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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 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 ; Yardley *et al*., 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 ; Chan *et al*., 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 ; Hansen *et al*., 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.

[TABLE 1]

The search generated 1598 potentially relevant studies. The studies were imported into an EndNote library and retrieved items were de-duplicated (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).

[FIGURE 1]

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 specifities 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.

[TABLE 2]

3. RESULTS

3.1. Profile of studies

The majority of studies were carried out in the United States (US) or Western Europe. The 23 included studies consisted of eight reviews comparing different heat health warning systems and interventions across countries, municipalities or cities (Grewe and Blättner, 2011; Grewe and Pfaffenberger, 2011; Kovats and Ebi, 2006; Lowe *et al*., 2011; Martinez *et al*., 2011 ; Paz *et al*., 2016). Two reviews dealt exclusively with effectiveness, thereof one structured review included and analyzed 14 studies (Bassil and Cole, 2010) and one systematic literature search included and analyzed 15 studies (Toloo et al., 2013). Five studies were included in both effectiveness reviews (see Table 5). Six studies classified as description studies (Knowlton *et al*., 2014; Kosatsky *et al*., 2005; Martin, 2016; Michelozzi *et al*., 2010; Price *et al*., 2013 ; Riley *et al*., 2012) and three survey studies (Berisha *et al*., 2017; Kunst and Britstra, 2013 ; O'Neill *et al*., 2010) met the inclusion criteria. Six studies used a qualitative or mixed methods design (Boeckmann, 2016; Bolitho and Miller, 2016; Mees *et al*., 2015; Paterson *et al*., 2012; Van Loenhout *et al*., 2016 ; White-Newsome *et al*., 2014).

The darker the country in Fig. 2 the more studies reported on interventions in the country, scaled up from local region, or city. None of the included studies reported on countries that appear in light grey.

[FIGURE 2]

3.2. VULNERABILITY: TARGET GROUPS AND RISK AND PROTECTIVE FACTORS

3.2.1. Vulnerable populations

Public health interventions target different groups in specific locations and address intrinsic as well as extrinsic risk factors. We found interventions implemented on different levels (federal level, state government level, city level, local level) (Bolitho and Miller, 2016; Knowlton *et al*., 2014; Kosatsky *et al*., 2005; Martin, 2016; Mees *et al*., 2015; Michelozzi *et al*., 2010; Paz *et al*., 2016; Price *et al*., 2013 ; White-Newsome *et al*., 2014) and aiming to reach whole populations or only particular vulnerable groups.

All studies mention age as a major significant intrinsic risk factor to be considered in interventions, due to impaired physiological and behavioral responses to heat (Grewe and Blättner, 2011). Warnings also address individuals with impaired medical status, such as persons suffering from a chronic disease and using specific medication or individuals who are obese or unfit, people with a disability, persons who suffer from mental illnesses or substance abusers (Lowe *et al*., 2011 ; Martin, 2016). Additionally “people in need of, or dependent on care”, those who are confined to bed and/or “institutionalized people” as well as their care takers are targeted by interventions (Mees et al., 2015). Risk in institutionalized people is explained by a combination of exposure and susceptibility and limited ability to influence thermal comfort (Grewe and Pfaffenberger, 2011). Young children are also listed, both

vulnerable because of weaker thermoregulation and potential higher outdoor exposure (Boeckmann, 2016 ; Van Loenhout *et al*., 2016), however, we did not encounter studies on interventions specifically targeting children's' care takers, guardians, or teachers. Some studies considered high risk working and living conditions and individuals who perform heavy physical exercise, outdoor seasonal or constructional workers (Riley et al., 2012), municipal police officers or rickshaw drivers (Knowlton et al., 2014). Interventions also specifically target people living in informal settlements, slums (Knowlton et al., 2014), top floor apartments, in high-rise buildings or in row homes (White-Newsome et al., 2014). In some cases interventions tackled social aspects of neighborhood, social networks and notions of security (O'Neill *et al*., 2010 ; Paz *et al*., 2016). In two studies homelessness was, for instance, identified as a highly influential extrinsic risk factor (Martin, 2016 ; Paterson *et al*., 2012). Other studies report on interventions targeting specific ethnic communities or especially diverse populations (White-Newsome et al., 2014), or defined vulnerability according to multiple criteria: homeless, under-housed, and frail, isolated, seniority, as well as being member of an aboriginal community (Kosatsky *et al*., 2005 ; Kovats and Ebi, 2006). Considering protective factors, studies mention those without access or capability to run an AC as targeted by interventions (Berisha et al., 2017).

3.2.2. Detection of risk and protective factors

Interventions and measures were divided into two types: those to detect and those to influence risk and protective factors. **Interventions to detect risk and protective factors** include meteorological forecasting, temperature monitoring, developing a robust understanding of the cause-and-effect relationships between thermal environment and health outcomes at population level and any form of surveillance systems (i.e. real-time surveillance of mortality and morbidity, syndromic surveillance of heat related hospital visits during extreme heat alerts) (Kovats and Ebi, 2006; Lowe *et al*., 2011 ; White-Newsome *et al*., 2014). Heat monitoring interventions constitute an integral part of every heat health warning system described in the studies. This is to detect what constitutes impeding dangerous hot weather in a specific area and translating it into forecasts and warnings. Additionally we found mapping of vulnerable people and passive and active outreach programs were frequent interventions and measures to detect risk and protective factors (Lowe et al., 2011).

