Title: Systematic review to quantify the impacts of heat on health, and to assess the effectiveness of interventions to reduce these impacts

Review team

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Summary of review process

The review begins with a literature search, identifying eligible articles (by screening of titles, abstract and full text); then with the extraction of data from full text eligible articles (a generic set of data from all articles and specialised set of data from articles on specific review questions); and concludes with analysis of extracted data and publication of findings (Table 1).

The review has 7 phases (see Table 1), namely:

Stage 1. Pilot search and study tools, and finalise protocol

Stage 2. Perform search, and upload titles and abstracts onto online software

Stage 3. Screen titles and abstracts for eligibility

Stage 4. Upload full text of screen positive articles onto online software

Stage 5. Screen full text articles and extract generic data from eligible publications, including assessments of study quality

Stage 6. Develop specific PICO questions (Populations, Interventions, Comparators and Outcomes) and protocols for these. Extract additional data on these PICO questions, using a subset of the publications

Stage 7. Analysis of data and manuscript writing

Stages 3, 5 and 6 are done in duplicate using online software, independently by two reviewers.

The review process follows the PRISMA flow chart and PRISMA statement (Appendix 1 and http://prisma-statement.org/). PRISMA consists of a checklist of items required for a high-quality systematic review, which we will adhere to. The protocol will be registered with PROSPERO (https://www.crd.york.ac.uk/prospero).

The software compares the coding of the two reviewers and notes any discrepancies, which can be resolved through discussion between the two reviewers, or by a third party. Appendix 2 describes the review software and related procedures. The roles of the review team and criteria for authorship are described in Appendix 4.

Table 1: Time lines and activities in each phase

Phase of review	1. Pilot search and study tools, and finalise protocol	2. Perform search, and upload titles and abstracts	3. Screen titles and abstracts	4. Upload PDFs of screen positive articles	5. Screen full text articles and extract data from eligible articles	6. Data analysis and manuscript writing
Month of project	Month 0-1	Month 2	Month 2-5	Month 5	Month 6-7	Month 9 onwards
Activities	Search strategy piloted, finalised and 'translated' into different search engines. Define variables for classifying articles on screening of title/abstracts. Pilot using online systematic review software (EPPI-Reviewer software).	Perform searches of selected databases. Add 'hits' to EPPI-Reviewer software. Remove duplicate items.	Apply the review inclusion and exclusion criteria to titles and abstracts. Done independently, in duplicate. Discrepancies resolved by the two reviewers or a third reviewer.	Upload full text articles onto EPPI-Reviewer.	Independently, in duplicate, screen the PDFs for eligibility. Resolve discrepancies in assessment of eligibility. Obtain additional articles by searching references of publications and consulting experts. Data extracted from eligible articles, covering characteristics of the study, the study population and setting, methods, intervention and outcomes. Consult topic experts, if required. Resolve discrepancies in extractions. Assess quality of included studies (quality checklist tools).	Analyse findings of data collected. Map the overall body of literature. Analyse data from more specific PICO questions on sub-groups of interest. Qualitative summary of data, in tabular form and text. Meta-analysis of some population sub-groups, interventions or outcomes, if low or medium heterogeneity. Disseminate findings in conferences and journal articles.

PICO: Population, Intervention, Comparator, Outcome. The review is guided by conceptual frameworks, which cover both heat waves and incremental rises in temperature (Table 2)

Table 2: Framework for interventions to reduce heat-health effects

LEVEL OF INTERVENTION	Level 1	Level 2	Level 3	Level 4	Level 5
DESCRIPTION OF INTERVENTION	Long-term planning for heat waves and responses to incremental rises in heat	Heat wave preparedness	Heat wave is forecast – alert and readiness	Heat wave action and emergency response	Clinical interventions
INTERVENTION EXAMPLES	*-identify and improve the resilience of individuals and populations most at risk* *-housing (including wall insulation and other interventions to reduce internal energy use and heat production)* *-air conditioning instalments* *-plans and interventions for specific occupations* -urban planning -environmental action (including increased green spaces, external shading, reflective paint and water features) -other infrastructure changes (such as porous pavements)	*-develop local and national emergency plans with multiple partners, targeting vulnerable groups* *- risk reduction awareness (e.g. messaging using a variety of media)* *- ensure hospitals, schools and other institutions are engaged in preparing for heat waves* - ensure organisers of large events and schools, for example, take account of possible heat risks	*-communicate media messages, especially to vulnerable groups* *-communicate alerts to health care workers and ensure that they are aware of heat wave plans*	*-media alerts about keeping cool* *- mobilise community and voluntary support* - review safety of public events - reduce health effects of fires during heat-waves	-interventions for treating patients with heat-related medical conditions, such as intensive care admission for heat stroke (not addressed in this review)

Text in italics indicates interventions of particular interest for the review. Grey shading indicates topics excluded from the review. The table covers heat wave action predominately. As one of the study outputs we will develop a framework that sets out relations between different levels of interventions to reduce effects of gradual increments in heat.

The next sections define which studies are eligible for the review; outline the 7 stages of the review; list the variables (codes) to be extracted from studies included in the review; and describe the data analysis methods.

1) Background

Worldwide, climate change presents major health challenges. The number of extreme weather events is rising rapidly, including heat waves (Aleke 2016). Extreme heat is a leading weather-related cause of morbidity and mortality. Heat exposure is becoming more widespread, frequent and intense as the environment as we know it unravels. Aside from heat waves, more gradual increments in heat have a considerable impact on health. The response to heat waves and gradual heat increments differs considerably, however. The political will to respond to extreme events and the intensity of interventions and efforts to evaluate these can be substantial. Although these events are considered low probability, they have immediate and large impacts compared to slowly changing environmental risks such as an incremental rise in heat, even though the latter may be responsible for more deaths overall in some settings. Importantly, the causes and ramifications of climate change interact to accentuate the effects of each other, with, for example, air pollution episodes from coal-based power being associated with stagnation events (little to no winds near the surface and light wind speeds above in the atmosphere) and consequent heating of heavily-polluted air.

Rises in temperature exacerbate health and social inequities. The effectiveness of heat-health interventions is inextricably linked with the level of vulnerability of target populations. Relatively-wealthier people can more readily adopt heat-health interventions, including individual preparedness, air conditioners and behaviour change (Paavola 2017). Heat impacts most on the elderly and those with chronic illnesses. These populations are most vulnerable, given their reduced thermoregulatory ability, as well as more limited mobility and resources to adjust to extreme temperatures. The intersection between climate change and rapid population ageing is a significant public health challenge (Bunker 2016). Some estimates indicate that for every 1°C rise in temperature, overall mortality escalates by 1%, but by 2% in those aged above 65 years (Wichmann 2017).

Heat exposures also hold particular dangers for pregnant women and young children (Garcia 2016), a concern given the already high levels of maternal and child mortality in many parts of the world. Temperature extremes also adversely impact birth outcomes, including changes in length of gestation, birth weight and stillbirths (Poursafa 2015; Kuehn 2017; Siemieniuk 2017). Heat waves are known to have negative impacts on mental health, which again will have differential effects on different population groups.

In urban areas, health risks in hot weather are higher than in rural or suburban areas, and these risks disproportionately impact on more vulnerable social groups (Heaviside 2017). Urban heat islands are a well-studied phenomenon, whereby urban areas are generally warmer than surrounding suburban and rural areas. Heat-health risks are thus generally higher in urban populations than those in rural or suburban areas, and rise with the extent of urban density (Heaviside 2017).

Several studies have examined the effects of increased heat and heat waves in occupational settings (Marchetti 2016), both among outdoor workers and those working in indoor uncooled settings (Kjellstrom 2016). Construction workers and miners, in particular, are at an elevated risk of heat stress, due to the strenuous nature of their work and high temperature work conditions, among other factors. As temperatures rise, the levels of risk from occupational heat may increase from 'low risk' to 'moderate or high risk', especially in the mining, agriculture and outdoor service sectors (Kjellstrom 2014). A seminal study in the mid-20th century of >200 000 underground miners in South Africa reported a mortality rate of 3.3 deaths/year/1000 miners if the temperature exceeded 34°C, compared to 0.7 deaths/year/1000 miners when temperatures ranged between 31 and 33°C (Wyndham CH 1965). Outdoor workers frequently experience heat-related effects, including sunburn, sleeplessness, exhaustion and reduced productivity (Mathee 2010). Oftentimes few, if any, measures are taken to reduce these effects.

Impacts of heat in domestic, education and health settings are also important to consider (Vardoulakis 2015). Several studies in South Africa clearly illustrate these concerns. For example, low-

cost government-built housing in South Africa and informal settlement houses (mostly made of sheets of corrugated iron, wood and plastic) are poorly insulated against heat and cold. During hot weather these structures can be 4-5°C warmer than outdoor temperatures, but then are cooler during cold spells by the same magnitude (Balmer M 2007; Scovronick 2012; Naicker 2017). Replacing informal settlement housing with formal brick and cement housing would reduce heat-related mortality by as much as a half (Scovronick and Armstrong 2012). Similarly, many school classrooms in the country are constructed of prefabricated asbestos sheeting with corrugated iron roofing, are overcrowded and lack ceiling fans (Bidassey-Manilal 2016). Temperatures in these structures often exceed 30°C and heat-health related symptoms are common (Bidassey-Manilal et al. 2016). Equally concerning is the evidence that temperatures in many waiting rooms in public-sector health facilities are dangerously high. A study of eight rural clinics found that the temperature in these clinics was as much as 4°C higher than outdoors, reaching temperature ranges associated with heat-health impact warning categories of 'caution' and 'extreme caution' (Muller 2017).

Given the factors mentioned above, it is clear that exposures to heat and outcomes of a heat-related intervention may differ markedly across sub-groups of the population, geographical area and settings. Thus, interventions related to heat and – indeed other effects of climate change – need to take into account the characteristics of the population, area and setting. The type and intensity of interventions that are required to reduce the effects of heat on health thus needs to vary according to socio-economic status, age group, gender, HIV status, occupational group and habitats, among other factors. Identical interventions applied in different populations may have considerably different efficacy, perhaps more so than with traditional biomedical interventions, such as vaccinations, for example.

Just as the impacts of heat on health and the effectiveness of interventions vary considerably, so does the research methodology on this topic. Indeed, the field is characterised by marked heterogeneity in all aspects of research. Most importantly, there is considerable variation in each of the elements of the PICO (Population, Interventions, Comparators, Outcome) question of this mapping and subsequent reviews. The exposure itself is heterogeneous and defined in various ways. The definition of a heat wave, for example, has not been applied consistently (Li 2015). This is problematic as the reported effects of raised heat vary with the definition used of heat waves, and their duration and intensity (Businge 2016). Interventions have been made across a range of settings, which may not be comparable. For example, it is possible that interventions, and their effectiveness in the Asia Pacific Region, will differ from those in Europe and North America, and indeed from effectiveness in Africa or elsewhere (Hashim 2016). Moreover, outcomes are measured in a myriad of ways (mortality, comfort level, dehydration, work productivity and renal function, for example), making it very difficult to draw overall conclusions of the effectiveness of individual interventions, or of different ones. However, despite the multiple levels of heterogeneity, it may be possible to cluster similar kinds of populations, interventions, comparators and outcomes across different settings (such as use of air conditioners during a heat wave in all settings).

Broadly speaking, within the field of climate change and health, work is being done to refine the methods of determining a) whether the occurrence of adverse health outcomes has changed with climate change, b) the extent to which that change could be attributed to climate change, and c) whether changes can be attributed to particular interventions (Ebi 2017). Many studies employ a time-series design, making it difficult to disaggregate the effects of an intervention from other changes in exposures, populations and interventions which occurred over the period of the study (Ebi 2017). Methodologically, therefore, in this review, it is key to explore the extent to which changes in heat-health outcomes can be attributed to the interventions delivered. In particular, attribution is difficult given the weak study designs employed in most studies to date, which incur a range of important biases.

