



Review article

Vulnerability to heatwaves and implications for public health interventions – A scoping review

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ABSTRACT

Background: Heatwaves form a serious public health threat, especially for vulnerable groups. Interventions such as active outreach programs, exposure reduction measures and monitoring and mapping of at-risk groups are increasingly implemented across the world but little is known about their effect.

Objectives: To assess how vulnerable groups are identified and reached in heat health interventions, to understand the effectiveness and efficiency of those interventions, and to identify research gaps in existing literature.

Methods: We performed a literature search in relevant scientific literature databases and searched with a four element search model for articles published from 1995 onward. We extracted data on intervention measures, target group and evaluation of effectiveness and efficiency.

Results: We identified 23 eligible studies. Patterns exist in type of interventions 1) to detect and 2) to influence extrinsic and intrinsic risk and protective factors. Results showed several intervention barriers related to the variety and intersection of these factors, as well as the self-perception of vulnerable groups, and misconceptions and unfavorable attitudes towards intervention benefits. While modest indications for the evidence on the effectiveness of interventions were found, efficiency remains unclear.

Discussion: Interventions entailed logical combinations of measures, subsumed as packages. Evidence for effective and efficient intervention is limited by the difficulty to determine effects and because single measures are mutually dependent. Interventions prioritized promoting behavioral change and were based on behavioral assumptions that remain untested and mechanisms not worked out explicitly.

Conclusions: Multifaceted efforts are needed to tailor interventions, compiled in heat health warning systems and action plans for exposure reduction and protection of vulnerable populations, to fit the social, economic and geographical context. Besides adequately addressing relevant risk and protective factors, the challenge is to integrate perspectives of vulnerable groups. Future research should focus on intervention barriers and improving the methods of effectiveness and efficiency evaluation.

1. Introduction

Climate change induced natural hazards such as extreme heat events have adverse health effects especially in vulnerable groups (Dukes-Dobos, 1981; Parsons, 2014). The impacts of heatwaves on human health are widely documented especially the correlation of heat and mortality and morbidity (Kovats and Hajat, 2008; Sheridan et al., 2009). During the 1995 heatwave in central United States of America

(USA) more than 1000 people lost their lives, with Chicago being particularly affected (Klinenberg, 2015; Palecki et al., 2001). The heatwave that occurred in Western Europe in 2003 resulted in over 71,000 excess deaths (Robine et al., 2008). Heatwaves are increasingly considered as a serious public health threat globally, especially for vulnerable groups (Bassil and Cole, 2010).

Health vulnerability to heatwaves is distributed unequally across and within societies. Especially the elderly and chronically ill are

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identified as the most susceptible subgroups at risk (Åström et al., 2015). Risks are classified as intrinsic and extrinsic in nature and linked to environmental and social factors. Protective factors identified are social independence, social support, education and community safety, and a working air conditioning (AC) (Bouchama et al., 2007; Williams et al., 2013). One study revealed that strong bonding networks can potentially exacerbate rather than reduce vulnerability of elderly people (Wolf et al., 2010b). The highest risk of death during a heatwave was associated with being confined to bed, not leaving home daily and being unable to care for oneself (Bouchama et al., 2007). In terms of pre-existing medical conditions, psychiatric illness was the factor most strongly associated with death, followed by cardiovascular illness and pulmonary illness (Bouchama et al., 2007). Similarly another study found that those between 65 and 74 who had a history of chronic pulmonary disease or suffered from a psychiatric disorder were particularly at risk, while for persons over 75 years factors such as living in a single household and being a women were most relevant (Wong et al., 2012). Dysfunctional thermoregulatory mechanisms, chronic dehydration, medications and diseases involving the systems that regulate body temperature are further identified risk factors which render elderly and multi-morbid patients such as diabetics more vulnerable to heat (Worfolk, 2000; Yardley et al., 2013a, 2013b). Other studies also looked at heatwave vulnerability in nursing and residential homes and criticize the lack of effective heat management which make people in need of care more vulnerable (Brown and Walker, 2008; Gupta et al., 2017; Rest and Hirsch, 2015; Skinner et al., 2009). Children due to their higher physiological sensitivity as well as outdoor workers due to their extensive physical exposure are routinely identified as more vulnerable (Bethel and Harger, 2014; Lucas et al., 2014; Vanos, 2015; Xu et al., 2012). For farmworkers and construction workers this may be coupled with low salaries and unfavorable living conditions (Al-Sayyad and Hamadeh, 2014; Chan et al., 2011, 2013) and more resources are demanded to protect them (Dutta et al., 2015). Homelessness and being a homeless veteran were also identified as risk factors (Nicolay et al., 2016) as well as belonging to a cultural and linguistic minority group (Hansen et al., 2013, 2014). Also behavioral factors, awareness and attitudes towards heatwaves were identified as protective or risk factors (Abrahamson et al., 2009; Akompab et al., 2013; Lane et al., 2014; Strengers and Maller, 2011; Wanka et al., 2014) as well as social and cultural understandings of comfort and vulnerability (Maller and Strengers, 2011). Some studies also conceptualize vulnerability to heatwaves more broadly in terms of social inequality and deprivation. Accordingly risk is identified as an intersection of poor health, social marginalization and built environmental impediments (Prudent et al., 2016; Werg et al., 2013).