Several cities, such as Paris, France, and Kassel, Germany, installed voluntary registration systems where vulnerable citizens can register themselves (Mees et al., 2015). In Rome and other Italian cities, a registration system operates through records of hospital admissions and general practitioners (GPs), and social workers. Some run a registration of susceptible individuals that uses population registries and other data for identification in the population aged 65 and over (Michelozzi et al., 2010). In Toronto, Canada public health authorities use an advanced modelling tool relying on extensive lists of indicators for exposure, sensitivity and adaptive capacity (Mees *et al*., 2015 ; Paterson *et al*., 2012). In Montreal, Canada, local health departments identify vulnerable individuals. This is combined with a door-to-door campaign to identify people suffering from heat and in need of assistance, performed

by municipal partners (Price et al., 2013). Hospitals, nursing homes, GPs and medical staff target registered at-risk subgroups also in preventive activities as well as active surveillance interventions (Michelozzi et al., 2010). Active surveillance of high and very high risk patients in Italy is, for instance, operated through a dedicated telephone line that triggers a network of health and social services in case of an emergency. GPs can actively monitor patients through telephone calls and home visits, modulation in pharmacological treatment, home-based treatments, and special attention towards at-risk patients discharged from hospital, when necessary (Michelozzi et al., 2010). Country comparison reviews describe home outreach visits or phone calls to vulnerable persons (by GPs, social workers or volunteers), evacuation of vulnerable persons from their homes to cooling centers as well as outreach to homeless persons as common interventions incorporated into heat health warning systems (Kovats and Ebi, 2006 ; Lowe *et al*., 2011). In highly affected US cities outreach programs were adopted in which service providers reach out and visit specific sites and provide direct assistance (White-Newsome et al., 2014). Detroit Homeland Security and Emergency Medics i.e. created a list of people who cannot be moved for heat; similarly in New York City (NYC) a list with most vulnerable clients is regularly updated (White-Newsome et al., 2014). A partnership with the US Postal Service Carrier Alert program exists in NYC and if a person does not pick up mail in three or four days the nearby community based organization is sent to see if the person is well (White-Newsome et al., 2014). Furthermore, the "Notify NYC" program and a partnership with the union of doormen were established (White-Newsome et al., 2014) to reach potentially vulnerable people who might not be visible as they may not leave their flats. In Philadelphia home-based outreach is targeted to residents who receive assistance from agencies and NGOs and in Phoenix contact is established through i.e. assisted living facilities and group homes (White-Newsome et al., 2014). Philadelphia is a prominent example as it also works with a buddy system, consisting of community volunteers who actively keep an eye on and pay visits to vulnerable citizens and nursing teams paying home visits following calls from the heat-line (Mees et al., 2015). In Japan heat protection information is directly provided to private citizens that have voluntarily registered in the warning distribution list (Martinez et al., 2011). Specific outreach activities such as regular home visits (yogurt and newspaper delivery, trash pick-ups) for elderly during hot spells and distribution of how-to-keep-cool-indoors advice are organized through volunteer networks such as the "Minsei committees" (Boeckmann, 2016 ; Martinez *et al*., 2011). In the heat action plan for Ahmedabad, India, vulnerable residents are identified and reached by location, i.e. implementing water tankers in urban slum dwellings or installing electronic temperature displays (Knowlton et al., 2014). Efforts to map vulnerable people as well as map weak spots in inter-organizational capacity through an overview of housing locations and facilities frequently go hand in hand with active outreach activities through established social service networks, or registered people or the general health care systems.

3.2.3. Influencing risk and protective factors

The review also points at interventions and measures to **influence risk factors** (including exposure) **and protective factors** (including behavior), which aimed for instance at heat exposure reduction. They entailed the allocation and dissemination

of instruments and tools that aid individual cooling of living environment or the body. There are fan and AC distribution programs, subsidy schemes for AC purchase costs and electricity cease disconnection for non-payment (Grewe and Pfaffenberger, 2011; Kovats and Ebi, 2006; Martin, 2016; Mees *et al*., 2015 ; White-Newsome *et al*., 2014). Other measures to reduce heat exposure were protective measures for occupationally highly exposed workers. We encountered exposure reduction interventions and measures that related to the establishment, access and use of cooling centers. Especially in the US, several studies considered moving vulnerable people to cooling centers, either from the street or evacuating them from their homes (Kosatsky *et al*., 2005; Lowe *et al*., 2011 ; White-Newsome *et al*., 2014). Authors also studied the setting up of cooling centers during heatwaves in cities. Thereto related, some studies reported about provisions to extend opening hours of public AC places and swimming pools, so people had the opportunity to increase time spent in cooler spaces. Specific awareness raising interventions among patients and health care providers also constituted an intervention to influence risk and protective factors. Examples include alerts to hospital emergency rooms and ambulance service and activation of emergency protocols in care, often applied in retirement homes and hospital settings (Grewe and Pfaffenberger, 2011; Kovats and Ebi, 2006; Lowe *et al*., 2011; Martin, 2016 ; O'Neill *et al*., 2010). In terms of health services, the urgency of involvement of institutions and civil society is emphasized – with sufficient resources, capacity, knowledge and specific interventions, including alerts to hospital emergency rooms, ambulance services and activation of emergency protocols in care and retirement homes and hospitals (Kovats and Ebi, 2006). In France, for instance, municipalities and public health services are explicitly instructed to safeguard and monitor medical and nursing care during heatwaves (Grewe and Pfaffenberger, 2011). Also the provision of cool rooms in care institutions and hospitals is a measure to influence heat health vulnerability. Other measures such as informing and training GPs and health care providers in hospitals, elderly care and nursing homes and those in home-care was mentioned to decrease the impact of heatwaves on health. In a concrete institutional care context, it is highlighted that self-initiated seeking of cooler locations may be challenging for persons in need of care with limited mobility or cognitive impairment. Care-takers and treating physicians are seen as logical actors to identify and target individuals who may be at risk during heat periods by choosing measures reducing exposure, such as “situational” nursing and medical measures (Grewe and Pfaffenberger, 2011). The national heat plan for The Netherlands also provides specific cooling measures to be implemented for residents of institutions both at the institutional and the individual level (Kunst and Britstra, 2013). In a study reporting about Canadian city programs to protect public health from the effect of summertime heat, local health centers targeted their vulnerable elderly clients requiring follow-up during heatwaves based on the identification of factors such as dehydration, medications, social isolation and lack of access to a nearby cooling room (Kosatsky et al., 2005).

