 0.95 (0.84 – 1.08) Skilled manual 0.93 (0.84 – 1.04) Semi-skilled 0.94 (0.84 – 1.05) Unskilled 0.92 (0.82 – 1.05) (p>0.2 for trend) <u>SAP rating of energy efficiency</u> (unadjusted) Q1: 51- (most eff) 1 Q2: 41- 1.03 (0.97 – 1.09) Q3: 32- 1.06 (1.00 – 1.13) Q4: ≤31 (least eff) 1.05 (0.99 – 1.11) (p=0.05 for trend) <u>Quartile of indoor temp (unadjusted)</u> Q 1 (warmest) 1 Q 2 1.11 (1.02 – 1.22) Q 3 1.04 (0.94 – 1.14) Q 4 (coolest) 1.20 (1.09 – 1.32) (p=0.002 for trend) *Multi-variable adjusted all-cause deaths* <u>Property age</u> (adj for age, sex, socio-economic group and central heating): Pre 1850 1 1850-99 0.97 (0.83 – 1.12) 1900-18 0.93 (0.80 – 1.09) 1919-44 0.96 (0.83 – 1.11) 1945-64 0.96 (0.83 – 1.11) 1965-80 0.87 (0.75 – 1.01) Post 1980 0.82 (0.68 – 0.98) (p=0.001 for trend) <u>Daily time-series</u>	

										Seasonal fluctuation and cold-mortality relationship greater in homes predicted to have low winter indoor temperatures, though the variation between the warmest and coldest houses was fairly small. *Effects of temperature on cardiovascular death, and the modification of these effects by home heating* Quintile of stnd'ized indoor temp (SIC) (deg C) — Percent increase in mortality per deg C fall in outdoor temp 1 <14.8 — 2.2 (0.6, 3.9) 2 14.8- — 1.1 (-0.5, 2.8) 3 16.6- — 1.2 (-0.5, 2.9) 4 18.4- — 1.3 (-0.4, 3.0) 5 19.4- — -0.1 (-1.7, 1.5) Trend (change per deg C increase in SIC): -0.13% (-0.26, -0.00) (p=0.04 for trend)	

Continued…

Ref	Study	Aim of study	Study design	Validity		Pop, setting	Exposure	Outcomes	Analysis	Results	Notes
				Int	Ext						
2000											
125	Bulajic-Kopjar M. Seasonal variations in incidence of fractures among elderly people. Inj Prev. 2000; 6(1): 16-9.[125]	To investigate seasonal variations in the incidence of fall related fractures among people 65 years and older.	Prospective, population based cohort	+	+	Population cohort of people aged 65 years and older in three urban areas in Norway (Stavanger, Trondheim, and Harstad) and their surrounding communities, 1990 to 1997 (a total of 459,904 person years). Cases were identified through a prospective registration system.	Cold season (October 1st to 31th March) and warm season (1st April to 30th September).	Fall-related fractures (classified as hip, arm or other). Those caused by motor vehicle crashes and occupational injuries are excluded.	Fall-related fracture rates were calculated by age (65-79, and over 80), sex, and nature of injury according to ICD-code. The contribution of icy and slippery conditions to the incidence of injuries was analysed by classifying cases in those caused by slipping on ice and snow and those due to all other mechanisms.	There were 10,992 (2390 per 100,000 person years) fall related fractures. The risk was higher in the colder seasons (October through March) among people aged 65-79 years (relative risk (RR) = 1.39, 95% confidence interval (CI) 1.32 to 1.47) and in people aged 80 years and older (RR = 1.17, 95% CI 1.09 to 1.22). Slipping on ice and snow seems to explain the excessive incidence of hip and arm fractures during winter months. *<u>Incidence of fractures by nature of injury, age, sex, and season</u>* *Incidence/ 10^5 person-years* *Winter Summer* *Incidence rate ratio (95% CI) [PAR %]* *Women* <u>65–79 years</u> Hip 820 684 1.20 (1.08 to 1.33) [9] Arm 1473 872 1.69 (1.55 to 1.84) [26] Other 560 478 1.17 (1.04 to 1.33) [8] Any 2853 2035 1.40 (1.32 to 1.49) [17] <u>>80 years</u> Hip 3235 3056 1.06 (0.98 to 1.15) [3] Arm 1544 1247	Cases were missed if they we treated outside of the registra system. Injuries may be over-reported (wrongly attributing injuries to slipping on ice), or under-reported (failing to des them properly).

										1.24 (1.10 to 1.40) [11] Other 813 618 1.31 (1.11 to 1.56) [14] Any 5592 4922 1.14 (1.07 to 1.21) [6] *Men* 65–79 years Hip 418 293 1.42 (1.20 to 1.70) [18] Arm 357 211 1.69 (1.39 to 2.05) [26] Other 270 262 1.03 (0.85 to 1.25) [1] Any 1044 766 1.36 (1.22 to 1.52) [15] >80 years Hip 1769 1571 1.13 (0.96 to 1.32) [6] Arm 527 346 1.52 (1.10 to 2.09) [21] Other 522 379 1.38 (1.01 to 1.88) [16] Any 2819 2297 1.23 (1.08 to 1.40) [10] Authors' conclusion: season affects the incidence of all types of fractures in elderly people. Slipping on ice and snow seems to be a causal mechanism behind the seasonal effect. Preventive measures targeting this causal mechanism are likely to reduce the risk of fracture, but the size of the effect is difficult to estimate with certainty.	
126	Clinch JP, Healy JD. Housing standards and excess winter mortality. J	To propose an hypothesis between poor housing standards (in	Two country ecological comparison	-	+	Ireland and Norway	Country comparison	Excess winter mortality	Informal comparison of excess winter mortality and other parameters in the	*Mean mortality rates:* *Ireland (95% CI)* *Norway (95% CI)* Proportionate mortality from cardiovascular disease (%)	Hypothesis paper with very li analytical basis: simple ecolog comparison.