Substantial changes in a population over time can also occur due to biological acclimatisation, behavioural changes and other ways the population has reduced its vulnerability to heat-health

effects. There is clearly marked variation in an individual's response or adaptive capacity to heat. Acclimatisation occurs with physiologically protective responses to changes in temperature. These changes can occur over a short time period, such as over a summer season. Arbuthnott noted in a review that evidence across a number of different settings, suggests that population susceptibility to heat and heat waves has decreased over time. This suggests that some population-level adaptation has occurred already. Temporal changes in population susceptibility are likely ongoing, make it difficult to compare the effects of a single intervention over time. These changes in heat-related susceptibility have important implications for health impact assessments of future heat-related risks, and for drawing conclusions from comparisons of outcomes of different interventions over time.

Despite the concerns raised above, there is much value in systematically collating existing evidence. Clearly, a more detailed understanding of changing temperature-related mortality and morbidity, and the effectiveness of possible interventions could make important contributions to managing future risk. There is much that remains unanswered in this field. Calls for additional systematic reviews on the topic were made as early as 2012 (Kovats 2012), yet few such reviews have been conducted. Most especially, gaps relate to evidence of the effectiveness of interventions and to understanding the research methodology in this field. In particular, there is much uncertainty about which research methods are best suited for attributing changes in health outcomes to the heat adaptation intervention that have been implemented.

Pre-existing reviews and evidence on the topic

The general *effects* of heat on morbidity have been assessed in detail, but, overall, surprisingly little has been done to study *interventions to counter these effects* (Li et al. 2015). The evidence of effects of heat are summed by several international organisations such as WHO (World Meteorological Organization 2015), and national bodies, such as the National Health Service in the United Kingdom (Public Health England 2018). Previous systematic reviews on interventions to counter heat-health effects cover literature published some years back, while other reviews are narrative, subject to a range of biases. One systematic review on the topic, by Boeckmann and Rohn, only included literature published before 2014 (Boeckmann 2014). Other reviews, also dated, have assessed specific interventions, such as heat warning systems (Toloo 2013; Toloo 2013) electric fans (Gupta 2012; Jay 2015) and air conditioning (Arbuthnott 2016).

Some reviews have systematically examined the effects of heat on specific populations, such as construction workers (Acharya 2018) and farm workers (Bello 2017). One study investigated climate change interventions in low- and middle-income countries, through a series of case studies (Ebi et al. 2017). One large economic evaluation was done that included heat-health studies (Schmitt 2016). Some reviews of reviews have been performed in this field, but none directly relevant to the question addressed in this review (Businge et al. 2016; Farzad 2017; Pattinson 2017). Clearly, it will be useful to update these reviews and numerous narrative reviews, given that volume of research on the topic has grown considerably in recent years.

China is a global leader in climate change mitigation and adaptation. They have accrued a remarkable volume of research on climate change *per se*, very little of which has been incorporated into the English body of literature. This is a major gap in knowledge on this topic. Being able to address this gap would be a major advance in the field and may ignite further efforts to disseminate the considerable body of knowledge gained by researchers that country. Building collaborations between researchers in China and in English-speaking countries could also create a platform for future Chinese-English systematic reviews. This could be a unique contribution to this and many other fields (Huang 2017).

In summary, a detailed, updated understanding of the effectiveness of heat-health interventions could make an important contribution to managing future risk from this growing problem. Additionally, there is much value in interrogating the research methodology in this field, especially assessing methods used to attribute changes in health outcomes to heat interventions.

3) Review objectives

Primary objective

1. To investigate the effectiveness, in the general population, of interventions to reduce the impacts of heat waves on mortality and morbidity

Secondary objectives

1. To map the field of research on heat and health research, both interventional and non-interventional research, by setting, study methodology and characteristics of studies
2. To identify the effectiveness of a range of interventions to reduce the harmful impacts of heat on health in the general population, population subgroups, different settings and in different study designs;
3. To quantify the impacts of heat on mortality and a range of morbidities;
4. To critically appraise the methodology used in heat-health interventional studies, and identify ways of optimizing methodologies in this field.

4) Criteria for considering studies for this review

Inclusion criteria

To be included in the review, articles need to satisfy all components of the PICO questions for this review: Population(s) studied; Intervention(s) of interest; Comparator group(s); and Outcome(s) of interest. No restrictions on date of publication will be applied. Only articles in Chinese, English or German will be included. Only peer-reviewed publications will be included, not grey literature.

Types of studies

All study designs using empirical data are eligible. The Box below presents definitions of different study designs that we will include, it is form the Cochrane Handbook, Box 13.1.a. In addition to studies with the designs presented in the Box, we will also include qualitative research, case studies, and health economic evaluations.

There is much heterogeneity in this field and few randomised trials, we thus include all study designs. At least one internal or external control group must be present. Control groups can be historical controls of the same populations, or parallel control groups, non-randomised controlled studies (including controlled before and after studies and interrupted time series studies). Studies describing costing of utilisation of existing services, or of heat-related interventions are included.

Systematic and narrative reviews (grey or non-grey literature) are not included, but serve as a means of identifying eligible studies. Modelling of the potential or hypothetical effectiveness of interventions will be excluded. Those that use actual data are not considered modelling studies, these sometimes use modelling as part of statistical analysis. For example, in a paper a logistic regression model was used to assess associations between a heat wave warning system and heat stroke in people in Johannesburg in 2014. This is not considered a modelling study. Only published studies will be included.

Definitions of study designs: Cochrane Handbook, Box 13.1.a

Non-randomized controlled trial.	An experimental study in which people are allocated to different interventions using methods that are not random.
Controlled before-and-after study.	A study in which observations are made before and after the implementation of an intervention, both in a group that receives the intervention and in a control group that does not.
Interrupted-time-series study.	A study that uses observations at multiple time points before and after an intervention (the 'interruption'). The design attempts to detect whether the intervention has had an effect significantly greater than any underlying trend over time.
Historically controlled study.	A study that compares a group of participants receiving an intervention with a similar group from the past who did not.
Cohort study.	A study in which a defined group of people (the cohort) is followed over time, to examine associations between different interventions received and subsequent outcomes. A 'prospective' cohort study recruits participants before any intervention and follows them into the future. A 'retrospective' cohort study identifies subjects from past records describing the interventions received and follows them from the time of those records.
Case-control study.	A study that compares people with a specific outcome of interest ('cases') with people from the same source population but without that outcome ('controls'), to examine the association between the outcome and prior exposure (e.g. having an intervention). This design is particularly useful when the outcome is rare.
Cross-sectional study.	A study that collects information on interventions (past or present) and current health outcomes, i.e. restricted to health states, for a group of people at a particular point in time, to examine associations between the outcomes and exposure to interventions.
Case series (uncontrolled longitudinal study).	Observations are made on a series of individuals, usually all receiving the same intervention, before and after an intervention but with no control group.

Types of participants

- Populations 'at risk' for heat conditions
- Humans, with no age or other restrictions, Thus infants, pregnant women and the elderly, for example, will be included, as well as groups such as those with chronic diseases and outdoor workers
- Studies set in any country, or any setting, including urban or rural areas, occupational, sports, schools, housing, health facilities, households or community based.

Types of interventions

- Any heat-health adaptation intervention will be included (see Review Framework: Table 2). Interventions, however, need to be related directly to heat, and not act through indirect interventional pathways that influence distal causes of heat increases, such as reductions in air pollution. Interventions also need to relate directly to health, not through nutrition (where a farmer alters the type of crops grown in heat-affected areas, for example). Distal interventions such as improved education level and raised income, while likely to reduce the occurrence of heat-related illnesses are not considered heat-related interventions in this review unless these were designed specifically to address effects of heat on health.
- Interventions that use surveillance data to inform heat interventions will be included. Plans for developing surveillance systems are included, as well as actual implementation of surveillance for heat interventions. Assessments of risk scores or measures that can be used to warn against future extreme events are included
- Studies only reporting findings of routine information or surveillance are excluded, there has to be an intervention to alter the heat or heat-related effects, or detection of these, for example
- Interventions related to cold episodes are excluded.
- Clinical interventions to treat individual patients with heat-related conditions, such as heat stroke are excluded.
- Basic laboratory interventions unrelated to direct patient care are also not considered interventions in this review
- Articles may include single or multiple interventions.
- We exclude studies that report on a comparison of two or more alternative ways of a measuring temperature, or a heat-related condition.

Outcomes

- To be included, the study must report at least one outcome, whereby an intervention is described, and linked to findings or outcomes of that intervention.
- Outcome measures of mortality and morbidity will be compared between the intervention and control groups to evaluate the primary objective, the effectiveness of interventions to reduce the health impacts of heat waves. These outcomes include mortality; attendance at emergency services or hospital admissions for heat-related conditions; and morbidity such as raised levels of infectious diseases and renal stones
- Other outcomes of interest are: measure of wellbeing, including discomfort; knowledge about heat and health; heat-health related behaviours; level of preparedness for heat wave, performance of heat wave warning systems and actions plans; coverage of services for reducing the impact of heat on health; and health policy implementation and effectiveness. We will also analyse data on perceptions or acceptability of an intervention; and measures of changes in social and environmental determinants of population health.
- Given the marked heterogeneity of outcomes in this field, additional outcomes will be extracted and analysed, as relevant
- The outcome does not have to be directly in humans, and can be whether or not a country has made a heat wave plan, for example.

- Outcomes of heat interventions in occupational settings can be assessed through changes in human performance or productivity and comfort, for example.
- Outcome measures vary considerably, by type of outcome, and by definition of outcomes and scales.
- Outcomes relating to potential adverse consequences or unintended consequences of the intervention will be extracted
- Outcomes in population sub-groups are of particular interest as these often reflect inequities.
- Studies reporting a change in human body temperature will be excluded, such as use of paracetemol.
- Studies reporting only a change in ambient temperature will not be analysed in the primary or secondary objectives, but as part of a scoping review on environmental health. For example, a study assessing a change in ambient urban temperature following the construction of a green area, or that an air conditioner lowers the temperature of a room. Studies with the outcome of ambient temperature or environmental temperatures relate more to environmental science or engineering research and these are unlikely to be systematically indexed in medical literature databases, nevertheless we will identify these and sum the findings of these studies.

5) Search strategy

We reviewed the search strategies used in previous relevant studies, such as the Boeckmann 2014 review; the Lancet and Health series on climate change and health, and other related reviews (Bouzid 2013; Toloo et al. 2013; Arbuthnott et al. 2016). We also discussed the search terms with review methodologists and topic experts. As attempts to locate a validated search strategy for identifying articles on climate change were not successful, we constructed our own search strategy for this topic. The search strategy for identifying articles on climate change was used in two related systematic reviews (Chersich 2018). The final search strategy for the review was piloted several times in scoping reviews.

We did not limit the date of the search period, nor constrain the search to specific languages. The search strategy was designed to exclude studies that involved only animals or plants, but to include studies that were on humans and animals, or on humans and plants. We excluded articles on genetics and heat-shock proteins, as many of those articles included terms for heat and thus reduced the sensitivity of the search.

We used a combination of free text keywords and subject headers (for example MESH terms in Pubmed) in databases that have these search functions. We first developed the strategy in Medline (Pubmed) and then adapted it to the other search engines, namely Web of Science. Science Citation Index Expanded (SCI-EXPANDED); Social Sciences Citation Index (SSCI); Arts & Humanities Citation Index (A&HCI).