Lastly, interventions and measures were identified that aimed at informing and instructing people about what they can do themselves to be protected from heat (Boeckmann, 2016). This occurred via media and government communication as well as dissemination of heat advice and cooling centers through leaflets, pamphlets and telephone heat-lines. Promotion of risk management typically points to the

importance of hydration, avoidance of heat exposure and seeking cool places, often accompanied by the recommendation to check upon vulnerable friends and family members (Knowlton et al., 2014). Informing and instructing people also included education and awareness programs though health promoters and peer trainers as it was carried out in California, reaching largely low-wage immigrant, non-union workforces (Riley et al., 2012). Awareness raising and educational campaigns are particularly linked to influencing behavior. Behavioral change advice is of high priority in public health interventions to reduce health vulnerability against heatwaves (Boeckmann, 2016). The emphasis on prevention of heatwave related health impacts is found in several studies:

"Heat stress may be preventable through early warning systems and response plans, meant to trigger behavior of citizens, such as shading windows, drinking water and seeking cooler places" (Mees et al., 2015*)*

While some studies specify characteristics and identification of at-risk groups or individuals quite in detail, other studies report little about the implementation of target-group directed interventions and how they identify and reach out to vulnerable groups (Paz et al., 2016). In general, the studies contain information on multiple interventions to detect and influence risk and protective factors. Interventions are not analyzed or measured separately.

3.3. EFFECTIVENESS AND EFFICIENCY OF INTERVENTIONS

The majority of studies criticize the lack of strong evidence of effectiveness of interventions and intervention packages such as heat health warning systems. Several studies highlight that evaluations on the effectiveness in reducing heatwave mortality and morbidity, predicting heatwaves, notifying vulnerable populations, and adoption of adaptation advice (associated with communications) are urgently required to inform good practices (Lowe *et al*., 2011 ; Mees *et al*., 2015). Other studies state that a standardized and evidence based best practice for evaluating programs and action plans is urgently required (Michelozzi *et al*., 2010; Paterson *et al*., 2012 ; Paz *et al*., 2016). Studies reported that heat health warning systems are extremely difficult to evaluate while there is a lack of published information on formal assessments of the effectiveness of the system as a whole or of individual intervention measures (Kovats and Ebi, 2006 ; O'Neill *et al*., 2010). In order to be able to evaluate a system, the components and operation have to be known as well as resources used to operate the system (Kovats and Ebi, 2006). Recommendations for additional evaluation criteria are simplicity, acceptability, sensitivity, timeliness, effectiveness of individual response measures and specificity (Kovats and Ebi, 2006). There is also the aspect of implementation linked to effectiveness analyzed in some studies. Implementation barriers were related to shortage of and expertise among personnel (negligence, lack of knowledge), as well as lack of awareness by residents, and the need to respect residents' independence (Kunst and Britstra, 2013). For the study on the educational campaign activities in California it was reported that the socio-political and economic context presented obstacles to the effectiveness of the heat standard and to education as a successful implementation strategy (Riley et

al., 2012). For detailed information on evaluation of effectiveness see Table 4: Evaluation of effectiveness included in the appendix.

Two reviews that were included in this scoping review precisely scrutinized studies which evaluated the effectiveness of public health interventions and heat health warning systems (Bassil and Cole, 2010 ; Toloo *et al*., 2013). Both reviews differentiate between effectiveness in reducing adverse health outcomes and effectiveness in alerting human response and build the core result part of this chapter, for charted details see Table 5: reviews on effectiveness in the appendix.

We did not detect studies that evaluated the efficiency of public health interventions to reduce the health impact of heatwaves.

3.3.1. Effectiveness in reducing negative health outcomes

Studies typically measured effectiveness in reducing heat-related morbidity and mortality through comparing time periods with and without heat health warning systems or response plans in place (Bassil and Cole, 2010 ; Toloo *et al*., 2013).

Toloo et al. (2013) reviewed studies on effectiveness and included six studies showing that substantially less people died after the implementation of a heat health warning system and one study being inconclusive. Yet, none of the studies were able to establish a causal relationship between the implementation of a system and reduced mortality. All reviewed studies acknowledged other factors that contributed to the reduction in expected mortality, such as overall improvements in health care, better living conditions including use of AC, heightened heat awareness, and the use of insulating building materials.

Bassil and Cole (2010), pointed to a Czech study which reported a decrease in mortality during the 2003 heatwave compared to earlier years. The authors, however, mention that it may be attributed to a greater public awareness of heat warnings (Kyselý and Kříž, 2008). An often quoted prominent study by Fouillet et al. (2008) supported the effectiveness of heat warnings, finding fewer heat-related mortalities in 2006 after a heat health warning system and its affiliated interventions were implemented. Beyond the factors mentioned above, improvements in public health response, the characteristics of a heatwave, and the upgrading and better performance of the electrical supply were attributed to a respective decreased mortality in studies (Bassil and Cole, 2010). Another example is a study from St. Louis, Missouri, which compared mortality in the 1980 and 1995 heatwave. It reports higher mortality rates in 1980, however, a simulated model suggested that the population was more vulnerable in 1995 despite an increase in AC availability and improved public health response (Smoyer, 1998). This was attributed to an increase in the “frail elderly” population over 74, rising poverty rates among the general population as well as increased number of persons over 65 years (Bassil and Cole, 2010).

A preliminary evaluation carried out in Italy in 2008 suggested that a reduction in the impact of heat on mortality had occurred since the introduction of a heat health warning system and prevention program (Michelozzi et al., 2010). However, the

potential effectiveness of individual interventions that were included in the heat prevention plans were still not formally evaluated. With reference to other studies, the authors emphasize that alternative explanations cannot be disregarded and more has to be done to improve evaluations (Michelozzi et al., 2010).

In the 2013 review, no study could be detected to measure the potential benefit of a warning system in terms of heat-related morbidity. Considering different ways of measuring, one US study looked at the dispatch of emergency medical services (used as proxy indicator for morbidity), which was reduced by 49–73% on heatwave days in 1999 with an alert system in place compared to 1995 without a system in place (Weisskopf et al., 2002). An increasing number of studies measured the number of emergency hospital admissions or calls to ambulances during heatwaves that often are reported to have increased (Toloo et al., 2013). However, there are differences between fatal and non-fatal admissions and related causes for admissions and the effectiveness of heat health warning systems in reducing morbidity requires further research (Toloo et al., 2013).