	Epidemiol Community Health. 2000; 54(9): 719-20.[126]	terms of thermal efficiency and heating systems) and high rates of excess winter mortality in Ireland							two countries	46.2 (45.34, 47.06) 46.2 (45.26, 47.14) Proportionate mortality from respiratory disease (%) 13.8 (13.36, 14.24) 9.9 (9.36, 10.44) Crude mortality from cardiovascular disease per 1000 population 4.1 (3.94, 4.26) 4.9 (4.76, 5.14) Crude mortality from respiratory disease per 1000 population 1.3 (1.25, 1.35) 1.1 (1.03, 1.17) Excess winter deaths per day from cardiovascular disease 39.6 (32.59, 46.61) 6.3 (5.39, 7.21) Excess winter deaths per day from respiratory disease 24.3 (20.08, 28.52) 4.3 (3.32, 5.28) Relative excess winter mortality from cardiovascular disease 0.25 (0.21, 0.29) 0.12 (0.10, 0.14) Relative excess winter mortality from respiratory disease 0.57 (0.46, 0.68) 0.4 (0.32, 0.48) Authors' conclusion: while Norway and Ireland exhibit similar (crude and proportionate) rates of mortality from cardiovascular and respiratory disease, relative excess winter mortality from cardiovascular disease in Ireland is 2.1 times that in Norway and for respiratory disease it is 1.4 times the Norwegian figure. A possible significant	The study method does not attempt to strafiy or adjust fo confounders, although a num mentioned in discussion (e.g. insulation, indoor temperatu diet). Applicable to UK as Ireland is similar in climate.

										explanation for this strong seasonality in Ireland is that Irish housing standards are considerably poorer than those in Norway, allowing falls in outdoor temperature to have a much greater impact on internal temperatures.	
127	Gemmell I, McLoone P, Boddy FA, Dickinson GJ, Watt GC. Seasonal variation in mortality in Scotland. International Journal of Epidemiology 2000;29(2):274-9.[127]	To assess seasonal variation in mortality in Scotland, 1981-1993, and its association with socioeconomic status and outdoor temperature.	Seasonal and time-series analysis	+	+	Scotland, 1981-1993	Season (Outdoor) temperature	Mortality by cause	Lagged Poisson regression analysis of numbers of deaths and average weekly temperature with adjustment for serial autocorrelation and influenza epidemics	There was significant seasonal variation in weekly death rates with a difference of about 30% between a summer trough and a winter peak. This variation was principally attributable to respiratory disease, cerebrovascular disease and coronary artery disease. Seasonal variation in mortality fell from around 38% in 1981-1983 to around 26% in 1991-1993. There was no clear evidence of a relationship between socioeconomic status and seasonal mortality, however the extent of the fall in seasonal variation was greater in deprived areas than in affluent areas. Overall, a 1 degree C decrease in mean temperature was associated with a 1% increase in deaths one week later. The lag in this relationship varied by cause of death and underlying temperature. Authors' conclusion: seasonal variations in mortality and the relationship between temperature and mortality are a significant public health problem in Scotland. It is likely that the strength of this relationship is a result	

										of the population being unable to protect themselves adequately from the effects of temperature rather than the effects of temperature itself.	
128	Keatinge WR, Donaldson GC, Bucher K, Jendritzky G, Cordioli E, Martinelli M, et al. Winter mortality in relation to climate. Int J Circumpolar Health. 2000; **59**(3-4): 154-9.[128]	To compare protective measures against cold in seven regions of Europe	Ecological country/ community-level) comparison	+	+	Men and women, 50-59 and 65-74 years in north Finland, south Finland, Baden-Wurttemburg, the Netherlands, London, and north Italy (24 groups), 1988 to 1992, and Athens and Palermo, 1992	Temperature-related mortality. Temperature from outdoor meteorologic al monitoring stations	Cause-specific mortality	Analysis of variations in protective against cold outdoor temperatures	Data for the oldest subject group studied, aged 65-74, showed that in this vulnerable group, high levels of protection against indoor and outdoor cold at given outdoor temperatures were found mainly in countries with cold winters, and were associated with low levels of excess mortality at a given level of outdoor cold. Regions such as London that had poor protection against cold and/or high baseline mortalities had higher levels of winter excess mortality than expected for the coldness of their winters.	
129	Lawlor DA, Harvey D, Dews HG. Investigation of the association between excess winter mortality and socio-economic deprivation. J Public Health Med. 2000; 22(2): 176-81.[129]	To look at the association between excess winter mortality and socio-economic deprivation, so that policy decisions to reduce this excess mortality could be appropriately directed.	Area (ecological) comparison of excess winter death index	+	+	England and Wales and specific data for Bradford and manufacturin g districts	Season – for mortality Effect modifier 'Super Profile' groups derived from the 1991 Census were used as a measure of socio-economic status.	Age-standardized excess winter death	The age-standardized excess winter death index (EWDI) was calculated for each Super Profile group, for the population of Bradford. The EWDI was also calculated for the manufacturing districts (ONS area classification), a relatively deprived group and compared with that in England & Wales.	No significant trend was found in age-standardized excess winter mortality across the Super Profile groups (C hi-sq for trend=0.24;=>.05). The manufacturing districts had a similar EWDI to the national value. Authors' conclusion: excess winter mortality is not associated with deprivation.	

Continued…

Appendix 5 table continued: 1999 studies											
Ref	**Study**	**Aim of study**	**Study design**	**Validity**		**Pop, setting**	**Exposure**	**Outcomes**	**Analysis**	**Results**	**Notes**
				Int	**Ext**						
1999											
130	Donaldson GC, Seemungal T, Jeffries DJ, Wedzicha JA. Effect of temperature on lung function and symptoms in chronic obstructive pulmonary disease. Eur Respir J. 1999; 13(4): 844-9.[130]	To investigate whether falls in environmenta l temperature increase morbidity from chronic obstructive pulmonary disease (COPD).	Panel study	+	+	Daily lung function and symptom data collected over 12 months from 76 COPD patients living in East London	Outdoor and bedroom temperature. Questionnaire s were administered which asked primarily about the nature of night-time heating.	FEV1 PEFR	Panel Regression of lung function/PEFR on outdoor and bedroom temperature	A fall in outdoor or bedroom temperature was associated with increased frequency of exacerbation, and decline in lung function, irrespective of whether periods of exacerbation were excluded. Forced expiratory volume in one second (FEV1) and forced vital capacity (FVC) fell markedly by a median of 45 mL (95% percentile range: -113-229 mL) and 74 mL (-454-991 mL), respectively, between the warmest and coolest week of the study. The questionnaire revealed that 10% had bedrooms <13 degrees C for 25% of the year, possibly because only 21% heated their bedrooms and 48% kept their windows open in November. Temperature-related reduction in lung function, and increase in exacerbations may contribute to the high level of cold-related morbidity from COPD.	
131	Gorjanc ML, Flanders WD, VanDerslice J, Hersh J, Malilay J. Effects of temperature and snowfall on mortality in Pennsylvania. Am J Epidemiol. 1999; 149(12):	To examine the relation between exposure to severe cold weather and mortality	retrospective study of	+	+	Pennsylvania, USA: deaths occurring during the month of January from 1991 to 1996 classified by weather division of residence and	"Extreme" climatic conditions, i.e. when snowfall was greater than 3 cm and when temperatures were below -7 degrees C, using 146	Total and cause-specific mortality: ischaemic heart, cerebrovasculara nd respiratory disease	Using division-days as units of observation (n = 1,560) mortality rates (counts/population) were analysed using generalized estimating equations, with allowance for	Total mortality increased on days of "extreme" climatic conditions (rate ratio (RR) = 1.27, 95 percent confidence interval (CI) 1.12-1.44). On days of extreme conditions (vs milder days), RR for mortality due to ischemic heart diseases were: <u>Men</u> 35-49 years: RR = 3.54 (2.35-5.35) 50-64 years: RR = 1.77 (1.32-2.38)	