Filters are used to identify articles on specific topic or study designs. These are often validated search strategies for locating articles on randomised controlled trials, for example. For this study, we located filters for locating articles on media interventions and animal studies. The Social Media filter was drawn from the University of Alberta, which has developed a series of filters: https://guides.library.ualberta.ca/health-sciences-search-filters/subject-filters. The filter for excluding articles on animals was obtained from: http://aub.edu.lb.libguides.com/c.php?g=329862&p=3023731. We adapted the filter for animals to plants. Some of the PICO reviews that cover specific research questions for sub-gruops may be limited to only low- and middle-income countries. We will use the LMIC filter: http://epoc.cochrane.org/lmic-filters for locating such studies.

We will develop a search strategy for locating articles in Chinese databases such as CNKI (www.cnki.net) as the review progresses. Some of these databases do not have a function for

exporting the results of a search, and the screening of titles and abstracts will have to be done on the same days as the search.

Many evaluations may be not be published in peer-reviewed journals. Including 'grey', or non-peer reviewed literature incurs multiple biases, more so than with peer-reviewed publications. Most especially, grey literature incurs publication bias, where studies with positive findings are substantially more likely to be published than studies with a null finding. Also, search strategies for locating this kind of literature are poorly defined and very difficult to replicate. The references of articles we include will be searched, these often contain grey literature references. These documents will not be used in the review, but may contain references to peer-reviewed literature that we may locate. Personal contacts will be made with experts in the field to obtain additional studies.

Search terms

In brief, the search entails locating articles on:

1. Heat-health exposures or conditions (using synonyms for heat and heat-related conditions) AND
2. a) articles on Climate change OR 2b) Media interventions OR 2c) Cooling interventions OR 2d) Health promotion.

To be included, a paper has to cover 1 (heat) AND (at least one of 2a OR 2b OR 2c OR 2d).

The search strategy for the different databases is presented in Appendix 3.

6) Screening of titles, abstracts and full text

Multiple reports of the same study must be collated, so that each study (rather than each paper) is the unit of interest in the review. In particular, we will attempt to find a process paper associated with the study which outlines further information.

This section outlines the instructions and codes for reviewers doing the screening of titles and, if required, of abstracts of articles located in the search. Eppi-reviewer software will be used for managing references, removing duplicates (as we upload records from several databases, many duplicates are likely) and most steps of the review (Appendix 2). The data extraction form will be set up on that software. The software is internet based, allowing members of the team to simultaneously work on the review from different locations and time zones. The platform includes several useful tools to optimise the efficiency of the review process.

Screening will be done in duplicate, by two reviewers working independently. Pairs of reviewers will be matched to draw on complementary skills, by pairing a clinician with a public health person, for example. Differences in extractions will be reconciled by a third reviewer, or through discussion between the two reviewers.

A low threshold will be used for classifying articles as requiring a full text search (i.e. if in doubt an article will be marked as screen positive). The plan is to over-include during screening of titles and abstracts, and then, if required, to exclude later. Removing 'included' articles is easier than trying to go back and screen for additional articles.

The codes, or study variables, for classifying records during screening have been piloted several times. The 'sub-categories' of the exclude variables may be useful for describing the body of literature we have reviewed. Coding the reasons for exclusion is one of components of the PRISMA statement, albeit only for the stage of full text screening. Using specific categories for the include variables, as opposed to simply labelling articles as "Include", will provide data for the mapping of literature, but also help direct the data extraction of full text articles, where reviewers will select certain groups of papers on their topic of interest.

A list of several key examples of coding, and practical illustrations of the coding rules, are included in the Appendix 5.

Coding instructions

The codes are presented in the box below, followed by definitions of each code. The code set is called "SCREENING OF TITLE/ABSTRACT on EPPI-Reviewer.

Each article must be coded within only one of the following 5 categories: duplicate, exclude (mark one of the sub-categories of exclude), include (mark one of the sub-categories of include), no abstract or query. A few articles will be coded into one of these 5 categories and also into the category background (defined below).

To be included, the study MUST be among a population at risk from a heat-related condition, have received some intervention, and report an outcome, such that an intervention is described and linked to some findings or outcomes of an intervention.

A few studies include modelling, in addition to reporting the findings of an intervention and outcomes. These must be marked as 'Exclude Modelling' AND with one of the Include categories.

The coding adheres to the study inclusion and exclusion criteria set out in Section 5. Notes on how to apply these criteria are provided below.

Box 1: Variables to extract in screening of titles and abstracts

1. DUPLICATE

2. **EXCLUDE** on title and/or abstract, and why excluded (hierarchy approach: mark only highest applicable item on list):

- An excluded language (language)
- Not human (microbe, insect, animal, plant, chemical), or not heat, or clinical (not on heat, or on heat but clinical study or basic science)
- Heat modelling study
- No heat intervention, or no outcome (on heat, but no intervention and/or outcome)
- Systematic or narrative review (heat review)
- Not research
- Other, specify

3. **INCLUDE**, code the study population or setting (multiple-response question, MARK ALL APPLICABLE)

- Heat intervention(s) with individuals or households
- Heat intervention with general population, communities, including schools
- Heat intervention in occupational settings
- Heat intervention(s) in sports, military, firefighters
- Heat intervention(s) in other settings
- Heat wave planning or warning systems
- Heat health systems or health promotion studies
- Heat environmental interventions
- Include, other

4. **NO ABSTRACT**, title indicates article may be relevant, but abstract not available

5. **QUERY**, need Full Text to decide if INCLUDE (specify reason for query).

6. **BACKGROUND** is coded as EXCLUDED, INCLUDED, NO ABSTRACT or QUERY on title/abstract, but the article may contain key references for us to screen or it is an article of much interest to the review topic

Instructions for coding on title and abstract

1. If duplicate articles are found, the first of the duplicate articles will be coded as exclude, include, no abstract or query, and then code the subsequent duplicate article(s) as duplicate.

2. If the study does not meet all the inclusion criteria then exclude it. For excluded articles, mark only one code. The codes are set up in a hierarchical manner. Mark the highest option, e.g. if an article describes a study among animals (not human) and is in Spanish, then mark "An excluded language", not "Not human, not heat" as language is higher on the list than "Not human, not heat".

2.1 Language not included in our list of languages. Exclude studies published in any language other than Chinese, English and German. If there is uncertainty about which language it is, use the Google Translate function to identify the language, or mark the record as Query). Most articles in non-English language in the items we have uploaded will provide an English language title and abstract. The title is often shown between square brackets ([ ]). If possible, classify the Chinese or German papers based on the title and abstract AND mark the item as a QUERY, noting why you have done so.

2.2 Population not human, not on heat, or on heat, but a clinical or basic science study. Studies with only microbes, insects, animals, plants or chemicals are excluded. Microbes include infectious disease involving viruses, bacteria and fungi. Studies with animals and humans, with plants and humans, or with infectious diseases and humans are not excluded, provided they meet the review inclusion criteria.

Not on heat, or on heat, but clinical study or basic science. Studies that are not on people 'at risk' for heat conditions, OR studies on people 'at risk' for cold conditions are coded here. Also use this code for studies that are on heat, but are only clinical interventions or basic science studies (cells, tissues). Clinical interventions may include, for example, treatment of heat stroke. We are not examining interventions to reduce fever, but studies that use fever as an outcome measure can be included.

Clinical interventions are excluded, for example, studies reporting treatment for patients attending an Accident and Emergency Department (casualty service) for heat stroke. Strictly speaking these patients have received an intervention (treatment of heat stroke). But, the review focuses on interventions to PREVENT heat-related conditions, not the treatment of those conditions. Studies on alternative ways of measuring heat are to be marked with this code, unless they are part of a broader set of interventions, such as those aiming to design heat-health warning systems, for example.

2.3 Modelling study on heat. A study that uses data to model hypothetical outcomes of an heat-related intervention. Use this code for articles that model a heat intervention or heat outcome of interest. Apply this code for studies that assess the future number of deaths or other conditions from heat-related conditions, for example. A few studies include modelling, in addition to reporting the findings of an intervention and outcomes. These must be marked as Exclude Modelling AND one of the Include categories.

2.4 Systematic or narrative review. A systematic review brings together the findings, from a range of previous studies in a systematic, explicit and replicable manner. A systematic review is explicit in its reporting of the search for studies (i.e. reports the search strategy for the databases searched) and the criteria for including and excluding studies; it may or may not include a meta-analysis. It may include a range of study designs, including qualitative research. Narrative reviews sum literature in a non-systematic manner. Both systematic and narrative reviews do not present new empirical data, but assess the findings of other research. The topic of the review needs to relate to heat and health. However, the study does not need to include a review of an intervention, but could cover a review of heat-related deaths, for example. The review articles may sum peer reviewed or grey literature, or both. These articles are very important as they may contain references we have not located in our search.

2.5 Study is on heat, but no relevant heat intervention, or no outcome: To be included, the study MUST report an intervention and outcome, whereby an intervention is described, and linked to findings or outcomes of an intervention. Therefore, exclude a paper using this code if it only describes the burden of disease, risk factors for heat-related conditions, or a possible intervention without reporting any intervention outcomes. Studies on coverage of services, number of people attending routine services or service delivery uptake are marked with this code, unless there was an intervention to change coverage of these services. Similarly, studies only reporting findings of routine information or surveillance are excluded and marked with this code – there has to be an intervention to alter heat or heat-related effects. Hypothetical interventions, where people are asked about their attitudes to a possible intervention in future coded in this category.

Do not use this code for studies that provided an intervention to raise uptake of services for heat conditions, or where attending a service is an outcome of an intervention (for example, use the include codes for a study which assessed the number of patients attending an Accident and Emergency Department after an intervention to raise access to those services). These kinds of studies often are health systems or health services type studies, and must not be marked with this code. Costs of services is an outcome and such

studies are coded with the include code 'include, health systems or health promotion'. These studies can be cost-effectiveness studies, cost-benefit studies or just studies summing the cost of an intervention.

For many of the type of articles described here it is hard to decide whether or not to include or exclude on review of the title and abstract alone, and should be marked as query or as include if in doubt.

2.6 Not research. Tick this option for papers that only include policy discussion, descriptions of government policies, editorials, or an opinion on a topic. This does not include articles that are systematic or narrative reviews, which should be marked with the code above.

2.7 Other. note the reason for excluding the study

3. If an article fulfils the inclusion criteria (based on the title/abstract), then tick one or more of the 'Include' categories. Tick all applicable include categories. For example, a study on a heat intervention for households near a mine, that includes miners and their families, should be marked Include individuals or households, and include occupational settings.

   The 'unit' that receives the intervention varies considerably. Interventions to be included in the review may be provided directly to individuals or groups of people; indirectly to health or other kinds of staff who then deliver an intervention; to houses, health facilities or other types of structures, among other possibilities. Please note that qualitative articles often report both interventions and outcomes, but the outcomes are 'hidden' among other text. Mark these articles as 'Query' if uncertain.
   Many studies measure 'outcomes', such as temperature of a house, but do not involve an intervention. These are sometimes considered to be 'health information' studies, or surveillance studies or surveys. These may include average measurements of temperature of a population, such as a school, or an audit of an occurrence, such as heat-related deaths or service utilisation (the number of people admitted with heat stroke, for example). We will not include these studies unless the temperature or service delivery measure, for example, is linked to an intervention, or is the outcome of an intervention. Mark such studies as 'Study is on heat, but no relevant heat intervention, or no outcome'.

Codes for Include fall within the following categories (tick all that apply)

3.1 Include heat intervention with individuals or households Intervention targets individuals or households in the general population, not those in occupational settings, for example. Outcome may be measured at any level, such as community or hospitals.

3.2 Include heat intervention with general population, communities, including schools. Interventions targeting general population, such as a heat wave plan for a town. Studies of individuals, households, occupational settings and sports must be marked with other relevant include codes, and not this one, unless the intervention has a focus on communities as well.

3.3 Include heat intervention in occupational settings

3.4 Include heat intervention in sports, military and firefighters. These studies often include small samples sizes and measures of interventions to improve performance of athletes, for example.