Both effectiveness-reviews included the same single study measuring the cost-effectiveness, namely a study which measured the cost-benefits of implementing the hot weather-health watch warning system in Philadelphia, Pennsylvania (Ebi et al., 2004). It concluded that for similar hot days with or without a warning issued during the 1995–1998 period, the excess mortality was reduced by an average of 2.6 lives per day, when a warning was issued. Access mortality was calculated as the difference between observed number of deaths and the underlying trend estimated from prior years. Accordingly, 117 lives were saved over three years for the age group of 65 and over, thereby using an adjusted figure of $4 million based on the Environmental Protection Agency's value of statistical life for this age group. In total, the saved lives would have valued $468 million in contrast to the cost of running the system of $210,000 over the same period (Ebi et al., 2004). It is noted that cost-effectiveness may only partially reflect the full *value* of a life lost, excluding intangible components such as the intrinsic value of a person to their family or community (Bassil and Cole, 2010). Kunst and Britstra (2013) recommend in their study that further research should assess the cost-effectiveness of measures aimed at preventing heat-related morbidity and mortality.

Bassil and Cole (2010) contrasted intervention efforts with meteorological factors or reduced susceptibility of the population and concluded that it remained unclear to what extent the mortality and morbidity reduction could be attributed to the intervention. Toloo et al. (2013) also pointed to the evidence of a harvesting effect, especially when several heatwaves occur in one season and discuss the analytical techniques used in the studies comparing the observed and expected mortality or use of emergency medical services between two heat periods (Toloo et al., 2013). Beyond that, the issue of different ranges of various responses and interventions is noted:

"… associating the reduction in mortality (or morbidity) to the effectiveness of HWS (ref. heat warning system) also incorporates the effectiveness of these response programs. Since the type, extent of availability and utilization of these responses

varied from one study to another, we cannot infer which measures were more effective than others." (Toloo et al., 2013)

Additional to evaluations of effectiveness in reducing mortality and/or morbidity, studies reported internal data collection to further continuously improve heat health warning systems and interventions. For instance, in Philadelphia, Pennsylvania, and Phoenix, Arizona, surveillance of heat-related deaths, emergency dispatches, hospitalizations and hospital discharges during extreme heat events were used to inform future preparedness plans and in Phoenix longitudinal data collection was carried out (White-Newsome et al., 2014). The effectiveness of the heat stroke prevention plan in Japan is monitored through publications of morbidity and mortality data in three out of five provinces, as well as through process indicators (3/5), including ambulance calls and number of service registrants (Martinez et al., 2011). Yet, no formal monitoring and evaluation in terms of outcome or process is carried out.

3.3.2. Effectiveness in alerting human response

Studies defining effectiveness in terms of rising public awareness or individual behavioral change measured e.g. if messages actually reached people, if they developed problem awareness, if they reported changes in individual practices or increased use of services (i.e. heat-lines called (Kalkstein, 2002), cooling centers visited, etc.). They typically rely on indirect indicators or are designed as public perception surveys.

One study found, for instance, that front-line workers (those who were involved in operating a warning system as well as those working with vulnerable groups) felt that vulnerable, elderly and socially isolated persons were often not aware of a heat alert being declared (Angus, 2006). Challenges in risk communication and behavior change are also noted in another study, as i.e. public messaging and education for those who are most vulnerable might not reach them as those are isolated and lack strong social networks (Martin, 2016). Furthermore, when considering that the Montreal study showed that from 21 reported heat-related community deaths of people with mental illnesses, of which many lived alone, 14 were contacted 24 h prior to their death by health care professionals, family members, neighbors and friends (Price et al., 2013) the question arises if active telephone outreach is effective for vulnerable groups.

A postal survey conducted in Portugal after the 2003 heatwave suggested that knowledge of the heat warning was nearly universal (92%), however, the elderly over 75 and less-educated were less likely to heed advice (Nogueira et al., 2005). According to a French survey, awareness of heat alerts was associated with a relatively high level of change in practice and increased uptake (INPES, 2006). Respondents also reported to increasingly support vulnerable friends and family (73%), fewer elderly reported having been helped (63%) and only 14% asked for help when they felt discomfort. In Phoenix, Arizona, less than 50% of those over 65 actually reported to have changed their behavior, which means that heat advice did not necessarily translate into action (Kalkstein and Sheridan, 2007). A telephone

survey inquiring over 65 year olds across four US cities came to similar results. While the knowledge of warnings was again quite high (90%), knowledge of details was less well understood and only a few actually changed their practices in response (Sheridan, 2007). This was related to the fact that many respondents did not believe they were at-risk or that the advice applied to them. Beyond that there existed confusion about the differences in risks from ozone and heat and its precautions (Sheridan, 2007). Remarkably, a similar risk perception was found in a recent US study, where only a few elderly recognized their own risk, but identified the heat risk and medical concerns in others (Abrahamson and Raine, 2009). Toloo et al. (2013) refer partially to the same studies and carve out this element of non-susceptible self-perception which makes it less likely to adopt protective behavior (Alberini *et al*., 2011; Kalkstein and Sheridan, 2007 ; Sheridan, 2007). A qualitative study by Wolf et al. (2010a, 2010b) interviewing persons aged over 75 in the United Kingdom (UK) learns that participants did not consider themselves as old, or threatened by heat while they identify others of the same age group as vulnerable (Wolf et al., 2010a). Interestingly, in a study on heat perception in people with chronic cardiac and pulmonary disease most of the chronically ill population did perceive themselves to be susceptible to heat and reported implementing preventive actions in response (Kosatsky et al., 2009).

To sum up, studies that investigated behavior and practices suggest that those who perceived themselves to be personally vulnerable were more likely to take protective actions (Abrahamson and Raine, 2009; Alberini *et al*., 2011; Ibrahim *et al*., 2012; Kalkstein and Sheridan, 2007; Richard *et al*., 2011; Semenza *et al*., 2008; Sheridan, 2007 ; Wolf *et al*., 2010a). Thus, those potentially at risk did not necessarily consider themselves vulnerable.

Likewise were the effectiveness of cooling centers and access barriers related to perceptions of vulnerability, aspects of practicality, and an unclear understanding of benefits (Berisha et al., 2017). According to Smoyer (1997), many elderly were not taking advantages of cooling centers because “they are only for really poor people” (Smoyer, 1997). In another study similar issues around stigma in using a cooling center were brought up, “it is only for seniors or homeless individuals” (White-Newsome et al., 2014). Residents of Baltimore, Maryland, related that they “did not like the idea of going to a cooling center during the day and getting comfortable only to return home where they do not have AC” (Martin, 2016), a perception that is obviously linked to a lack of understanding of the overall benefits of cooling centers. Considering that 78% of cooling center visitors in another study reported to use the facilities for their primary services rather than to seek refuge from heat (or because they perceived themselves to be at-risk), a focus on upgrading existing social service provision and to better inform potential users appears sensible.