	1152-60.[131]					cause.	weather stations over the 10 divisions		overdispersion and auto-correlation. Lag 3 for resp deaths, 0 otherwise. Division included as fixed effect, but no apparent control for time trands	65+ years: RR = 1.58 (1.37-1.82) Cold and snow had independent effects. Among women, mortality for those aged 65 years and older increased for respiratory causes (RR = 1.68, 95 percent CI 1.28-2.21) and cerebrovascular causes (RR = 1.47, 95 percent CI 1.13-1.91). Cold and snow exposure may be hazardous among men as young as 35 years.	
132	Jacobsen SJ, Sargent DJ, Atkinson EJ, O'Fallon WM, Melton LJ, 3rd. Contribution of weather to the seasonality of distal forearm fractures: a population-based study in Rochester, Minnesota. *Osteoporos Int* 1999;**9**(3)**:**254-9.[132]	To examine the contribution of weather to the seasonality of distal forearm fractures	Observational study: analysis of data from Rochester Epidemiology Project	++	++	Men and women aged >=35 years, Rochester, Minnesota, USA, 1952-89	• Season • Weather type: - snow - freezing rain - rain - high winds	Distal forearm fracture (incidence), classified as moderate or severe trauma.	Poisson regression model. <u>Confounder adjustment:</u> descriptive by season and weather type; adjusted for season and all weather variables simultaneously Age in women was classified as younger (35-64) and older (>=65).	• Distal forearm fractures due to falls were more frequent in the winter ($p < 0.0001$) among men and women • Winter excess partially explained by a greater relative risk of distal forearm fractures on days with: *Women <65 years* freezing rain (1.65; 95% CI 1.28-2.13) snow (1.42; 95% CI 1.17-1.74) *Women >=65 years* freezing rain (1.63; 95% CI 1.23-2.17) Author notes: the greater seasonality of forearm compared with hip fractures is explained by the fact that more of them occur out-of-doors. Among younger women, a 2.6-fold increase in the risk of fractures was seen in winter when adjusted for adverse weather. Residual effects of season after adjusting for daily weather	Reduced relative risks when compared to UK studies may attributable to a culture more inclined to driving rather than walking. Subject to ecological fallacy. T persistence of seasonality aft adjusting for weather could b to residual confounding. The setting where the fracture oc (indoor or outdoors) and time day. The results are only valic white women.

										conditions suggest that other factors play a role	
133	Shah S, Peacock J. Deprivation and excess winter mortality. J Epidemiol Community Health. 1999; 53(8): 499-502.[133]	To investigate the effect of material deprivation on the winter rise in mortality and temperature dependent variations in mortality	Ecological comparison of seasonal mortality at electoral ward level.	+	+	Croydon, London, United Kingdom: all deaths of Croydon residents, 1990–1995	Seasonal definition: EWD	Main outcome measures were: EWD ratio and monthly deaths	Regression modelling, with monthly average temperature and Townsend score as main predictors (modifiers).	Age and sex standardised seasonality ratios for all deaths by ward deprivation quintiles before and after exclusion of nursing and residential home deaths Results: - Quintile of Townsend index - Standardised seasonality ratio (95% CI) - Standardised seasonality ratio (95% CI) after excluding nursing and residential home deaths Quintile I 121.7 (109.1 to 135.8) 119.7 (106.0 to 135.1) Quintile II 120.3 (107.5 to 134.6) 120.2 (105.8 to 136.6) Quintile III 117.2 (105.0 to 130.8) 113.0 (100.0 to 127.9) Quintile IV 125.4 (110.9 to 141.8) 121.5 (106.2 to 139.0) Quintile V 115.9 (103.7 to 129.5) 115.3 (102.6 to 129.6) Croydon average 119.7 (116.1 to 123.4) 117.4 (111.1 to 124.1) No clear evidence of a relation between age and sex standardised seasonality ratios and Townsend scores for all deaths or cardiovascular deaths	Although ecological in design seems well done – e.g. other relevant variables controlled However it also used the Tow score which the other study suggests is a weak measure o area-deprivation so any asso may be under-represented. It be useful to compare findings studies which used Townsend others. However Debbie Lawl study that does not use the Townsend score also shows n association

										or respiratory deaths. No evidence of an interaction between Townsend score and temperature in the model of ward mortality rates (p=0.73). These findings were not affected by exclusion of deaths of nursing and residential home residents. Author conclusion: “study provides no evidence of an effect of deprivation on excess winter mortality or temperature dependent variations in mortality. The findings question simple assumptions about the relation between deprivation and excess winter mortality and highlight the need for further study to guide interventions.”	
134	Sheth T, Nair C, Muller J, Yusuf S. Increased winter mortality from acute myocardial infarction and stroke: the effect of age. J Am Coll Cardiol. 1999; 33(7): 1916-9.[134]	To examine seasonal variations in mortality from acute myocardial infarction (AMI) and stroke by	Observational study	+	+	Canada: 300,000 deaths in the Canadian Mortality Database for years 1980 to 1982 and 1990 to 1992.	Seasonal definition: month	Death from acute myocardial infarction and strroke	Seasonal variations were analyzed by month and for the four seasons (winter beginning in December). A chi-square test was used to test for homogeneity at p < 0.01, and relative risk ratios (RRs) for high and low periods were determined in relation to the overall mean. For each of four age subgroups, the magnitude of the seasonal variation	AMI deaths were highest in January (RR = 1.090) and lowest in September (RR = 0.904), a relative risk difference of 18.6%. The seasonal mortality variation in AMI deaths (winter vs. summer) increased with increasing age: <65 years 5.8% 65 to 74 years 8.3% 75 to 84 years 13.4% >85 years 15.8% (p < 0.005 for trend) Stroke mortality peaked in January (RR = 1.113) and had a trough in September (RR = 0.914), a relative risk difference of 19.9%.	

									was reported as the difference in mortality between the highest and lowest frequency seasons.	The seasonal variation in stroke mortality also increased with age. <65 years none 65 to 74 years 11.6% 75 to 84 years 15.2% >85 years 19.3% ($p < 0.005$ for trend) Authors' conclusions: the elderly demonstrate a greater winter increase in AMI and stroke mortality than younger individuals.	