3.5 Include heat interventions in other settings

3.6 Include heat-wave plan or warning systems

3.7 Include health systems or health promotion intervention(s) related to heat. These interventions relate to the 6 WHO health system building blocks, or to interventions to increase patient demand for relevant services. Any intervention to raise patients' use of

heat-reduction services should be included, such as media campaigns, cash transfers, or outreach. Studies of socio-economic or environmental interventions, for examples, improving housing, are marked with this code. Studies on integration of heat and other health services are considered health system studies. Also includes studies reporting outcomes of: organisation of care interventions; or outcomes of national, provincial or district-level programmes. The 6 blocks are: 1. Service delivery, such as heat warning systems; packages of services, such as climate change adaptation plans that include a heat intervention; a control program consisting of single or multiple conditions; delivery models; infrastructure; management; safety, quality. 2. Health workforce, such as training of health workers, national workforce policies, investment plans for human resources; advocacy; norms, standards for guiding human resources performance. 3. Information, such as strengthening of facility-, population-based information and surveillance systems; setting of global standards, assessment of new monitoring tools. 4. Medical products, technologies, such as norms, standards, policies; reliable procurement; equitable access to products or technologies. 5. Health financing, including national health financing policies; financing tools, data on health expenditures; costing. 6. Leadership and governance, for example health sector policies, oversight of service delivery, regulations.

Health promotion includes: health promotion activities and health education activities within the community, and for the community, including that which occurs in health service settings. Key topics of interest are: Health education; community preparedness; interventions to alter the role or level of involvement of men or women or of other community influential; community participation in the development, delivery, quality or evaluation of an intervention, service or programme; community participation in public accountability, participatory learning and action cycles, promotion of human rights, training of providers in communication and counselling, community health workers or services in the community.

3.8 Include heat environment interventions Studies on environment involving an intervention and outcomes, even if not directly measured in humans. These can be urban heat island studies, or greening of an urban area.

4. No abstract: The title is indicative of a relevant study, but no abstract is available. If, based on title alone, you are unable to make a decision on whether the article is not relevant, mark the abstract as a query. The review team will then obtain the full text of these articles and assess them for eligibility. If no abstract is available, but the title clearly indicates an article is not relevant, then exclude the paper. The key words of the article may assist in classifying the abstract.

5. QUERY code. Throughout the review, if you are unclear about which code to apply, code the study as QUERY. Please note the reason you are unclear in the notes box which is called "info". Click on "info" to add any notes or queries you have. This applies throughout the review, please note any concerns in the info box as you go along, rather than noting issues in emails or other places.

6. Background articles. Please flag papers which will be especially useful when writing up the background to the reviews, or to developing the conceptual framework. These articles must also have been coded as exclude, include, or query. These studies might be those which do not meet our inclusion criteria, or ones that do. Do not aim to be comprehensive with coding such articles.

7) Screening of Full Text articles

Here, we screen the full text of all articles coded during screening of Titles/Abstract as: Include (any of the include categories); No abstract available; or Query. PDFs of all articles with those codes are uploaded into EPPI-Reviewer.

When a PDF is uploaded onto EPPI-Reviewer, in the coding group "retrieval of full text", click the box "Retrieved and uploaded". That enables the team to keep track of which articles we still need to find the full text of. Please confirm that the PDF that was uploaded is the same as the abstract, some errors in uploading may occur. Delete the PDF if it is the incorrect one. If the PDF is correct, but there is additional information that you require, note that in the Query Box for that article. For example, the PDF of the study protocol may have been uploaded, but not the final article. Or, the protocol may be provided as a supplementary file in a link within the article and it is necessary to view the protocol to ascertain eligibility.

In this stage, the full text articles are checked to ensure that the codes applied when the titles and abstracts were screened are correct. Screening is done in duplicate, as with screening of titles and abstracts.

Perform Full Text Screening, by checking the article is eligible, and reclassify the codes applied during screening of the Title/Abstract, if required.

Some articles that were included on screening of title and abstract will be excluded on review of full text. If the full text article does not meet the inclusion criteria (as defined in Section 4 of the protocol) then EXCLUDE it. For excluded articles, mark only one code. As with screening of titles and abstract, the exclude category uses a hierarchy approach, whereby the reviewer must mark only the exclusion criteria highest on the list that applies to the study,

Each full text article must be coded within only one of the following categories: duplicate; exclude (only one exclude category, the highest applicable category); include (multiple responses are possible, please tick all include categories that apply); or query. A few articles will be coded into one of these five categories and also into the category background (defined above).

Codes for screening of full text articles and instructions for each code are identical to those used in screening of titles and abstracts (see box and instructions in section above)

8) Data extraction

Data on study characteristics will be extracted by a single reviewer. Outcome data will be extracted in duplicate, independently and disagreements resolved in discussion or by a third party. The categories of the data extraction we intend to extract from included studies on study characteristics are type of study and design; participants; types of interventions; types of outcome measures; study details, such as aim of study, dates of study; recruitment of participants; analysis methods. Categories of results variables are: participant recruitment and characteristics; intervention delivery, duration and process evaluation; outcomes definition, type, time points measured, unit of measurement, reporting, comparator groups; results for each outcome; harms or unintended consequences; and presence of author conflict of interest.

Data on context, implementation factors, equity, cost and sustainability will be extracted, where available. Where possible, we will conduct additional searches for contextual information, such as implementation factors, cost and sustainability, beyond that presented in the included studies. Data from process evaluations will be extracted. Data on the characteristics of included studies will be presented in a table.

All potential moderators/confounders of study outcomes will be included in the extraction form (even though it will be difficult to formally test or analyse these factors in the final review). Processes to adjust for confounding will be extracted.

Several categories of data relate to equity. Firstly, the socio-demographic characteristics known to be important from an equity perspective. This includes characteristics (if provided) from the PROGRESS Plus (Place, Race, Occupation, Gender, Religion, Education, Socioeconomic status, Social status, Plus groups such as migrants and coastal communities) framework. For each included study we will report which of the PROGRESS Plus factors were reported for participants at baseline and which were reported at endpoint. In addition to the PROGRESS framework, we will also collect data on whether or not interventions included particular strategies to address diversity or disadvantage. The equity variables are presented in the Cochrane-Campbell Methods Group Equity Checklist (http://equity.cochrane.org/sites/equity.cochrane.org/files/uploads/equitychecklist2011.pdf). This may help to identify the impact of interventions on equity.

Authors of primary studies will be contacted where information is missing or clarification is needed. We will attempt to avoid duplicate publication bias by identifying multiple reports on the same study, comparing the findings of these reports and identifying possible contradictions in the results. Contradictions in results (or study description) will be clarified, if possible, by contacting the author of the study. If needed, the contradictory results will be presented in the narrative description of the study findings.

Data that are missing from reports will be marked as such so it is clear that missing data was not due to a reviewer forgetting to extract that variable.

9) Data analysis of effectiveness of heat-health interventions

The primary objective will be assessed by comparing levels of mortality and morbidity in the intervention group and controls. There are a wide range of interventions and health outcomes. The main outcome is a change in mortality between the intervention and control groups. Measures of morbidity will also be assessed to answer the primary objective of the review. In the field of climate change and health there are major challenges in attributing health outcomes to an intervention and in conducting research of high quality. Analysis will take these limitations into consideration especially the risks of bias in the included studies.

Data from all the included articles will be presented in summary of findings table. It is likely that a number of quantitative outcome measures may be identified. For outcomes reported as continuous data, will report means or changes in mean scores between the intervention and control group(s), where possible. Weighted mean difference can also be reported for continuous outcomes. Standardised mean differences will be reported when different studies use different scales to report the same outcome (e.g. scales of levels of comfort in ‘at risk’ populations). Dichotomous (or binary) outcomes can expressed as relative risks, odds ratio or risk difference. We will attempt to combine such data in meta-analyses to obtain overall measures of effectiveness.

Data analysis occurs at two levels. Firstly, to address the primary objective, we will draw overall conclusions about the effectiveness of interventions on health outcomes. We will qualitatively sum the overall body of data.

Depending on the level of heterogeneity, and if appropriate to do so, we will attempt to perform a meta-analysis. This may involve at least some exploratory meta-analyses to summarise the effects of an intervention (or of an intervention in sub-groups, or in a specific geographical areas). This decision rests on the degree of heterogeneity of the interventions located, populations studied and outcomes, among other causes of heterogeneity. In many of these sub-group analyses, as part of addressing the secondary objectives, we will examine the effectiveness of different interventions provided in specific subgroups and settings.

The research field of heat and health is characterised by marked heterogeneity, which complicates data analysis. The exposure itself is heterogeneous: reported effects vary with the definition used of heat waves, and their duration and intensity (Xu 2016). The definition of a heat wave has also not been applied consistently (Li 2015). Several factors may account for heterogeneity of findings, including population characteristics, setting and outcomes measures.

Outcomes of heat-health interventions are measured in a myriad of ways. These include: a reduction in heat stroke incidence and cardiovascular mortality and personal comfort. Heat stroke incidence may be measured through proxy indicators of health services use, for example, emergency medical care at facility or diagnoses of patients admitted to a facility. Other potential outcomes include a change in knowledge and behaviour.

A different set of interventions – and effectiveness of these - may apply to heat waves and to the more incremental rises in temperature that are taking place. We will attempt to disaggregate these two areas in analysis. And, if the same intervention is applied in both instances, we will attempt to identify differential effectiveness of the interventions in each area. Heat waves may be relatively uncommon, but have an immediate and high impact compared to slowly changing rise in temperature occurring, even though the latter may be responsible for more deaths overall. It is thus important to analyse in detail the differences in effectiveness between interventions for heat waves and those for slow gradual increments in heat. Analysis may be done separately for different types of data sources.

There are marked challenges in quantifying the impact of heat on mortality and morbidity. The study designs, measures of disease and populations are heterogeneous. Attribution of impact is particularly challenging – populations self-manage heat in different ways, biological acclimatization occurs and effects of 'harvesting' complicate analysis. Nevertheless, we will collate the evidence, and present overall findings, where possible, and draw overall conclusions, tempered by the quality and heterogeneity of the data.

Analysis of outcomes in different study populations

The particular focus of analysis will be on urban settings given that cities are a particularly high-risk environment for adverse health effects of heat with their dense population patterns, lack of green and open spaces as well as the urban heat island effect. Rural studies will still be included in some analyses, however, since increments in heat also affect these areas, and many rural populations have particular vulnerabilities and we wish to examine how those influence the effectiveness of interventions (Glaser 2016; Houghton 2017).

Analysis of outcomes for different interventions

There are several interventions of particular interest which we will examine in sub-group analyses. These include the effectiveness of heat early warning and response systems (HEWSs) for heat waves, which integrate weather forecasts with risk assessment, communication, and reduction activities (Hess 2016). Also, health impact assessments of the effects of heat on health, especially in cities, are increasingly being done, and warrant analysis. Interventions may occur at a national or local level (Sheehan 2017). They may aim to reduce heat island exposure, such as through leaflets handed out, information campaigns, shaded buildings and green roofs. Heat-appropriate behaviour education campaigns may aim to raise awareness and change behaviours. Other possible interventions of interest we will analyse may include electric fans, air conditioning and use of 'cooling centres'. Oftentimes several interventions are delivered as a package – a complex intervention. This makes it difficult to determine the impact of individual interventions, but will allow us to comment on the effectiveness of a package of interventions, which may have synergistic effects, and be more effective than each intervention provided individually. Sub-group analysis will explore causes of heterogeneity, attempting to identify groups where interventions have had the most (or least) effectiveness. Analysis and subsequent articles written disaggregate each of the above issues, and will be published in a series of articles.