Analyzing the effectiveness of the National Heatwave Plan in the UK, health care providers and staff of regional public health units, social care inspectors and primary care trusts expressed concern over whether information actually reached vulnerable people (Johnson and Bickler, 2007). Ibrahim et al. (2012)discovered that health care providers were aware of protective factors regarding heat exposure but were less familiar with basic principles of thermoregulation. An evaluation of the Dutch

national heat plan among long-term care institutions in Amsterdam identified barriers relating to shortage of and expertise among personnel, and residents' independence (Kunst and Britstra, 2013). These factors all play a role considering the effectiveness of interventions.

In line with existing publications, Boeckmann (2016) suggested to use indicators such as media uptake of warning messages. However, the phenomenon of message fatigue by the general public as well as the media can be a barrier during long heat periods (Martin, 2016). Behavioral advice during heatwave includes often universal tips for the general population and specific tips for at risk groups (e.g. multi-morbid elderly who take particular medications). For vulnerable groups who are in need of care professional monitoring also in term of liquid and electrolyte intake is emphasized as detrimental (Grewe and Pfaffenberger, 2011).

4. DISCUSSION

The primary objective of this review was to assess how vulnerable groups are identified and reached in heat health interventions, and to understand the effectiveness and efficiency of those interventions that are published in peer-reviewed journals.

Most public health interventions target both, the general population and vulnerable groups. Vulnerability is approached based on intrinsic and extrinsic risk factors, and it is primarily defined in terms of age. Other criteria are medical condition and dependency on care. Beyond individual criteria, circumstances such as heavy duty and outdoor occupational exposure are mentioned, which render people more vulnerable to health effects of heatwaves. Also people living in poorly isolated or ill-protective accommodations (e.g. top floors in buildings, row homes, slums) are targeted. Furthermore, public health interventions also identify deprived people in terms of socio-economic status, i.e. homeless persons and indigenous minorities. The definition of target groups and the involvement of those at risk is linked to past heatwave experiences and the analysis of mortality data.

Interventions were divided into two types, 1) interventions to **detect** and 2) interventions to **influence** risk and protective factors. The former include: monitoring systems, exposure modelling, mapping of vulnerable people and local inter-organizational capacity as well as outreach programs; the latter include: heat exposure reduction measures which also entails awareness raising and educating patients as well as health care providers about protective heat behavior. Behavioral change advice is given high priority in public health interventions. However, studies provide merely descriptions on heat advice ("stay hydrated", "avoid heat", "check on vulnerable people in your social network") but the mechanisms of how exactly behavior can be changed and what models could be used largely remain unexplained.

In the majority of the 23 included studies we found that interventions generally entail packages - which is logical because a "learning systems" or "system resilience" approach would include a combination of "prevention, detection, mitigation and amelioration" interventions (Group *et al*., 2009 ; Thomson *et al*., 2009). Heat health

warning systems and heat action plans implement a whole set of intervention activities aiming at detecting and influencing primarily extrinsic risk factors. We found public health interventions to draw upon monitoring and mapping of vulnerable people and enhancing weak spots in local inter-organizational capacity to detect but also prevent risks. Mitigation of risk, suffering and adverse health effects is approached by interventions such as active outreach programs to vulnerable people, exposure reduction through distribution of fans, AC, etc., setting up cooling centers and evacuating people. The results show intervention barriers, such as the variety and intersection of different risk factors that renders a person being at risk, the self-perception of those at risk, and overall ideas about interventions, e.g. cooling centers and how they are perceived as beneficial or not.

The research on effectiveness of public health interventions to reduce the potential influence of heatwaves on health is valuable but modesty is appropriate. The majority of studies criticized the lack of strong evidence of effectiveness. At the same time, we found several studies claiming an absence of standardized and evidence based best practice for evaluating interventions and programs to counter heat health effects (White-Newsome et al., 2014). Effectiveness was either measured as reduced mortality and morbidity or analyzed as alerting human response and an overall effectiveness of interventions was found plausible (Bassil and Cole, 2010 ; Toloo *et al*., 2013). One particular methodological challenge was to proof to what extent the reduction in mortality and morbidity could be attributed to the particular intervention.

Many interventions were aimed at encouraging behavioral change. Eventually, their effectiveness is likely to depend on the motivation (awareness of own vulnerability, intention to adhere), capability (physical and mental conditions, literacy, skills and knowledge) and opportunity (actual access to services and proposed solutions, financial means to make investment) of people (Michie et al., 2011). Such behavioral factors are not worked out in detail in any of the included studies and remain unspecified. Interventions that included education and awareness measures were frequently deployed and linked to influencing behavior. Adequate behavioral advice is, however, complex because it has to match people's risk- and self-perception and experience, which remains under-researched (Singer et al., 2016).

Based on the included studies we identified the most common linear assumptions about behavior. First, that informing people about the danger of heat and particular risks will actually make them aware and adapt their behavior according to advice. Second, at-risk individuals recognize their own vulnerability and therefore will feel concerned by heat alerts and heat messaging. Third, benefits of visiting cooling centers and other heat advice behavior are commonly understood and taken seriously. Fourth, care-takers of vulnerable groups possess the (infrastructural and human resource) capacity to intensify care provision during heatwaves and are sufficiently trained in thermoregulation and possible heat reduction measures. Such assumptions may be problematic as they determine the actual effect of interventions and how vulnerable persons and groups may be reached. With effective promotion and communication of healthy behavior being a contested field of public health research (Kreslake et al., 2016) this is an important finding. In terms of usage

behavior, the case of cooling centers in Arizona was remarkable. It shows that vulnerable people did not believe high summer temperatures could put their health at risk and 78% of cooling center visitors visited the place to use primary services provided rather than to seek refuge from heat (Berisha et al., 2017). This points to the argument that existing social service facilities should be strengthened in order to reach vulnerable people and protect them from heatwave health risks. The question also arises in how far heat advice is adequate and practicable for the diverse groups of people. A study on the 1995 heatwave in Chicago found i.e. that many affected elderly did not open the window or seek cooling during night times due to security reasons (Klinenberg, 2015).