Vulnerability to heatwaves is increasingly exacerbated through the Urban Heat Islands (UHI) phenomenon caused by a reduction in latent heat flux and an increase in sensible heat in urban areas as vegetated and evaporating soil surfaces are replaced by relatively impervious low albedo paving and building materials (Imhoff et al., 2010). At the same time there is a growing aging urban population and climate models projecting future heatwaves to become more intense, more frequent and longer lasting in the near future (Meehl and Tebaldi, 2004). The measurable severity of adverse health effects may depend on methodological challenges and data insecurities, as well as the timing of a heatwave, with amplified effects on first seasonal heatwaves (Liss et al., 2017; Xu et al., 2016). The prevention of deaths and mortalities caused by excessive heat events is of public health concern. Interventions, programs and heat health warning systems are increasingly implemented across different countries (Kovats and Hajat, 2008). Today, little is known about their effects as well as the degree to which risk and protective factors (or vulnerability factors) described earlier are addressed by interventions, programs and systems across geographies, and on whose behalf.

This scoping review aims to assess who is targeted by interventions and investigate the effectiveness and efficiency of public health

interventions aimed at reducing heatwaves' health impact.

2. Materials and methods

A scoping review is particularly suitable for the broad topic of interventions to reduce health vulnerability to heatwaves and their effectiveness. The review is based on the framework by Arksey and O'Malley (2005) and allows for the inclusion of studies with different methodological designs and from varied disciplines. According to the five stages, research questions were identified, relevant studies were located and selected, the data was charted and collated and results were reported (Arksey and O'Malley, 2005). We included methodological advancements to clarify the applied concepts in the research question and redefine search terms (Daudt et al., 2013; Levac et al., 2010).

We performed a literature search in PubMed, Web of Science, Scopus, ScienceDirect, Psychinfo and Embase in February and March 2017 to identify relevant studies. The search model had four elements: 1) approaches, interventions and programs, 2) adverse health effects, 3) heatwaves, and 4) vulnerable populations, adjusting search strings and MeSH terms. Search strings for the first element were composed of keywords used in Bassil and Cole (2010) and further complemented to reach all relevant studies on interventions. A detailed overview including the applied filters (publication date 1995–2017) is provided in Table 1.

The search generated 1598 potentially relevant studies. The studies were imported into an EndNote library and retrieved items were deduplicated (Bramer et al., 2016). This resulted in 784 studies for screening. EM first screened the title and abstract of these studies and excluded a total of 698 studies. Then, the full text of the eligible 86 articles was examined, resulting in 23 articles. Five co-authors (AA, BA, MD, PW and RK) double-checked the 86 articles for final inclusion, an 82% median agreement (range: 75–86%) was reached. Mismatched articles were subject to a case by case discussion until a joint decision was reached. For the study selection process see flow diagram in Fig. 1. During the double-check procedure the research questions were further refined and inclusion and exclusion criteria finalized (Levac et al., 2010).

2.1. Inclusion and exclusion criteria

Studies were *included* when they analyzed public health interventions to counter adverse health effects of heatwaves in vulnerable populations, and when they analyzed the effectiveness or efficiency of these interventions. Studies were *excluded* when interventions were not linked to health outcomes (e.g. studies on mitigation measures in urban designs, personal coping behavior, and functional cooling wear) and when full text was not available or when studies were published in a language other than English or German.

Due to the limited number of relevant studies and the scoping review approach, no quality assessment criteria (in terms of stronger or weaker methodologies) was enforced.

2.2. Charting the data and reporting the results

The details of studies included in the review are presented in tables. Each publication was first categorized based on the year, location(s) of the intervention and the type of research approach (see Table 2). From each study we extracted data relating to the type of intervention, the specificities it entailed, the target group and the main results of the study; the charted data is included in the appendix Table 3. Data on evaluation of effectiveness and efficiency was also extracted and presented (see separate charts in appendix Table 4 and Table 5). Four co-authors (AA, MD, PW and RK) cross-checked all tables and extracted data for completeness.

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