Assessment of heterogeneity and synthesis of data

We will assess the heterogeneity (or differences) between the included studies. This includes assessing methodological heterogeneity (e.g. how similar or different the included studies are in terms of study design, types of participants, interventions and outcomes), as well as statistical heterogeneity (i.e. variability in the intervention effects being evaluated in the different studies).

We will assess statistical heterogeneity to determine whether it is suitable to conduct a meta-analysis or to analyse your studies qualitatively. The I^2 statistic will be used to quantify the level of heterogeneity present, and the Chi square test for heterogeneity ($p<0.10$). These will be calculated in STATA V13.0. However, statistical assessment of heterogeneity alone is not a substitute method for exploring the causes of variation between the studies. If there is a high level of heterogeneity between studies, it may be inappropriate to conduct a meta-analysis. Meta-analysis will only be considered when a group of studies is sufficiently similar in terms of participants, interventions and outcomes to provide a meaningful summary. If the studies are comparable in these respects, but there remains a very high level of heterogeneity, we may decide not to conduct a meta-analysis, and to present the results in a qualitative analysis.

In the qualitative synthesis, studies may be grouped by the type of intervention, the length of the intervention, the type of outcome, or by study design. At this point, it is difficult to identify what is most appropriate way to group the studies. Decisions about how to structure the qualitative synthesis will be made in consultation with the review team.

The effectiveness of the review will be interpreted in conjunction with considerations of the study limitations, consistency of effect, imprecision, indirectness and publication bias.

10) Assessment of risk of bias

A series of validated tools will be used to assess the quality of the research done in the included studies. Several tools are required due to the wide range of study designs included in the review. The tools developed by NICE: National Institute for Health and Care Excellence (NICE: National Intitute for Health and Care Excelence 2012). The Quality Assessment Tool for Quantitative Studies (www.myhamilton.ca/nr/rdonlyres/6b3670ac-8134-4f76-a64c-9c39dbc0f768/0/qatool.pdf), developed by The Effective Public Health Practice Project (EPHPP), to be used in conjunction with their Quality Assessment Tool for Quantitative Studies Dictionary (www.myhamilton.ca/nr/rdonlyres/f5944f3b-15a9-46e7-8afd-1cd67628e33d/0/qadictionary.pdf). Findings of the assessment of risk of bias will be tabulated, with bias assessed by each outcome so that outcomes can be judged as being at low, medium or high risk of bias given overall considerations of study design and potential impact of each of the identified biases. The level of risk of bias will inform the degree of certainty of the conclusions of the review.

11) Additional research questions

The review provides an opportunity to address several research questions in addition to those described above, these include:

a) Summing the different ways that heat waves have been defined in the literature to date
b) The modelling studies often report the likely number of deaths that will occur as temperatures rise, or when heat waves occur. It is possible that there is a systematic pattern in these data (for example, the number of predicted deaths may have risen over time)

12) Limitations and strengths of the review

Limitations related to analysing data extracted

Detecting changes and attributing change – the principal aims of this review – is clearly complex, especially due to the difficulties in measuring the effects of heat on health. Clearly, in many instances, it will be challenging to definitively link particular study outcomes to a specific intervention, the alternative hypotheses may not have been tested, or possible to test. Nevertheless, the systematic collation of evidence will likely provide several key insights on the topic. Indeed, examining the methodologies used, and the strengths and limitations of these will provide very important information. We will collate all methods used and the quality of each study included, and then assess the overall rigour of studies in the field and suggest important aspects of current methods which need to be improved in future research, and propose improvements in the methods applied, or highlight which of the methods used to date are of highest quality.

Exposures are heterogeneous and are thus difficult to compare, with heat waves, for example, varying considerably in intensity and frequency across different settings. External comparator groups, if any, are often very different from the intervention group. Matching cities, for example, and controlling for potential confounding variables would be very difficult to do. Though the studies may attempt to control for confounding variables, especially socio-economic status, it is probable that some degree of residual confounding will remain. In time-series studies, many factors, including the underlying health system may change over the time period of the study, making it difficult to attribute a change in outcome to the exposure alone. Moreover, individuals or communities may have taken actions in addition to those studied which alter the outcomes studied. And it may be difficult to separate biological adaptation from that resulting from an intervention. Long-term effects of interventions may not be detected in studies that have only short-term follow up periods. Many of the interventions applied are complex interventions, consisting of several components. It may thus be difficult to disentangle the relative contribution of each component, or synergies between these.

Many studies on the topic may be published in grey literature and may be difficult to access in a systematic manner. Publication bias is especially pronounced in grey literature, with studies of effective interventions much more likely to be published than studies where effectiveness was not demonstrated. More effective interventions may also receive high numbers of hits in internet search engines, and thus are listed higher in a search on Google Scholar, for example. Interventional work done by non-governmental organisations and local community-based organisations may not be published in grey or peer-reviewed literature. Given these considerations, the exclusion of grey literature makes it difficult to claim that the review sums all research on a topic, especially in a field where much of the data are published in grey reports.

A further limitation is that only heat-related interventions and outcomes will be included, not cold-related effects, even though these have a considerable impact on health in many settings. While this limits the scope of the review, this is necessary to retain focus.

Including Chinese language literature is a considerable strength of the study. The large body of literature from research in China is often not included in systematic reviews. Much important information is thus missed.

Despite the limitations described, clearly, a more detailed understanding of changing temperature-related mortality and morbidity, and the effectiveness of possible interventions could make important contributions to managing future risk. Data analysis aims to provide just that understanding.

13) Dissemination of review findings

We aim to produce between five and ten journal articles from this body of work. The review covers a range of populations and interventions, meaning that the main results, providing an overview of the field, can be summed in one paper, but then detailed findings of heat-health interventions in different population groups or settings will be presented in separate papers. Papers may cover, for example, heat-health interventions in occupational settings or schools, and in specific population groups, such

as elderly people. Additionally, the review presents several methodological concerns that the team could address in a journal article.

We will actively disseminate the findings at international conferences. There is rapidly growing recognition of the value in systematically collating existing evidence in this field.

Most importantly, disseminating articles that provide a more detailed understanding of the effectiveness of interventions to reduce heat-related mortality and morbidity, could make a very important contribution to managing future risk for this rapidly growing public health threat.

Appendix 1: PRISMA Checklist and flow diagram

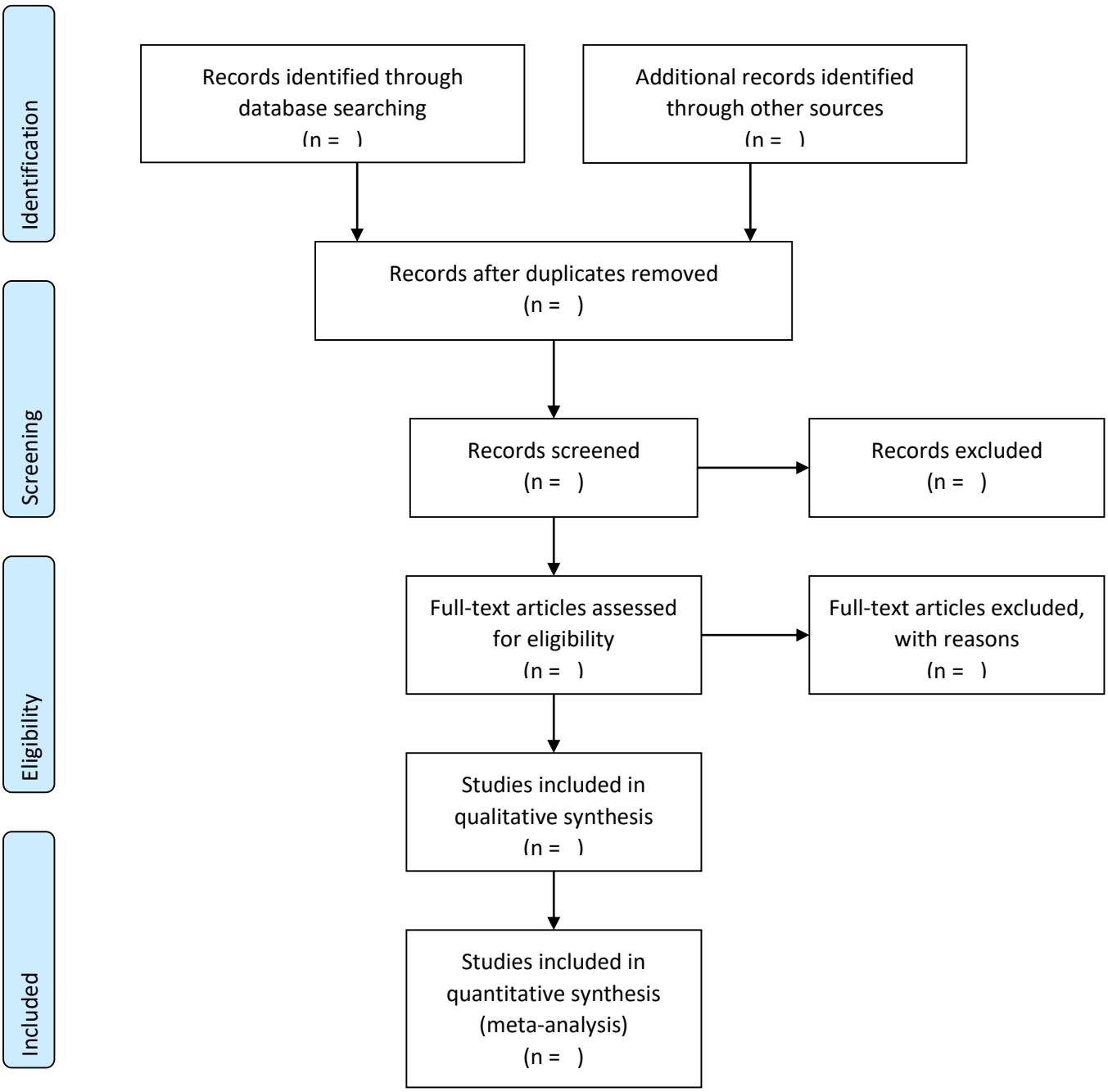
Section/topic	Item #	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	

Section/topic	Item #	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

For more information, visit: www.prisma-statement.org

PRISMA 2009 Flow Diagram



Appendix 2: Instructions for use of EPPI-Reviewer

EPPI-Reviewer 4 will be used for screening of titles, abstracts and full text, and for data extraction from included articles. This software is developed and maintained by the EPPI-Centre of the Institute of Education at the University of London, UK (eppi.ioe.ac.uk).

Use only Internet Explorer with EPPI Reviewer, Silverlite does not work with Chrome, Firefox etc.

The EPPI-Reviewer manuals, help function and videos are on http://eppi.ioe.ac.uk/cms/Default.aspx?tabid=3061

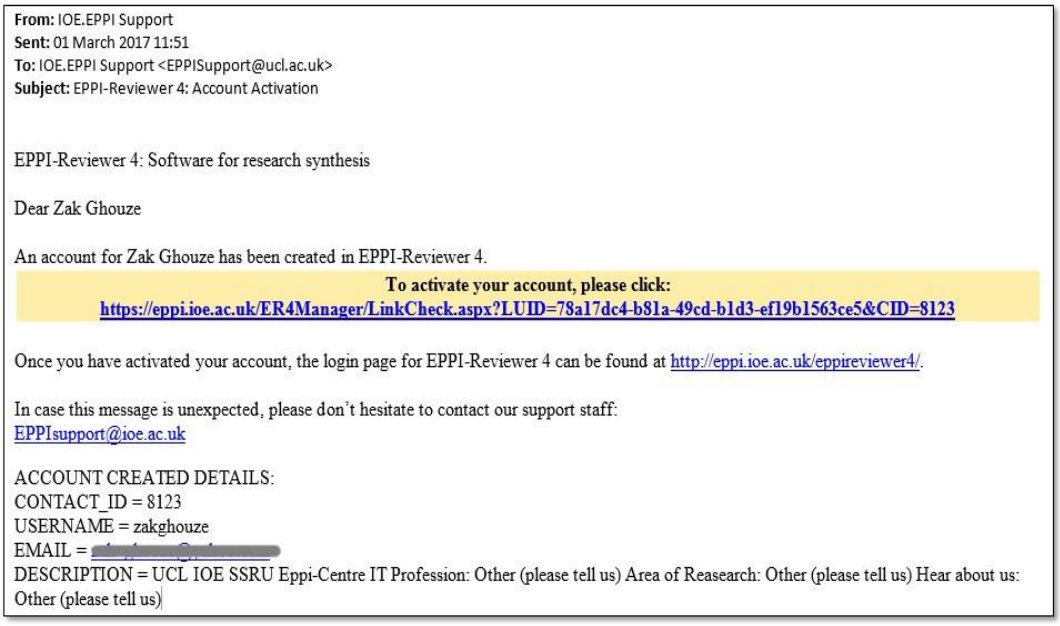
There are also YouTube tutorials: http://www.youtube.com/user/eppireviewer4

These explain the process in under 10 minutes, especially https://www.youtube.com/watch?v=Hi4fVyV4Zk8 and https://www.youtube.com/watch?v=1ixoSaxFBCQ

To get a user name and password, please sign up for a one month free trial.