Challenges for evaluating effectiveness are, to begin with, meteorological in nature, as excessive heat events vary over time and affect populations differently, levels of acclimatization may change and alternative explanations cannot be disregarded (Bassil and Cole, 2010 ; Toloo *et al*., 2013). For instance, there is uncertainty to what extent mortality reduction can in fact be solely attributed to a heat health warning system or a particular intervention. Beyond that, an assessment of the effectiveness of intervention can be hindered by the short time frame in which systems are implemented and the limited availability of data (Bassil and Cole, 2010 ; Toloo *et al*., 2013). In order to link changes at the level of individuals to particular interventions, it is necessary to resolve methodological issues linked to measuring these changes (e.g. changes in drinking and cooling behavior or in perceived benefits, motivation and knowledge to adhere to guidelines) whilst taking into account the degree to which measures are useful in a particular context (Abrahamson *et al*., 2009 ; Martin, 2016).

Since we found little information on effectiveness, no information on efficiency and only one study on cost-effectiveness (Fouillet et al., 2008), our review can only produce limited conclusions concerning preferred interventions in different context, the output/input ratio of interventions and the effect of intervention in relation to its costs for policy- and decision making. This scoping review shows that the effectiveness of public health interventions which mostly consist of entangled packages is plausible. We found limited published evidence on evaluation of environmental health interventions against heat, one study also points to the problem of under-investment in program and policy implementation (Bassil and Cole, 2010). In order to adopt an adequate intervention to respond to the mounting health risks due to heatwaves we believe the outlined results and synthesized analysis provide an essential knowledge base to draw from. We utilized a diverse data set that allowed us to map out applied terminology, underlying (behavioral) assumptions, analyze challenges in evaluations, and contrast findings. Still, more research is required on components of effectiveness as well as particular measures within an intervention, to understand outcomes in relation to mechanisms in their particular contexts (Pawson *et al*., 2005 ; Pawson and Tilley, 1997), especially when it comes to influencing behavior of more or less vulnerable target populations (Michie et al., 2011).

Finally, we must emphasize the existence of a major research gap in terms of equity evaluations. We know very little about how fairly services are distributed among various target groups (Waters et al., 2006).

LIMITATIONS

The methodological decision to use scientific literature data bases had the implication that studies from countries with a strong scientific community and a good tradition in publishing in peer-reviewed journals were dominant in this review (see Fig. 2: World map). The authors realize that not all interventions are published in peer-reviewed journals and selected published studies are not automatically representative for all interventions that may be applied in different countries. Also, the time dimension of studies that are included in the review and social and political contexts might have changed considerably in the last twenty years.

Like in many literature reviews we cannot rule out the possibility that we missed relevant publications and potentially relevant information from research in other languages. We recommend caution in the cross-national and cross-cultural generalizability of findings from particular study contexts and point to considerations of cultural and socio-economic characteristics of societies, including health care systems and roles and possibilities of stakeholders at different levels, when planning and implementing public health interventions.

5. CONCLUSIONS

Public health interventions aim to reduce heat vulnerability through detecting and influencing risk and protective factors in the general population and in particular vulnerable groups. Interventions are mostly studied in packages that are impossible to disentangle and probably should not be disentangled because they strengthen each other. At the same time, this challenges the evaluation of effectiveness and efficiency, and as a result, as long as not resolved, leaves policymakers in a lack of clarity about the most optimal combination of measures to implement in response to heat waves. Studies find that most of the effects reported in terms of mortality and morbidity are positive but strong evidence is lacking. Considering the synthesized results from this scoping review, multifaceted action in line with the discussed interventions and measures is advisable in the context of heatwave interventions. Policymakers as well as funding institutions can use this scoping review to guide decision making. Implementation barriers must be understood within their social, political, economic and geographical context. In order to formulate guidance for policymakers we need to strengthen the evidence on interventions and understand better the components of heat health interventions and functioning of behavioral factors.

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Declarations of interest

None.

APPENDIX A. SUPPLEMENTARY MATERIAL

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TABLES

Table 1. : Databases, search models and hits.

Database	Query		Hits (incl. duplicates)	Hits (excl. duplicates)
PubMed	Search measure*[tiab] OR polic*[tiab] OR intervention*[tiab] OR plan[tiab] OR plans[tiab] OR program*[tiab] OR response[tiab] OR evaluat*[tiab] OR warning*[tiab] OR alert*[tiab] OR watch[tiab] OR "public health response"[tiab] OR prevention[tiab] OR preparedness[tiab] OR strateg*[tiab] OR "risk management"[tiab] OR "disaster management"[tiab] OR "disaster planning"[tiab] OR "emergency management"[tiab] OR "relief planning"[tiab] OR adaptation[tiab] OR adaption[tiab] OR approach*[tiab] OR "Disaster Planning"[Mesh] **AND** health[tiab] OR "heat related illness*"[tiab] OR "Heat Stress Disorder*"[tiab] OR "Heat Stress Syndrome*"[tiab] OR "Heat Cramp*"[tiab] OR heatstroke*[tiab] OR "heat strok*"[tiab] OR sunstroke*[tiab] OR "Heat Exhaustion"[tiab] OR "Heat Prostration"[tiab] OR "Heat Collapse"[tiab] OR "heat related risk*"[tiab] OR morbidity[tiab] OR mortality[tiab] OR "Heat Stress Disorders"[Mesh] **AND** "heat wave*"[tiab] OR heatwave*[tiab] OR "extreme heat*"[tiab] OR "hot temperature*"[tiab] OR "extreme heat"[Mesh] OR "hot temperature"[MeSH] OR ((hot[tiab] OR heat[tiab]) **AND** (climate[MeSH] OR Heat[MeSH])) **AND** vulnerab*[tiab] OR underserved[tiab] OR "Sensitive Population*"[tiab] OR "Disadvantaged"[tiab] OR "Underserved Population*"[tiab] OR "Underserved Patient*"[tiab] OR "Vulnerable Populations"[Mesh]	Filter: Publication date from 1995/01/01-2030/12/31Filter: NOT (animals[mh] NOT humans[mh])	188	174
Web of Science	**TOPIC:** (measure* OR polic* OR intervention* OR plan OR plans OR program* OR response OR evaluat* OR warning* OR alert* OR watch OR "public health response" OR prevention OR preparedness OR strateg* OR "risk management" OR "disaster management" OR "disaster planning" OR "emergency management" OR "relief planning" OR adaptation OR adaption OR approach*) ***AND*TOPIC:** (health OR "heat related illness*" OR "Heat Stress Disorder*" OR "Heat Stress Syndrome*" OR "Heat Cramp*" OR heatstroke* OR "heat strok*" OR sunstroke* OR "Heat Exhaustion" OR "Heat Prostration" OR "Heat Collapse" OR "heat related risk*" OR morbidity OR mortality) ***AND*TOPIC:** ("heat wave*" OR heatwave* OR "extreme heat*" OR "hot temperature*") ***AND*TOPIC:** (vulnerab* OR underserved OR "Sensitive	**Timespan:** 1995–2017. **Indexes:** SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI.	352	216