Continued…

Appendix 5 table continued: 1998 studies											
Ref	**Study**	**Aim of study**	**Study design**	**Validity**		**Pop, setting**	**Exposure**	**Outcomes**	**Analysis**	**Results**	**Notes**
				Int	**Ext**						
1998											
135	Levy AR, Bensimon DR, Mayo NE, Leighton HG. Inclement weather and the risk of hip fracture. *Epidemiology* 1998;**9**(2):172-7.[135]	To determine association between inclement weather and hip fractures	Observational study: analysis of hospital admissions data	++	+	Hospital admissions for fracture neck of femur (ICD-9 code 820) for entire population of Montreal >=50 years, Quebec, 1982-92: 4018 days (n=18,455 cases)	• Season Meteorologic parameters: • amount of snow, rain, and freezing rain • (maximum) temperature	Hip fracture	One cycle sine function to model seasonality Analysis of age-and sex-specific proportion of hip fractures occurring each day (as proportion of all fractures) analysed by Poisson regression <u>Confounder control:</u> models with season and combinations of meteorological conditions Sub-groups by sex and age (5 bands): 50-64, 65-74, 75-79, 80-84, >=85	*Monthly frequency of occurrence of hip fracture: adjusted to 365/12=30.4 days per month* Adjusted frequency F M Jan 1345.4 453.1 Feb 1300.9 409.3 Mar 1128.7 346.2 Apr 1035.6 341.5 May 1087.5 323.6 Jun 1097.4 305.0 Jul 1087.5 309.9 Aug 1128.9 336.4 Sep 1248.4 340.5 Oct 1187.6 351.1 Nov 1182.6 363.8 Dec 1359.2 414.8 Peak-to-trough ratio 1.2 1.4 Annual peak* 343˚ 5˚ *360 ˚ of year starts at 1 Jan *Adjusted associations between inclement weather, season and hip fractures. All ages.* Proportional risk *Women* *(95% CI)* <u>Inclement weather index</u> T_{max} >5˚C, no rain/snow 1.0 T_{max} >5˚C, rain/snow 0.96 (0.92, 1.01) T_{max} -5to5˚C, no rain/sn 1.02 (0.93, 1.11) T_{max} -5to5˚C, rain/snow 1.04 (0.97, 1.11)	

										T_{max} <-5˚C, no rain/sn 1.13 (1.02, 1.25) T_{max} <-5˚C, rain/snow 1.07 (0.98, 1.17) Any freezing precip 1.14 (1.04, 1.24) <u>Season</u> Summer (JJAS) 1.0 Autumn (ON) 1.04 (0.98, 1.09) Winter (DJFM) 1.05 (0.99, 1.12) Spring (AM) 0.94 (0.89, 0.99) *Men* <u>Inclement weather index</u> T_{max} >5˚C, no rain/snow 1.0 T_{max} >5˚C, rain/snow 0.92 (0.85, 1.00) T_{max} -5to5˚C, no rain/sn 1.09 (0.93, 1.26) T_{max} -5to5˚C, rain/snow 1.02 (0.90, 1.16) T_{max} <-5˚C, no rain/sn 1.00 (0.83, 1.20) T_{max} <-5˚C, rain/snow 1.16 (0.99, 1.35) Any freezing precip 1.36 (1.17, 1.58) <u>Season</u> Summer (JJAS) 1.0 Autumn (ON) 1.09 (0.99, 1.20) Winter (DJFM) 1.12 (1.00, 1.26) Spring (AM) 1.03 (0.94, 1.13) • Cyclical pattern in occurrence of hip	

										fractures. Peak: mid-December for women, first week of January for men • Seasonality less pronounced among women than men • Days with lower temperatures, snow, and freezing rain were associated with increased rates of hip fracture. • Greatest risk associated with freezing rain. • Association between inclement weather and hip fractures was stronger among younger persons, both women and men. • After adjusting for meteorologic variables, there remained increases in winter of 5% among women and 12% among men	

Continued…

Appendix 5 table continued: 1997 studies											
Ref	**Study**	**Aim of study**	**Study design**	**Validity**		**Pop, setting**	**Exposure**	**Outcomes**	**Analysis**	**Results**	**Notes**
				Int	**Ext**						
1997											
136	Ballester F, Corella D, Perez-Hoyos S, Saez M, Hervas A. Mortality as a function of temperature. A study in Valencia, Spain, 1991-1993. Int J Epidemiol. 1997; **26**(3): 551-61.[136]	To assesses the relationship between daily deaths and variations in ambient temperature	Time series	+	+	City of Valencia, Spain (over 750,000 inhabitants), 1991-1993	Temperature (daily mean) and relative humidity from local monitoring station.	Mortality: - All causes - All causes in subjects >70 years - All causes excluding external causes - Cardiovascular diseases - Respiratory diseases - Neoplasms	Autoregressive Poisson analysis using four lag periods. Confounder control: Seasonality, influenza, black smoke, humidity, day of the week, holidays	Relation between temperature and mortality by cause of death: analysis of cold months (Nov-April). Threshold temperature: 15 deg C Relative risks (95% CI) for a 1 deg C decrease in temperature at lags of: 0 days 1-2 days 3-6 days 7-14 days All causes 1.015 (1.005, 1.024) 1.016 (1.005, 1.026) 1.016 (1.004, 1.028) 1.032 (1.018, 1.046) All causes in subjects >70 years 1.016 (1.005, 1.028) 1.024 (1.011, 1.037) 1.023 (1.009, 1.037) 1.037 (1.021, 1.054) All causes—external causes 1.016 (1.006, 1.026) 1.016 (1.006, 1.027) 1.017 (1.005, 1.029) 1.031 (1.017, 1.045) Cardiovascular diseases 1.021 (1.006, 1.036) 1.026 (1.010, 1.043) 1.015 (0.997, 1.033) 1.043 (1.021, 1.064)	