You need to install the Silverlite software. EPPI Reviewer will prompt you to download the software.

Set up you user accounts using the Account Manager (at https://eppi.ioe.ac.uk/cms/Default.aspx?tabid=2935). Once you have done this, you should receive an email with a link to click to validate their new accounts, as shown below.



From: IOE.EPPI Support
Sent: 01 March 2017 11:51
To: IOE.EPPI Support <EPPISupport@ucl.ac.uk>
Subject: EPPI-Reviewer 4: Account Activation

EPPI-Reviewer 4: Software for research synthesis

Dear Zak Ghouze

An account for Zak Ghouze has been created in EPPI-Reviewer 4.

To activate your account, please click:
https://eppi.ioe.ac.uk/ER4Manager/LinkCheck.aspx?LUID=78a17dc4-b81a-49cd-b1d3-ef19b1563ce5&CID=8123

Once you have activated your account, the login page for EPPI-Reviewer 4 can be found at http://eppi.ioe.ac.uk/eppireviewer4/.

In case this message is unexpected, please don't hesitate to contact our support staff:
EPPIsupport@ioe.ac.uk

ACCOUNT CREATED DETAILS:
CONTACT_ID = 8123
USERNAME = zakghouze
EMAIL = [redacted]
DESCRIPTION = UCL IOE SSRU Eppi-Centre IT Profession: Other (please tell us) Area of Reasearch: Other (please tell us) Hear about us: Other (please tell us)

Once you have a user name, please let Matthew Chersich know what it is, so we can link you to the review. You will then receive an electronic invitation to join the review.

To log onto the review:

Enter your user name and password. Click on Go next to 'Heat and Climate', then the Collaborate tab (2nd from right in top row of tabs). Locate the articles allocated to you in the list of coding assignments. It is important that you click on the articles allocated to your user name, and only screen those articles. Look for your name under the reviewer column (if you click on another person's

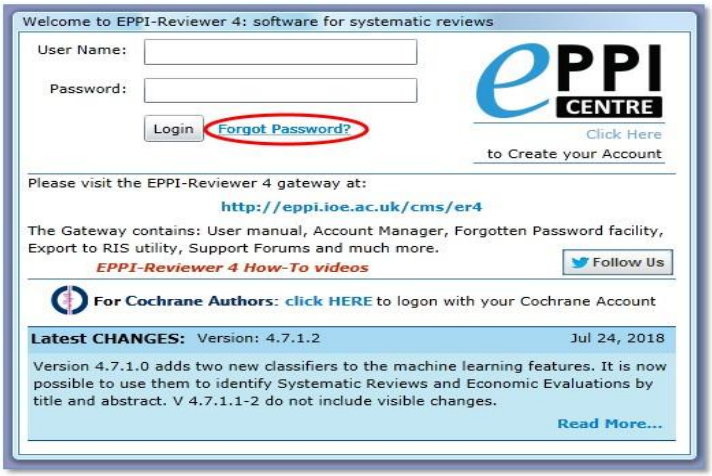
allocation that work will not be saved). Each set of articles is allocated to two reviewers. The allocations are named using the first 4 letters of the two reviewers' first names and the date of allocation (mmdd). For example, bare_cara_1008 is the allocation for Barend and Caradee made on October 8. Then **click on number in the remaining column** to open your allocations **(DO NOT CLICK ON ROWS THAT DO NOT CORRESPOND TO YOUR LOG-ON OR CLICK ON NUMBERS IN ANY OTHER COLUMN THAN REMAINING).** Once your list of articles to screen has opened, click on GO at the top left of the page to open your allocated articles for screening.

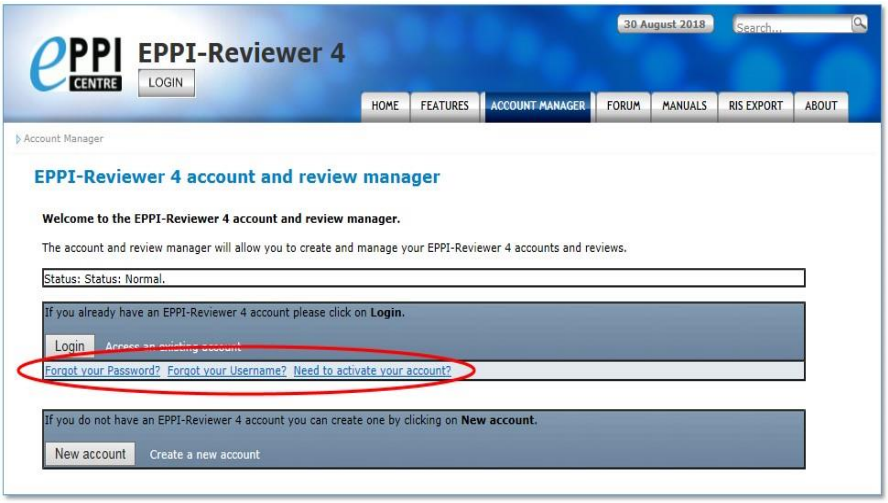
Note that the definition of each variable (code) can be viewed by clicking on the code name and looking at the grey-shaded box at the bottom left of the screen. Please do not alter the definitions, the codes or coding structure. Rather contact Matthew with any suggestions about how to improve the codes or definitions.

If you want to enter a comment or question, click on the box called 'info' next to the code, you can type details into that box.

Once you have opened your allocation of articles to screen, on the top left, click on the code set "Screening on Title and Abstract". When the categories are expanded, you will be able to see the phrase "Duplicate" at the bottom of the list.

If you forget your password or username, there is a reminder utility available from the EPPI Reviewer 4 start-up screen, or the Account Manager.





Appendix 3: Search strategy for MEDLINE (Pubmed) and Web of Science

Pubmed search:

Search covers terms for:

1. The population (those affected by heat: no 1 below) AND
2. Intervention (No. 2a: climate change OR 2b Media OR 2c cooling OR 2d Health promotion)
3. NOT 3 (genetics)

1. Search for the Population (those with heat-related conditions)

(((“ambient temperature”[title/abstract] OR “heat strain”[title/abstract] OR “heat exposure”[title/abstract] OR “heat stress”[title/abstract] OR Heating[mesh] OR “Heat Stress Disorders”[MESH] OR “hot temperature*”[title/abstract] OR “extreme heat”[MESH] OR “Heat stroke”[MESH] OR “heatstroke”[title/abstract] OR “heat index”[title/abstract] OR “heat episode”[title/abstract] OR “Heat Stress Disorders”[MESH] OR “heat event”[title/abstract] OR “Body temperature”[Mesh:noexp] OR “extreme temperature*”[title/abstract] OR “summer temperature*”[title/abstract] OR “Heat Exhaustion”[mesh] OR “summer weather”[title/abstract] OR “summer temperature*”[title/abstract] OR “heat wave”[title/abstract] OR “heatwave”[title/abstract] OR “indoor temperature”[title/abstract] OR “global temperature*”[title/abstract])))) NOT (((("Animals"[Mesh] NOT ("Animals"[Mesh] AND "Humans"[Mesh]))))) NOT (“Chemicals and Drugs Category”[MeSH]) NOT ((("Plants"[Mesh] NOT ("Plants"[Mesh] AND "Humans"[Mesh]))))

AND

2. Search strategy for interventions

a. locating Climate change articles in Pubmed

((“global warming”[Title/Abstract] OR “global warming”[MESH] OR climatic*[Title/Abstract] OR “climate change"[Title/Abstract] OR “climate change”[MESH] OR “Desert Climate”[mesh] OR “El Nino-Southern Oscillation”[Mesh] OR Microclimate[mesh] OR “Tropical Climate”[mesh]))

b. Search for media (a validated search for social media)

media[title/abstract] OR communication*[title/abstract] OR audiovisual[title/abstract] OR helpline*[title/abstract] OR hotline*[title/abstract] OR telecommunication*[title/abstract] OR educat*[title/abstract] OR radio[title/abstract] OR television[title/abstract] OR TV[title/abstract] OR internet[title/abstract] OR campaign*[title/abstract] OR advert*[title/abstract] OR print*[title/abstract] OR “information campaign”[title/abstract] OR telemedicine[title/abstract] OR telehealth[title/abstract] OR telepharmac* OR e-health[title/abstract] OR ehealth[title/abstract] OR e-pharmac*[title/abstract] OR “social media”[mesh] OR “social media”[title/abstract] OR “social network*”[title/abstract] OR Twitter[title/abstract] OR Facebook[title/abstract] OR Linkedin[title/abstract] OR Pinterest[title/abstract] OR YouTube[title/abstract] OR "daily motion"[title/abstract] OR Yelp[title/abstract] OR Foursquare[title/abstract] OR "Google Circles"[title/abstract] OR Qype[title/abstract] OR Ello[title/abstract] OR Instagram[title/abstract] OR "Pip.io"[title/abstract] OR "Google Buzz"[title/abstract] OR Orkut[title/abstract] OR Tumblr[title/abstract] OR onesocialweb[title/abstract] OR asmallworld[title/abstract] OR bebo[title/abstract] OR myspace[title/abstract] OR folkdirect[title/abstract] OR (virb[title/abstract] OR Friendster[title/abstract] OR storyofmylife[title/abstract]

c. Search for cooling

cooling[title/abstract] OR “Air condition*”[title/abstract] OR “Air-condition*”[title/abstract] OR climatization[title/abstract] OR climatisation[title/abstract] OR ventilation[title/abstract] OR Fan[title/abstract] OR fans[title/abstract]

d. Search for health promotion and risk

adaptation[title/abstract] OR adapting[title/abstract] OR response[title/abstract] OR alert[title/abstract] OR implement*[title/abstract] OR awareness[title/abstract] OR strategy*[title/abstract] OR strategies[title/abstract] OR ”risk management”[title/abstract] OR ”risk management”[mesh] OR “emergency management”[title/abstract] OR “preparedness”[title/abstract] OR “disaster management”[title/abstract] OR warning*[title/abstract] OR “health promotion”[MeSH] OR “Health education”[MeSH] OR “communication campaign*”[Title/abstract] OR guideline*[Title/Abstract] OR recommendation*[Title/Abstract] OR “Health Services for the Aged”[mesh] OR “health facility planning”[MESH] OR “Public health surveillance”[MeSH] OR “home intervention”[title/abstract] OR “home care”[title/abstract] OR homecare[title/abstract] OR “home care services”[MESH] OR “patient care planning”[MESH] OR “Comprehensive Health Care”[mesh] OR outreach[title/abstract] OR “Patient care team”[MESH] OR multidisciplinary[title/abstract] OR “home visit”[title/abstract] OR “home assessment”[title/abstract] OR “patient management”[title/abstract] OR “social support”[MESH] OR shelter[title/abstract]