Database	Query		Hits (incl. duplicates)	Hits (excl. duplicates)
	Population*" OR "Disadvantaged" OR "Underserved Population*" OR "Underserved Patient*")			
SCOPUS	(**TITLE-ABS** (measure* OR polic* OR intervention* OR plan OR plans OR program* OR response OR evaluat* OR warning* OR alert* OR watch OR "public health response" OR prevention OR preparedness OR strateg* OR "risk management" OR "disaster management" OR "disaster planning" OR "emergency management" OR "relief planning" OR adaptation OR adaption OR approach*) OR KEY ("Disaster Planning")) **AND** (**TITLE-ABS** (health OR "heat related illness*" OR "Heat Stress Disorder*" OR "Heat Stress Syndrome*" OR "Heat Cramp*" OR heatstroke* OR "heat strok*" OR sunstroke* OR "Heat Exhaustion" OR "Heat Prostration" OR "Heat Collapse" OR "heat related risk*" OR morbidity OR mortality) OR KEY ("Heat Stress Disorders")) **AND** (**TITLE-ABS** ("heat wave*" OR heatwave* OR "extreme heat*" OR "hot temperature*") OR KEY ("extreme heat" OR "hot temperature") OR (**TITLE-ABS** (hot OR heat) **AND** KEY (climate OR heat))) **AND** (**TITLE-ABS** (vulnerab* OR underserved OR "Sensitive Population*" OR "Disadvantaged" OR "Underserved Population*" OR "Underserved Patient*") OR KEY ("Vulnerable Populations"))	AND (LIMIT-TO (PUBYEAR, 2017) *until* LIMIT-TO (PUBYEAR, 1995)) AND KEY (animals AND NOT humans)	545	250
ScienceDirect	((**TITLE**(measure* OR polic* OR intervention* OR plan OR plans OR program* OR response OR evaluat* OR warning* OR alert* OR watch OR "public health response" OR prevention OR preparedness OR strateg* OR "risk management" OR "disaster management" OR "disaster planning" OR "emergency management" OR "relief planning" OR adaptation OR adaption OR approach*) OR KEY("Disaster Planning")) **AND** (TITLE(health OR "heat related illness*" OR "Heat Stress Disorder*" OR "Heat Stress Syndrome*" OR "Heat Cramp*" OR heatstroke* OR "heat strok*" OR sunstroke* OR "Heat Exhaustion" OR "Heat Prostration" OR "Heat Collapse" OR "heat related risk*" OR morbidity OR mortality) OR KEY("Heat Stress Disorders")) **AND** (TITLE("heat wave*" OR heatwave* OR "extreme heat*" OR "hot temperature*") OR KEY("extreme heat" OR "hot temperature") OR (TITLE(hot OR heat) **AND** KEY(climate OR Heat))) **AND** (TITLE(vulnerab* OR underserved OR "Sensitive Population*" OR "Disadvantaged" OR "Underserved Population*" OR "Underserved Patient*") OR KEY("Vulnerable	pub-date > 1994	126	32

Database	Query		Hits (incl. duplicates)	Hits (excl. duplicates)
	Populations")))			
	((**ABS**(measure* OR polic* OR intervention* OR plan OR plans OR program* OR response OR evaluat* OR warning* OR alert* OR watch OR "public health response" OR prevention OR preparedness OR strateg* OR "risk management" OR "disaster management" OR "disaster planning" OR "emergency management" OR "relief planning" OR adaptation OR adaption OR approach*) OR KEY("Disaster Planning")) **AND** (ABS(health OR "heat related illness*" OR "Heat Stress Disorder*" OR "Heat Stress Syndrome*" OR "Heat Cramp*" OR heatstroke* OR "heat strok*" OR sunstroke* OR "Heat Exhaustion" OR "Heat Prostration" OR "Heat Collapse" OR "heat related risk*" OR morbidity OR mortality) OR KEY("Heat Stress Disorders")) AND (ABS("heat wave*" OR heatwave* OR "extreme heat*" OR "hot temperature*") OR KEY("extreme heat" OR "hot temperature") OR (ABS(hot OR heat) **AND** KEY(climate OR Heat))) **AND** (ABS(vulnerab* OR underserved OR "Sensitive Population*" OR "Disadvantaged" OR "Underserved Population*" OR "Underserved Patient*") OR KEY("Vulnerable Populations")))	pub-date > 1994AND NOT KEY(animals AND NOT humans)		
Psychinfo (Ovid)	(measure* or polic* or intervention* or plan or plans or program* or response or evaluat* or warning* or alert* or watch or "public health response" or prevention or preparedness or strateg* or "risk management" or "disaster management" or "disaster planning" or "emergency management" or "relief planning" or adaptation or adaption or approach*).ti,ab. or Emergency Preparedness/ **AND** (health or "heat related illness*" or "Heat Stress Disorder*" or "Heat Stress Syndrome*" or "Heat Cramp*" or heatstroke* or "heat strok*" or sunstroke* or "Heat Exhaustion" or "Heat Prostration" or "Heat Collapse" or "heat related risk*" or morbidity or mortality).ti,ab. or "Heat Effects"/ **AND** ("heat wave*" or heatwave* or "extreme heat*" or "hot temperature*").ti,ab. or ((hot or heat).ti,ab. and (exp "Climate Change"/ or "Heat Effects"/)) **AND** (vulnerab* or underserved or "Sensitive Population*" or "Disadvantaged" or "Underserved Population*" or "Underserved Patient*").ti,ab. or "At Risk Populations"/	limit to yr = "1995 - Current" AND not (Animal not Human).po.	22	13
Embase (Ovid)	(measure* or polic* or intervention* or plan or plans or program* or response or evaluat* or warning* or alert* or watch or "public health response" or prevention or	limit to yr/"1995 - Current" AND not((exp	365	99