										Respiratory diseases 1.023(0.994, 1.054) 1.046 (1.013, 1.080) 1.022 (0.987, 1.059) 1.017 (0.976, 1.060) Neoplasms 1.006 (0.987, 1.026) 1.000 (0.979, 1.022) 1.018 (0.995, 1.042) 1.015 (0.988, 1.042) A statistically significant association between temperature and mortality, including in cold (winter) season, with variations by age and cause of death. The effect of temperature is greater in persons aged over 70 years of age, and it is also greater in cases of circulatory and respiratory diseases.	
137	Bjornstig U, Bjornstig J, Dahlgren A. Slipping on ice and snow--elderly women and young men are typical victims. Accid Anal Prev. 1997; 29(2): 211-5.[137]	To examine epidemiological factors associated with slipping on snow and ice.	Observational study: analysis of routine data	+	+	Umea health district, Sweden (population 118,544)	Slip/fall coded by cause (snow, ice). Only slips on the same level (e.g. no falls from roofs) were considered. Analysed for age group and sex.	Injury requiring hospitalisation, including fractures, due to slips or falls on snow or ice. Severity of injury types graded by Abbreviated Injury Scale (AIS). The cost of medical care for these injuries was estimated.	Descriptive analysis of routine data.	The injury rate was highest among the elderly, especially elderly women. High burden of injuries also in young men 20-29 years. Half of all injuries were fractures; for women 50 years and over two-thirds were fractures, mostly of an upper extremity. The 'cost' of medical care of these slipping injuries was almost the same as the 'cost' of all traffic injuries in the area during the same time. Most injuries occurred during leisure time. Author 'speculates' "Injury reducing	Alcohol consumption is a pot confounding factor. Falls not requiring hospitalisa were not included, meaning t was a bias towards the most vulnerable (e.g. the elderly).

										measures, such as more effective snow clearing, sand and salt spreading in strategic areas, better slip preventive aids on shoes, and 'padding' of older women, would reduce the injuries and their consequences."	
138	Christophersen O. Mortality during the 1996/7 winter. Popul Trends. 1997; (90): 11-7.[138]	To describe the timing of the winter peak, the population affected and the main causes of death in the winter peak of mortality in the 1996/7 winter (associated with an estimated 49 thousand excess deaths)	Analysis of routine data	+	+	England	Seasonal definition: winter	Mortality	The relationship between excess winter mortality, temperature and influenza was explored.	The peak in the number of deaths in December 1996 and January 1997 coincided with a peak in the number of deaths attributed to influenza and with low temperatures. However, the excess winter mortality was higher than expected, based on the experience of previous winters.	Standard EWM method + exploration of influence of influenza
139	Donaldson GC, Keatinge WR. Early increases in ischaemic heart disease mortality dissociated from and later changes associated with respiratory mortality after cold weather in south east England. J	To identify the time courses and magnitude of ischaemic heart (IHD), respiratory (RES), and all cause mortality associated with common 20-30 day patterns of cold weather	Cross-sectional time-series study	+	+	Population of south east England, including London, over 50 years of age from 1976-92	Mean daily temperatures obtained from three hourly measurement s at the Weather Centre, London. Effect modifiers	Daily mortality as deaths per 10^6 population. Absolute number of daily deaths extracted in relation to primary cause. Ischaemic heart disease (IHD) classified as ICD 410.0-414.9, respiratory disease (RES) as 460.0-519.9, and	Daily temperatures and daily cause-specific mortality on successive days before and after a reference day were regressed on temperature of reference day using high pass filtered data in which changes with cycle length <80 days were unaffected (< 2%), but slower	Colder-than-average days in the linear range 15 to 0 degrees C were associated with a "run up" of cold weather for 10-15 days beforehand and a "run down" for 10-15 days afterwards. The increases in deaths were maximal at 3 days after the peak in cold for IHD, at 12 days for RES, and at 3 days for all-cause mortality. The increase lasted approximately 40 days after the peak in cold. RES deaths were significantly delayed compared with IHD deaths. Excess deaths per million associated with these short-term temperature displacements were 7.3	

	Epidemiol Community Health. 1997; **51**(6): 643-8.[139]	in order to assess links between cold exposure and mortality					None <u>Confounders</u> Linear trends	all-cause mortality as 0-999.9. Rates before 1984 adjusted for changing in coding instructions that year. Daily estimates of population obtained by linear regression of mid-year population estimates (OPCS, Series DH1, table 2) against date.	cyclical changes and trends were partly or completely suppressed. Annual delays for different causes of death were compared with each other by Wilcoxon matched pairs rank test. Results compared with overall relations of mortalities to temperature, which include seasonal and longer changes, obtained by direct regression of unfiltered mortalities on temperature at successive delays.	for IHD, 5.8 for RES, and 24.7 for all cause, per one day fall of 1 degree C. These were greater by 52% for IHD, 17% for RES, and 37% for all-cause mortality than the overall increases in daily mortality per degree C fall, at optimal delays, indicated by regressions using unfiltered data. Similar analyses of data at 0 to -6.7 degrees C showed an immediate rise in IHD mortality after cold, followed by a fall in both IHD and RES mortality rates which peaked 17 and 20 days respectively after a peak in cold. <u>Conclusion</u>: Twenty to 30 day patterns of cold weather below 15 degrees C were followed:(1) rapidly by IHD deaths, consistent with known thrombogenic and reflex consequences of personal cold exposure; and (2) by delayed increases in RES and associated IHD deaths in the range 0 to 15 degrees C, which were reversed for a few degrees below 0 degree C, and were probably multifactorial in cause. These patterns provide evidence that personal exposure to cold has a large role in the excess mortality of winter.	
140	Donaldson GC, Keatinge WR. Mortality related to cold weather in elderly people in southeast England, 1979-94. BMJ 1997; 315(7115): 1055-6.[140]	To describe reductions in excess winter mortality in England, 1979-1994.	Time-series	+	+	Deaths in men and women aged 65-74 years in Greater London and ten other English counties, 1979-1994.	Mean daily temperature from measurements at the weather centre in London. Looked at the effect on	Mortality from ischemic heart disease, cerebrovascular disease, respiratory disease, and all-causes. Calculated number of deaths	Regression coefficients of mortality on fall in temperature were calculated for each year by generalised linear modelling for Poisson distribution, over the range 18°C to 0°C.	The annual increase in all-cause mortality per °C fall in temperature (excess winter mortality) declined by 32.3% between 1977 and 1994 (P = 0.005). The corresponding annual increase in mortality from ischaemic heart disease fell by 39.3% (P = 0.002), cerebrovascular disease by 57.1% (P < 0.001), and respiratory disease by	