3. Not genetics

NOT (Genetic Phenomena[MeSH] OR DNA[title/abstract] OR RNA[title/abstract])

Full search:

(((((((adaptation[title/abstract] OR adapting[title/abstract] OR response[title/abstract] OR alert[title/abstract] OR implement*[title/abstract] OR awareness[title/abstract] OR strategy*[title/abstract] OR strategies[title/abstract] OR ”risk management”[title/abstract] OR ”risk management”[mesh] OR “emergency management”[title/abstract] OR “preparedness”[title/abstract] OR “disaster management”[title/abstract] OR warning*[title/abstract] OR “health promotion”[MeSH] OR “Health education”[MeSH] OR “communication campaign*”[Title/abstract] OR guideline*[Title/Abstract] OR recommendation*[Title/Abstract] OR “Health Services for the Aged”[mesh] OR “health facility planning”[MESH] OR “Public health surveillance”[MeSH] OR “home intervention”[title/abstract] OR “home care”[title/abstract] OR homecare[title/abstract] OR “home care services”[MESH] OR “patient care planning”[MESH] OR “Comprehensive Health Care”[mesh] OR outreach[title/abstract] OR “Patient care team”[MESH] OR multidisciplinary[title/abstract] OR “home visit”[title/abstract] OR “home assessment”[title/abstract] OR “patient management”[title/abstract] OR “social support”[MESH] OR shelter[title/abstract])) OR (cooling[title/abstract] OR “Air condition*”[title/abstract] OR “Air-condition*”[title/abstract] OR climatization[title/abstract] OR climatisation[title/abstract] OR ventilation[title/abstract] OR Fan[title/abstract] OR fans[title/abstract])) OR (media[title/abstract] OR communication*[title/abstract] OR audiovisual[title/abstract] OR helpline*[title/abstract] OR hotline*[title/abstract] OR telecommunication*[title/abstract] OR educat*[title/abstract] OR radio[title/abstract] OR television[title/abstract] OR TV[title/abstract] OR internet[title/abstract] OR campaign*[title/abstract] OR advert*[title/abstract] OR print*[title/abstract] OR “information campaign”[title/abstract] OR telemedicine[title/abstract] OR telehealth[title/abstract] OR telepharmac* OR e-health[title/abstract] OR ehealth[title/abstract] OR e-pharmac*[title/abstract] OR “social media”[mesh] OR “social media”[title/abstract] OR “social network*”[title/abstract] OR Twitter[title/abstract] OR Facebook[title/abstract] OR Linkedin[title/abstract] OR Pinterest[title/abstract] OR YouTube[title/abstract] OR "daily motion"[title/abstract] OR Yelp[title/abstract] OR

Foursquare[title/abstract] OR "Google Circles"[title/abstract] OR Qype[title/abstract] OR Ello[title/abstract] OR Instagram[title/abstract] OR "Pip.io"[title/abstract] OR "Google Buzz"[title/abstract] OR Orkut[title/abstract] OR Tumblr[title/abstract] OR onesocialweb[title/abstract] OR asmallworld[title/abstract] OR bebo[title/abstract] OR myspace[title/abstract] OR folkdirect[title/abstract] OR (virb[title/abstract] OR Friendster[title/abstract] OR storyofmylife[title/abstract])) OR ((("global warming"[Title/Abstract] OR "global warming"[MESH] OR climatic*[Title/Abstract] OR "climate change"[Title/Abstract] OR "climate change"[MESH] OR "Desert Climate"[mesh] OR "El Nino-Southern Oscillation"[Mesh] OR Microclimate[mesh] OR "Tropical Climate"[mesh])))) NOT ((Genetic Phenomena[MeSH] OR DNA[title/abstract] OR RNA[title/abstract]))) AND ((((("ambient temperature"[title/abstract] OR "heat strain"[title/abstract] OR "heat exposure"[title/abstract] OR "heat stress"[title/abstract] OR Heating[mesh] OR "Heat Stress Disorders"[MESH] OR "hot temperature*"[title/abstract] OR "extreme heat"[MESH] OR "Heat stroke"[MESH] OR "heatstroke"[title/abstract] OR "heat index"[title/abstract] OR "heat episode"[title/abstract] OR "Heat Stress Disorders"[MESH] OR "heat event"[title/abstract] OR "Body temperature"[Mesh:noexp] OR "extreme temperature*"[title/abstract] OR "summer temperature*"[title/abstract] OR "Heat Exhaustion"[mesh] OR "summer weather"[title/abstract] OR "summer temperature*"[title/abstract] OR "heat wave"[title/abstract] OR "heatwave"[title/abstract] OR "indoor temperature"[title/abstract] OR "global temperature*"[title/abstract]))) NOT ((("Animals"[Mesh] NOT ("Animals"[Mesh] AND "Humans"[Mesh]))))) NOT ("Chemicals and Drugs Category"[MeSH]) NOT ((("Plants"[Mesh] NOT ("Plants"[Mesh] AND "Humans"[Mesh])))))

Web of Science search:

Final search done 9 October 2018 (7621 hits)

Terms for heat and interventions:

(TS=(ambient temperature OR heat strain OR heat exposure OR heat stress OR extreme heat OR Heat stroke OR heatstroke OR heat index OR heat episode OR heat event OR extreme temperature OR heat exhaustion OR heat wave OR heatwave OR hot temperature OR global temperature OR summer temperature OR summer weather OR outdoor temperature OR "Air conditioner*" OR "air conditioning")) OR

(TI=(ambient temperature OR heat strain OR heat exposure OR heat stress OR extreme heat OR Heat stroke OR heatstroke OR heat index OR heat episode OR heat event OR extreme temperature OR heat exhaustion OR heat wave OR heatwave OR hot temperature OR global temperature OR summer temperature OR summer weather OR outdoor temperature OR "air conditioner*" OR "air conditioning"))

AND LANGUAGE: (English OR Chinese OR German) AND DOCUMENT TYPES: (Article)

WC/SU

(WC=(Medicine, Research & Experimental OR Public, Environmental & Occupational Health OR Health Care Sciences & Services OR Primary Health Care OR Film, Radio, Television OR urban studies OR Behavioral Sciences OR communication OR Infectious Diseases OR Planning & Development)) OR

(SU=(Communication OR Biomedical Social Sciences OR Health Policy & Services OR Public, Environmental & Occupational Health OR Urban Studies OR Research & Experimental Medicine OR Infectious Diseases OR Health Care Sciences & Services OR Behavioral OR Film, Radio & Television))

NOT

NOT TS=(wildlife OR animal OR fish OR flora OR conservation OR soil OR “heat shock protein” OR ”heat shock proteins” OR genetic OR “DNA” OR “RNA”)

Indexes:

Science Citation Index Expanded (SCI-EXPANDED) --1945-present

Social Sciences Citation Index (SSCI) --1945-present

Arts & Humanities Citation Index (A&HCI) --1975-present

Appendix 4: Composition of the team and authorship criteria

- One of the aims of the review is to build a team of long-term collaborators (both senior- and junior-level staff). The importance of this field is growing rapidly, and the group of researchers on this project is well placed to take an international lead on the topic.
- The topic is wide-ranging, with considerable variation in the: populations studied, types of interventions, study settings and methodology. This complexity, per force, requires a multi-disciplinary team. Each member contributes unique, essential and complementary experience and skills.
- A successful review requires considerable support from library and information science staff, who help design the search strategy and locate full text articles, for example.
- We aim to involve several junior researchers who will be mentored and build their capacity by being exposed to the review methodology, a diverse body of literature and team members with a range of skills.
- Authorship will be contingent on amount of the work done, this includes screening, extraction from included articles, analysis and writing up of articles.
- As per international guidelines (Uniform Requirements for Manuscripts Submitted to Biomedical Journals: Writing and Editing for Biomedical Publication: http://www.icmje.org/urm_full.pdf), all authors are expected to make a contribution to drafting the article and revising it critically for important intellectual content. This means co-authors should help to write the paper and review versions as they progress.
- To be included as an author, a person must have completed at least an overall 20% of the screening of title/abstracts, or data extraction from the included articles. This could be made up of 20% screening and 0% extraction, or 10% of screening and 10% of extraction, for example. For example, if there are 10,000 abstracts to screen, someone screening 2000 will qualify for authorship. A person who is less confident with doing data extraction, should focus on ensuring they have done higher numbers of screening of articles to reach the 20% threshold.
- Authors will be listed in order of the percentage contribution they made to screening of articles and extraction of data. However, weight will also be given to the contribution of analysis and writing up of the article, and the person leading the latter two processes for each article will generally be named as first author of that paper.
- External advisors with knowledge of specific topic areas or methodologies will be consulted, as required. These advisors may be included as authors of specific papers, depending on the amount of input they have provided.
- In some instances, senior staff who provide overall oversight, may be included as an author on a paper, even if they have done less than the percentage required.
- Though we will make concerted attempts attempt to publish in journals that do not have a limit on author number, some journals do limit the number of authors that can be listed. The term 'Climate Change and Heat-Health Study Group' may be used (a group author) if the number of authors on the paper exceeds the number of authors that a journal allows for. The article and the journal will list the names of individuals within this group, who are identified as being directly responsible for the manuscript. Medline (Pubmed) indexes the group name and the names of individuals the included in the group.

- In some instances, a person who has not contributed to the screening and data extraction may perform a sub-analysis of a subset of studies. They will be eligible for authorship, with their position on the list of authors contingent on their contribution to the paper.
- Other members of the team who made some contribution to the study, but did not fulfil the above criteria, may be named in the acknowledgements section of the paper.
- Co-authors are expected to provide timely inputs to the drafts of articles as they are circulated. The amount of time given to co-authors to provide inputs will generally be 2 weeks. Should that period pass and no input be received from the co-author, it will be assumed that they have cleared the draft. Co-authors may request an extension in the period given for review, which may be given.

Appendix 5: Examples of coding for screening for eligibility on title/abstract and full text articles

Correct code: Exclude Heat, but no intervention or outcome

Example 1: BACKGROUND: The relationship between ambient temperature and risk of delivery is poorly understood. We examined the association between heat and risk of delivery among preterm and term pregnancies with the use of a time-to-event design to minimize bias from seasonal variation in conception rates. METHODS: We used data on 206,929 term and 12,390 preterm singleton live births for Montreal, Canada, from June through September, 1981-2010. The exposure variables were (1) maximum daily temperatures in the week preceding birth and (2) number of consecutive days with temperatures of 32 degrees C or above during the preceding week. We estimated hazards of delivery among preterm (<37 gestational weeks), early-term (37-38 weeks), and full-term (>/=39 weeks) pregnancies for both exposures in Cox regression models, adjusting for maternal characteristics. Sensitivity analyses were carried out adjusting for markers of air pollution. RESULTS: Maximum temperatures reached at least 32 degrees C during the preceding week for 19,829 births (9.0%). Relative to a maximum of 20 degrees C, the hazard of delivery within term was 4% higher for maximum temperatures of 32 degrees C or higher, but no association was found for preterm delivery. Associations were stronger with early-term than with full-term delivery. Extreme heat episodes with 4 to 7 days of maximum temperature of at least 32 degrees C were associated with a 27% greater hazard of delivery among early-term pregnancies relative to other days. CONCLUSION: High ambient temperature and extreme heat episodes may trigger earlier delivery among term births.

Example 2: BACKGROUND: Retinal detachment is an important cause of visual loss, but the association with outdoor heat exposure has not been studied. Our objective was to determine the relationship between acute exposure to high outdoor temperature and risk of retinal detachment. MATERIALS AND METHODS: We analysed 14,302 individuals with inpatient procedures for retinal detachment from April through September between 2006 and 2013 in the province of Quebec, Canada. Using a time-stratified case-crossover study design, we examined the association of retinal detachment with outdoor summer temperature the preceding week. We estimated odds ratios (OR) and 95% confidence intervals (CI) for mean weekly temperature according to subtypes of retinal detachment (traction, serous, rhegmatogenous, breaks), and assessed associations by age and sex. RESULTS: Exposure to elevated temperature the preceding week was associated with a higher likelihood of traction detachment, but not other forms of retinal detachment. Associations were stronger at <75 years of age in both men and women. Relative to 15 degrees C, a mean weekly temperature of 25 degrees C was associated with an OR for traction detachment of 2.71 (95% CI 1.56-4.71) before 55 years, 2.73 (95% CI 1.61-4.64) at 55-64 years, and 1.98 (95% CI 1.30-3.02) at 64-75 years. DISCUSSION: Elevated outdoor temperatures may be associated with an increased risk of traction retinal detachment. In light of climate change, a better understanding of the impact of heat waves on the eye and other sensory organs is needed.

Comment: some may have labelled these abstracts as 'Exclude not heat, or clinical or basic science intervention' as the abstract presents 'clinical' outcomes like birth weight or eye disease. When we say 'clinical' we mean clinical care, or medical interventions with patients. These studies examine important associations between heat and health outcomes. We want to identify these types of articles.

Correct code: Exclude Not heat, or clinical intervention or basic science

Example 1: Abstract: *Fever* increases mortality and morbidity and length of stay in neurocritically ill patients. Various methods are used in the neuroscience intensive care unit (NSICU) to control fever.

Two such methods involve the Arctic Sun hydrogel wraps and the Gaymar cooling wraps. The purpose of our study was to compare these two methods in neurocritical care patients who had temperature >37.5 degrees C for more than three consecutive hours and that was refractory to standard treatments. Data of patients requiring cooling wraps for treatment of hyperthermia at an NSICU at an academic, tertiary referral center were retrospectively reviewed. The average temperature before cooling was 38.5 degrees C +/- 0.38 degrees C and 38.4 degrees C +/- 0.99 degrees C for the Gaymar and Arctic Sun groups, respectively (p = 0.89). The Gaymar group took on average 16 +/- 21.9 hours to reach goal temperature, whereas the Arctic Sun group took 2.22 +/- 1.39 hours (p = 0.08). The average time outside of the target temperature was 57.0 +/- 58.0 hours in the Gaymar group compared with 13.7 +/- 17.1 hours in the Arctic Sun group (p = 0.04). Average duration of using the cooling wraps was similar between the two groups; 81.8% of patients had rebound hyperthermia in the Gaymar group compared with 20% in the Arctic Sun group (p = 0.0089). The Arctic Sun group had a nonsignificant increased incidence of shivering compared with the Gaymar group (40% vs. 18.18%, p = 0.36). We found that Arctic Sun surface cooling device was more efficient in attaining the target temperature, had less incidence of rebound hyperthermia, and was able to maintain normothermia better than Gaymar cooling wraps. The incidence of shivering tended to be more common in the Arctic Sun group.

Comment: There is an intervention here (Arctic Sun hydrogel wraps and the Gaymar cooling wraps), but it is among people with fever, not heat from the environment. Also, it for clinical treatment of those with a heat condition. We are interested in prevention of heat conditions. Had the used 'Arctic Sun hydrogel wraps and the Gaymar cooling wraps' to prevent heat-related diseases during a heat wave, then we would have included it.

Correct code: Include occupational settings

Example 1: Abstract: BACKGROUND: Work-related heat stress assessments, the quantification of thermal loads and their physiological consequences have mostly been performed in non-tropical developed country settings. In many developing countries (many of which are also tropical), limited attempts have been made to create detailed job-exposure profiles for various sectors. We present here a case study from Chennai in southern India that illustrates the prevalence of work-related heat stress in multiple processes of automotive industries and the efficacy of relatively simple controls in reducing prevalence of the risk through longitudinal assessments. METHODS: We conducted workplace heat stress assessments in automotive and automotive parts manufacturing units according to the protocols recommended by NIOSH, USA. Sites for measurements included indoor locations with process-generated heat exposure, indoor locations without direct process-generated heat exposure and outdoor locations. Nearly 400 measurements of heat stress were made over a four-year period at more than 100 locations within eight units involved with automotive or automotive parts manufacturing in greater Chennai metropolitan area. In addition, cross-sectional measurements were made in select processes of glass manufacturing and textiles to estimate relative prevalence of heat stress. RESULTS: Results indicate that many processes even in organised large-scale industries have yet to control heat stress-related hazards adequately. Upwards of 28% of workers employed in multiple processes were at risk of heat stress-related health impairment in the sectors assessed. Implications of longitudinal baseline data for assessing efficacy of interventions as well as modelling potential future impacts from climate change (through contributions from worker health and productivity impairments consequent to increases in ambient temperature) are described. CONCLUSIONS: The study re-emphasises the need for recognising heat stress as an important occupational health risk in both formal and informal sectors in India. Making available good baseline data is critical for estimating future impacts.

Comment: The study methods do not directly mention an intervention, but infer the presence of interventions they are assessing (see underlined text). It is worth checking the full text of this paper. It is possible that some of the differences they note between locations might be due to different interventions, or type of clothing worn, or something they mention in the paper. It is good to be conservative. This study must also be marked as exclude modelling.

Correct code: Exclude Heat, but no intervention or outcome

Example 1: Abstract: Assessing geographic variability in heat wave vulnerability forms the basis for planning appropriate targeted adaptation strategies. Given several recent deadly heatwaves in India, heat is increasingly being recognized as a public health problem. However, to date there has not been a country-wide assessment of heat vulnerability in India. We evaluated demographic, socioeconomic, and environmental vulnerability factors and combined district level data from several sources including the most recent census, health reports, and satellite remote sensing data. We then applied principal component analysis (PCA) on 17 normalized variables for each of the 640 districts to create a composite Heat Vulnerability Index (HVI) for India. Of the total 640 districts, our analysis identified 10 and 97 districts in the very high and high risk categories (> 2SD and 2-1SD HVI) respectively. Mapping showed that the districts with higher heat vulnerability are located in the central parts of the country. On examination, these are less urbanized and have low rates of literacy, access to water and sanitation, and presence of household amenities. Therefore, we concluded that creating and mapping a heat vulnerability index is a useful first step in protecting the public from the health burden of heat. Future work should incorporate heat exposure and health outcome data to validate the index, as well as examine sub-district levels of vulnerability.

Comment: there is no intervention and no comparator group here. As much as one might wish to include this article, it has to be excluded.

Example 2: BACKGROUND: Tibet, average altitude more than 4,000 meters, is warming faster than anywhere else in China. The increase in temperatures may aggravate existing health problems and lead to the emergence of new risks. However, there are no actions being taken at present to protect population health due to limited understanding about the range and magnitude of health effects of climate change. METHODS: The study was a cross-sectional survey of 619 respondents from urban Lhasa, Tibet in August 2012 with the aim to investigate public perceptions of risk, heat experiences, and coping resources. RESULTS: Respondents are aware of the warming that has occurred in Lhasa in recent years. Over 78% reported that rising temperature is either a "very" or "somewhat" serious threat to their own health, and nearly 40% reported they had experienced heat-related symptoms. Sex, age, education and income influenced perceived risks, health status, and heat experience. The vast majority of respondents reported that they had altered their behaviour on hot summer days. Bakuo, a sub-district at the city center, is considered especially vulnerable to heat because of sparse vegetation, high population density, poor dwelling conditions and a high proportion of low-income population. However, neighborhood social ties were stronger in Bakuo than other study locations. CONCLUSIONS: The study suggests that actions are needed now to minimize downside effects of

rapid warming in Tibet, because of increasing human exposure to high temperatures and uneven distribution of the resources needed to cope.

Comment: There must be a somewhat direct intervention, not risk factors like level of education (though strictly speaking education is an intervention). One could argue that improving education or income are a means of reducing heat-related illnesses. We can come back to these papers and extract information on risk factors like education, socio-economic status.

Example 3: The association between ambient temperature and mortality has been established worldwide, including the authors' prior study in California. Here, they examined cause-specific mortality, age, race/ethnicity, gender, and educational level to identify subgroups vulnerable to high ambient temperature. They obtained data on nine California counties from May through September of 1999-2003 from the National Climatic Data Center (countywide weather) and the California Department of Health Services (individual mortality). Using a time-stratified case-crossover approach, they obtained county-specific estimates of mortality, which were combined in meta-analyses. A total of 231,676 nonaccidental deaths were included. Each 10 degrees F (approximately 4.7 degrees C) increase in mean daily apparent temperature corresponded to a 2.6% (95% confidence interval (CI): 1.3, 3.9) increase for cardiovascular mortality, with the most significant risk found for ischemic heart disease. Elevated risks were also found for persons at least 65 years of age (2.2%, 95% CI: 0.04, 4.0), infants 1 year of age or less (4.9%, 95% CI: -1.8, 11.6), and the Black racial/ethnic group (4.9%, 95% CI: 2.0, 7.9). No differences were found by gender or educational level. To prevent the mortality associated with ambient temperature, persons with cardiovascular disease, the elderly, infants, and Blacks among others should be targeted.

Correct code: Include Sport, military, firefighters

Example 1 BACKGROUND: There seems to be a discrepancy between the available heat stress guidelines and the actual risk of heat-related illness among professional beach volleyball players competing under hot and humid conditions. OBJECTIVE: To monitor heat stress and record cases of heat-related medical forfeits on the Swatch FIVB Beach Volleyball World Tour. METHODS: The FIVB Heat Stress Monitoring Protocol covered events on the FIVB Beach Volleyball World Tour and FIVB Beach Volleyball World Championships during the 2009, 2010 and 2011 seasons (51 events, most of these double gender). The protocol consisted of (1) measuring the Wet Bulb Globe Temperature (WBGT) on centre court prior to the start of every match, and (2) recording any heat-related medical forfeits during the tournament. RESULTS: Data were collected during 48 of 51 events. There were nine events where the peak WBGT exceeded the US Navy Black flag conditions of >32.3 degrees C and an additional two events where the peak WBGT exceeded 31 degrees C, (meeting Red flag conditions.) In two events, the average WBGT equalled at least 31 degrees C. One case of a medical forfeit related to heat stress was recorded over the 3-year surveillance period: an athlete whose fluid balance was compromised from a 3-day bout of acute gastroenteritis. CONCLUSION: The incidence of significant heat illness among athletes competing on the FIVB Beach Volleyball World Tour appears to be quite low, even though weather conditions frequently result in a WBGT index >32 degrees C. Currently available guidelines appear to be inadequate to fully assess the risk of heat stress and too conservative to inform safety decisions in professional beach volleyball.

Comment: They did something to prevent heat-related illness

Correct code: Include individual, household

Example 1: Two experiments were conducted to examine the influence of ambient temperature upon physical aggression. In the first, male subjects received either a positive or negative evaluation from a confederate and were then provided with an opportunity to agress against this person by means of electric shock. On the basis of previous research, it was predicted that high ambient temperatures (92-95 degrees F) would facilitate aggression by those receiving positive evaluations but actually inhibit such behavior by those receiving negative assessments. Results confirmed both of these predictions and also indicated that more moderate but still uncomfortably warm temperatures (82-85 degrees F) produced similar effects. The second experiment employed procedures similar to the first and examined the suggestion that administration of a cooling drink would reduce the impact of high

ambient temperatures upon overt aggression. This prediction, too, was confirmed. The possible mediating role of negative affect with respect to the influence of ambient temperature and other environmental factors upon aggression was discussed.

Comment: The study is in a population with heat exposure, the intervention is a drink, the outcome is level of aggression.

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