							mortality over the range of 18 deg C to 0 deg C.	per day per million population.	Coefficients were also calculated for baseline mortality at 18 deg C. Changes in annual values with time were analysed by ordinary linear regression. Controlled for influenza and used the lag with the highest coefficient for each cause of death.	36.9% (P = 0.009). Baseline mortality at 18°C also fell, but only by 16.9% for all causes (P < 0.001), 24.4% for ischaemic heart disease (P < 0.002), 38.9% for cerebrovascular disease (P < 0.001), and 12.6% for respiratory disease (P = 0.038). Influenza had little effect on the falling death rates. Authors comment: Substantial declines in excess winter mortality from 1977 to 1994 were not due to fewer deaths from influenza. They can be attributed in part to improvement in non-seasonal background factors such as general medical care and diet, since baseline death rates also fell. Assuming that such background factors affected baseline mortality and mortality related to cold proportionately, about half of the decline in excess winter mortality can be explained by such non-seasonal factors. The rest can most easily be attributed to improvements in home heating and to factors such as greater car ownership, which reduce outdoor exposure to cold.	
141	Seretakis D, Lagiou P, Lipworth L, Signorello LB, Rothman KJ, Trichopoulos D. Changing seasonality of mortality from	To investigate whether declining coronary mortality has been accompanied by a change in the seasonal	We used published data on coronary mortality by year to evaluate the time trend in seasonal	-	+	Used monthly coronary deaths in the United States from 1937 through 1991. Deaths by cause and month were	Abstracted data on "diseases of the heart" for the entire United States for 1937 through 1969. Most of	Used the yearly peak-to-trough ratio as primary outcome and assessed its trend over time by linear regression; depicted time trends using	Estimated the peak-to-trough ratio in the monthly frequency of US coronary deaths using the Edwards harmonic technique. This method fits a sine	The peak-to-trough ratio diminished by about 2% per year until around 1970, when the trend reversed. In New England, the decline was steeper than in the South, as measured from all deaths. Concludes that seasonal patterns in coronary mortality in the United States	Fairly short paper, little detai on methods

	coronary heart disease. Jama. 1997; 278(12): 1012-4.[141]	pattern and to investigate hypothesis that diminishing exposures to environmental cold and heat have affected the seasonal pattern.[141]	pattern. We fit a sine curve to the monthly frequency of deaths in each year & examined the trend over time in the ratio of peak to trough of the curve.			not available by geographic area within the United States, but we were able to examine total monthly deaths in 2 regions with contrasting climates, New England and the South.	these deaths were due to ischemic heart disease. We also abstracted data on "ischemic heart disease" for 1970 through 1991, the latest year for which data were available. No explicit treatment of temperature.	polynomial smoothing.	curve to the monthly frequencies on the assumption that monthly variation demonstrates a single annual cycle. From the fitted sine curve, one can estimate the peak and the trough of the annual cycle. The ratio of peak-to-trough occurrence is a measure of the intensity of the seasonal pattern. Trend over time in the peak-to-trough ratio is measured by fitting linear regressions. We also depicted the curvature of time trends using polynomial smoothing methods.	have changed with time. These changes are compatible with the gradual expansion of adequate heating and the subsequent increased use of air-conditioning. Microclimatic influences on coronary mortality could explain in part the socioeconomic gradient of cardiovascular mortality.	
142	The Eurowinter Group. Cold exposure and winter mortality from ischaemic heart disease, cerebrovascular disease, respiratory disease, and all causes in warm	To assess whether increases in mortality per 1 degree C fall in temperature differ in various European regions and to	Ecological country/ community-level) comparison of temporal analysis of daily time-series temperature-mortality	+	+	Men and women, 50-59 and 65-74 years in north Finland, south Finland, Baden-Wurttemburg, the Netherlands, London, and	<u>Temperature-related mortality.</u> Temperature from outdoor meteorological monitoring stations	Cause-specific mortality	Percentage increases in deaths per day per 1 degree C fall in temperature below 18 degrees C (indices of cold-related mortality) were estimated by generalised linear modelling. We	The percentage increases in all-cause mortality per 1 degree C fall in temperature below 18 degrees C were greater in warmer regions than in colder regions (eg, Athens 2.15% [95% CI 1.20-3.10] vs south Finland 0.27% [0.15-0.40]). At an outdoor temperature of 7 degrees C, the mean living-room temperature was 19.2 degrees C in	<u>Reviewer comment</u> No seasonal control in time-s analyses

	and cold regions of Europe. Lancet. 1997; **349**(9062): 1341-6. [142]	relate any differences to usual winter climate and measures to protect against cold	relationship. Also, surveys conducted to assess individual risk factors and behaviour.			north Italy (24 groups), 1988 to 1992, and Athens and Palermo, 1992			assessed protective factors by surveys and adjusted by regression to 7 degrees C outdoor temperature	Athens and 21.7 degrees C in south Finland; 13% and 72% of people in these regions, respectively, wore hats when outdoors at 7 degrees C. Multiple regression analyses (with allowance for sex and age, in the six regions with full data) showed that high indices of cold-related mortality were associated with high mean winter temperatures, low living-room temperatures, limited bedroom heating, low proportions of people wearing hats, gloves, and anoraks, and inactivity and shivering when outdoors at 7 degrees C ($p < 0.01$ for all-cause mortality and respiratory mortality; $p > 0.05$ for mortality from ischaemic heart disease and cerebrovascular disease). Interpretation: Mortality increased to a greater extent with given fall of temperature in regions with warm winters, in populations with cooler homes, and among people who wore fewer clothes and were less active outdoors.	

Continued…

Appendix 5 table continued: 1996 studies											
Ref	Study	Aim of study	Study design	Validity		Pop, setting	Exposure	Outcomes	Analysis	Results	Notes
				Int	Ext						
1996											
144	Laake K, Sverre JM. Winter excess mortality: a comparison between Norway and England plus Wales. Age Ageing. 1996; 25(5): 343-8.[144]	The primary objective is to relate winter mortality to age, outdoor temperature, and influenza to make comparisons between Norway and England plus Wales.	Two country ecological comparison.	+	+	England & Wales and Norway	Country comparison. Monthly data from August 1970 to July 1991 of all deaths (n = 12 154 000) and deaths attributed to influenza, broken down into three broad age bands (45-64, 65-74 and 75 years and above), and monthly mean temperature in London, were supplied for England and Wales. Information on age at death and month, year and cause of death (ICD7-9) was made available from the Norwegian	Monthly mortality based on death records.	Seasonal mortality was calculated for the winter (December- March). Bivariate analyses used to examine excess winter mortality (December-March) in England and Wales, and South-east Norway.	A weak statistically insignificant (the difference sign test of trend [7]) decline in relative winter excess mortality in England and Wales during 1970-91. The relative excess winter mortality in the two countries was not correlated (Kendall tau = 0.18, 95%CI = —0.16-0.52), indicating that peaks and troughs in winter mortality occurred asynchronously. Relative excess winter mortality increased by age in both data sets and was higher in England and Wales. England and Wales, death certificates had any mention of influenza, and most of these deaths, were 27573 (0.2%) and 84%. Simple linear regression analyses showed a trend towards higher mortality in colder winters, and more markedly so in England and Wales (range mean winter temperature 3.2-7.2°C, beta = -0.012, 95%CI = -0.032-0.008) than in Norway (temperature range -6.1 -1.1°C, beta = -0.008, 95%CI = -0.022-0.006). Using monthly data, restricted to December-March, simple linear regression disclosed a statistically significant relationship (beta = -0.021, 95%CI = -0.027 to -0.015, R = 0.44) in the data from England and Wales. The probability of a winter death	Study method adjusts for confounders by influenza, ou temperature (base on Londor age. Co-morbidities are not included. Applicable to Engla

							Central Bureau of Statistics for the period 1966-86 on all Norwegians aged 45 and over at death (n = 774 700). Meteorological data for Norway were provided by the Norwegian Institute of Meteorology.			versus a non-winter death was modelled by multiple logistic regression using age and influenza deaths as categorical explanatory variables, and mean winter temperature as an interval-scaled covariate. A good model fit was achieved for the British data After multivariate adjustment, temperature emerged as an independent and significant risk factor of winter death in England and Wales only	

Continued…

Appendix 5 table continued: 1995 studies

Ref	Study	Aim of study	Study design	Validity		Pop, setting	Exposure	Outcomes	Analysis	Results	Notes
				Int	Ext						
1995											
143	Jacobsen SJ, Sargent DJ, Atkinson EJ, O'Fallon WM, Melton LJ, 3rd. Population-based study of the contribution of weather to hip fracture seasonality. *Am J Epidemiol* 1995;**141**(1)**:**79-83.[143]	To assess the daily occurrence of hip fracture among women aged 45 years and older compared with the occurrence of inclement weather as recorded in hourly readings by the National Weather Service in Rochester for the same time period	Observational study: analysis of data from Rochester Epidemiology Project	++	++	Women aged >=45 years presenting with hip fracture, Rochester, Minnesota, 1952 to 1989	• Season • Weather type: - snow - freezing rain - rain - high winds	Hip fracture (incidence)	Poisson regression model. <u>Confounder adjustment:</u> descriptive by season and weather type; adjusted for season and all weather variables simultaneously	*Weather and season relative risks (RR) and 95% confidence intervals (CI) of hip fracture among women, Rochester, Minnesota, by age, 1952-1989: results from Poisson regression model* *<u>Unadjusted</u>* RR (95% CI) *Aged 45-74 years* <u>Weather type</u> Snow or blowing snow 1.41 (1.10, 1.81) Freezing rain/drizzle 1.82 (1.27, 2.62) Rain 0.83 (0.64, 1.06) High wind 0.87 (0.36, 2.09) <u>Season</u> Autumn 1.05 (0.76, 1.46) Winter 1.44 (1.06, 1.96) Spring 1.10 (0.80, 1.52) *Aged >=75 years* <u>Weather type</u> Snow or blowing snow 1.13 (0.96, 1.32) Freezing rain/drizzle 1.00 (0.74, 1.35) Rain 0.91 (0.78, 1.05) High wind 1.33 (0.87, 2.05) <u>Season</u> Autumn 1.03 (0.85, 1.25) Winter 1.16 (0.96, 1.40) Spring 0.81 (0.66, 0.99) *<u>Adjusted for all factors (each weather type and season) simultaneously</u>* *Aged 45-74 years* <u>Weather type</u> Snow or blowing snow 1.22 (0.91, 1.63) Freezing rain/drizzle 1.60 (1.06, 2.41)	<u>Author conclusion</u>: data suggest that factors oth than weather that may be lin the seasonal pattern in hip fr occurrence and that operate ages.

										Rain 0.87 (0.67, 1.13) High wind 0.79 (0.32, 1.92) Season Autumn 0.95 (0.67, 1.33) Winter 1.16 (0.81, 1.65) Spring 1.08 (0.78, 1.50) *Aged >=75 years* Weather type Snow or blowing snow 1.01 (0.84, 1.22) Freezing rain/drizzle 0.89 (0.65, 1.21) Rain 0.96 (0.82, 1.13) High wind 1.35 (0.88, 2.08) Season Autumn 1.03 (0.84, 1.25) Winter 1.15 (0.93, 1.43) Spring 0.80 (0.65, 0.98) Among the women aged 45-74 years, the risk of hip fracture was increased on days with snow or freezing rain; reduced after controlling for weather Among women aged 75 years and older, ice and snow were not strongly related to fracture occurrence. The winter-related increase in risk (RR = 1.16, 95% CI 0.96-1.40) was essentially unchanged after controlling for weather and was similar to the weather-adjusted seasonality of hip fracture occurrence in younger women.	
145	Langford IH, Bentham G. The potential effects of climate change on winter mortality in England and	To evaluate the possible influence of climate change on excess winter death and	Statistical modelling (quantitative risk assessment)study	+	+	Population mortality data, England and Wales, 1968 to 1988	Mortality: - all causes - chronic bronchitis - pneumonia - ischaemic heart disease	Death from: -- all causes -- chronic bronchitis, -- pneumonia -- ischaemic heart disease	Statistical (time-series) models of the associations between monthly mortality rates and temperature, influenza epidemics	Highly significant negative associations were found between temperature and death rates from all causes and from chronic bronchitis, pneumonia, ischaemic heart disease and cerebrovascular disease.	Longitudinal study using observation data analysis of a cause winter excess death un climate change scenarios lack uncertainty analysis. Many fa are likely to have an effect or

	Wales. Int J Biometeorol. 1995; **38**(3): 141-7.[145]	temperature-related mortality in England and Wales					-cerebrovascular disease.	-- cerebro-vascular disease.	<u>Confounding</u> Influenza	Higher temperatures predicted for 2050 might result in nearly 9000 fewer winter deaths each year with the largest contribution being from mortality from ischaemic heart disease. Such estimates depend on assumptions about the factors that may affect (modify) the temperature-mortality relationship	changes in EWD not accounte (e.g. underlying health of population and protective na of dwellings) <u>Reviewer comment</u> Temp-mortality relationship l to modify over time.
146	Lau EM, Gillespie BG, Valenti L, O'Connell D. The seasonality of hip fracture and its relationship with weather conditions in New South Wales. Aust J Public Health. 1995; **19**(1): 76-80.[146]	To determine the seasonal pattern in hip fracture rates and its relationship to weather variables	Observational study of hospital admission data	++	++	Hospital admission data, New South Wales (Sydney), Australia. Years: 1981, 1983, 1986, 1988, 1989, 1990. Patients aged 50 and older included.	• Season *Monthly weather parameters:* • Mean daily minimum temperature • Mean cloud cover • Number of days with strong wind • Number of days of fog • Number of days of mist • Number of days with 0.1 mm or more rainfall	• Hip fracture	Poisson regression of *monthly* admission rates. Seasonality of hip fracture rates examined for men women, those under 75 years old, and those over 75 years old. Non-significant variables were omitted from later models.	Consistent seasonal pattern for hip fracture: trough in the summer, peak in winter, statistically significant (P < 0.01) in men and in women, and in people 75 years and over. Mean daily minimum temperature for each month was the single weather variable independently and consistently associated with the monthly rates of hip fracture in both younger and older people. Sex-adjusted relative risk for hip fracture for different weather variables (50-74 years) Weather RR CI Minimum Temp 1.10 1.07-1.14 All variables-adjusted relative risk for hip fracture for different weather variables (50-74 years) Weather RR CI Minimum Temp 1.12 1.06-1.17 Sex-adjusted RR for hip fracture for different weather variables (>75 years) Weather RR CI Minimum temp 1.18 1.15-1.20	The weather conditions in Au are unlikely to be similar to th the UK. The location of any falls whicl lead to fractures (indoors or outdoors) was not recorded. Variation in activity levels dur different seasons may drive s of the variations in fracture ri

Continued…

Appendix 5 table continued: 1994 studies											
Ref	**Study**	**Aim of study**	**Study design**	**Validity**		**Pop, setting**	**Exposure**	**Outcomes**	**Analysis**	**Results**	**Notes**
				Int	**Ext**						
1994											
147	Parker MJ, Martin S. Falls, hip fractures and the weather. *Eur J Epidemiol* 1994;**10**(4):441-2.[147]	To investigate whether sub-clinical hypothermia contributes to the risk of a fall and hip fracture	Prospective observational study of consecutive hospital admissions	+	+	Patients admitted with hip fracture to Birmingham Accident Hospital. Patients under the age of 60 years, those who fall in hospital, and those with no history of a fall were excluded. N=514, of whom 429 met inclusion criteria.	Meteorological parameters (from Birmingham University Weather Centre): • Temperature • Air frost • Ground frost	• Hip fracture	Days with 0, 1, 2, >2 fractures compared with daily meteorological parameters by Chi-squared test	No statistically significant variation by month/season. Weak association with the day of fall and ground frost (p=0.04); none for air frost (p=0.08) or minimum temperature (p=0.15).	The study limitations include small sample size; an older population, the majority of w were female; the patients adr to the single study In the hos may not be representative of wider population; the locatio the fall, such as indoors or outdoors, was not included i analysis; and the population be less inclined to leave the h during poor weather, and modifying their risk of fractu relative to the wider populati

Continued…

Appendix 5 table continued: 1993 studies											
Ref	Study	Aim of study	Study design	Validity		Pop, setting	Exposure	Outcomes	Analysis	Results	Notes
				Int	Ext						
1993											
148	Kunst AE, Looman CW, Mackenbach JP. Outdoor air temperature and mortality in The Netherlands: a time-series analysis. Am J Epidemiol. 1993; 137(3): 331-41.[148]	To address the question of whether the relation between outdoor temperature and death rates are attributable to the direct effects of exposure to heat and cold on the human body in general, and on the circulatory system in particular.	Time-series	+	+	Deaths in the Netherlands, 1979-1987	Meteorological variables: 24-hr average temperature, wind speed and relative humidity. Data were from a single centrally located station. Also controlled for influenza with data from a monitoring network of 45 general practices. Controlled for air pollution using data on sulphur dioxide from six stations.	All-cause mortality and mortality from neoplasms, cardiovascular diseases, respiratory diseases, all other diseases, and external causes.	Poisson regression analysis controlling for influenza, air pollution, and "season"; distinguishing lag periods; examining effect modification by wind speed and relative humidity; and distinguishing causes of death. Also controlled for long-term mortality trends and demographic changes in the population. Tested lags: 0, 1-2, 3-6, ,7-14, 15-30	In most lag periods, cold and heat is positively related to the actual mortality level. The largest effects (both statistically significant), after controlling for influenza, sulphur dioxide and season: Cold (lag 3-6): An increase of 0.45% per degree Heat (lag 0): An increase of 1.76% per degree. Cold at most lags was significantly associated with all causes of death except external causes, with respiratory effects relatively higher than cardiovascular effects. Both tended to be higher than for all-cause mortality. Heat had a rapid positive effect on all causes of death, and particularly on respiratory diseases and external causes. Heat effects per degree were higher than cold effects. Authors conclude that important direct effects of exposure to cold and heat on mortality were suggested by the following findings: 1) control for influenza incidence only reduced temperature-related mortality to a modest extent (the role of air pollution and "season" was negligible); 2) much of the temperature-related mortality, occurred within the first week; and 3) effect modification by	

										wind speed was in the expected direction. The finding that 57% of "unexplained" cold-related mortality and 26% of the "unexplained" heat-related mortality was attributable to cardiovascular diseases suggests that direct effects are only in part the result of increased stress on the circulatory system. For heat-related mortality, direct effects on the respiratory system are probably more important. For cold-related mortality, the analysis yielded evidence of an important indirect effect involving increased incidence of influenza and other respiratory infections	
149	Macey SM, Schneider DF. Deaths from excessive heat and excessive cold among the elderly. Gerontologist. 1993; 33(4): 497-500.[149]	This study examines preventable deaths attributed to excessive heat and excessive cold for persons 60 years of age and over.	Observational study	+	+	USA: National mortality data for years 1979-1985.	Excessive heat or excessive cold listed as the primary cause of death (N = 3326 for cold and 2077 for heat).	Mortality from excessive heat (ICD-9 code 900) or excessive cold (ICD-9 code 901) for individuals 60 years of age or older.	Descriptive statistics and simple correlations.	A strong female bias was found for deaths from excessive heat and a stronger male bias for deaths from excessive cold. Non-white elderly and elderly living in rural areas were disproportionately likely to suffer deaths from temperature-related causes.	

Appendix 6: Examples of quality assessment checklists used

The quality of reviewed studies was assessed using a prescribed checklist of 19 criteria relating to study design, conduct, analysis and reporting as appropriate for quantitative observational studies. The list of criteria is given below, and the Excel spreadsheet of results of the assessment for included studies is separately attached.

Questions/criteria for assessment of the quality studies

Description of the source population?

Is the eligible population representative of the source population?

Do the selected participants represent the eligible population?

Minimisation of bias in exposure classification and comparison group?

Was selection of exposure variables based on a sound theoretical basis?

Was contamination acceptably low?

How well were confounding factors identified and controlled for?

Is the setting applicable to the UK?

Were outcome measures and procedures reliable?

Were outcome measurements complete?

Were all important outcomes assessed?

Was there a similar follow-up time of exposure and comparison groups?

Was follow-up meaningful?

Was the study sufficiently powered?

Were multiple exposure variables considered in the analyses?

Were analytical methods appropriate?

Was the precision of association given or calculable?

Are the study results internally valid (unbiased)?

Are the findings generalisable to the source population (externally valid)?