Database	Query		Hits (incl. duplicates)	Hits (excl. duplicates)
	preparedness or strateg* or "risk management" or "disaster management" or "disaster planning" or "emergency management" or "relief planning" or adaptation or adaption or approach*).ti,ab. or disaster planning/ **AND** (health or "heat related illness*" or "Heat Stress Disorder*" or "Heat Stress Syndrome*" or "Heat Cramp*" or heatstroke* or "heat strok*" or sunstroke* or "Heat Exhaustion" or "Heat Prostration" or "Heat Collapse" or "heat related risk*" or morbidity or mortality).ti,ab. or exp heat injury/ **AND** ("heat wave*" or heatwave* or "extreme heat*" or "hot temperature*").ti,ab. or ((hot or heat).ti,ab. and (heat/ or "Climate Change"/)) **AND** (vulnerab* or underserved or "Sensitive Population*" or "Disadvantaged" or "Underserved Population*" or "Underserved Patient*").ti,ab. or "high risk population"/ or vulnerable population/	animal/or nonhuman/) not exp human/)		
			1598	**784**

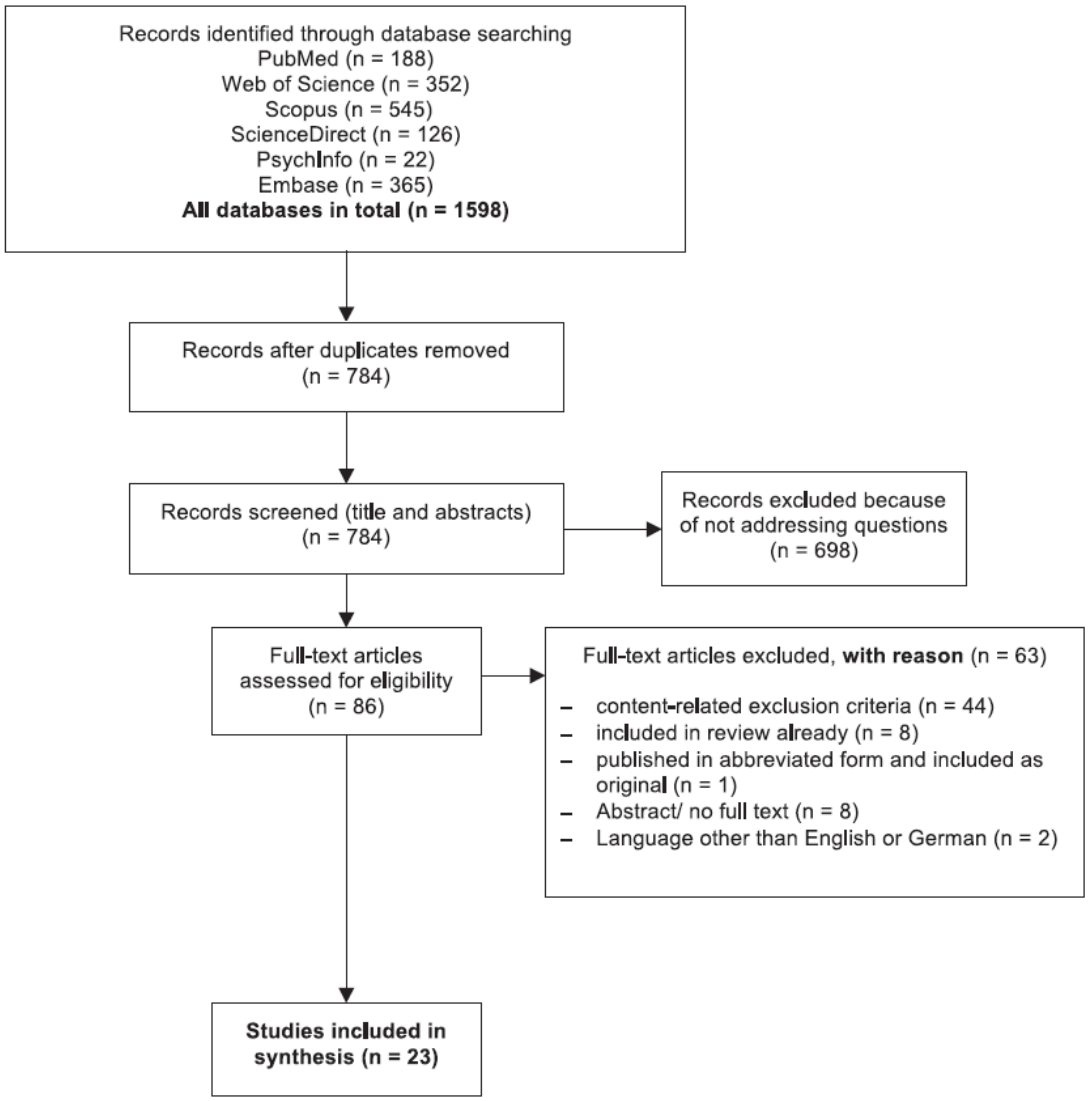

Fig. 1. Flow diagram of study selection process.

Table 2. Profile of studies.

Author	Year	Country	No	Study design
Lowe, D., K.L. Ebi and B. Forsberg	2011	Belgium, France, Germany, Hungary, Italy, Macedonia, Netherlands, Portugal, Romania, Spain, UK, Switzerland	12	Scoping review to identify and characterize heatwave early warning systems in European countries
Grewe, H.A. and B. Blättner	2011	Belgium, Denmark, England, France, Italy, Luxembourg, Netherlands, Portugal, Spain	9	Overview, description of heat health action plans
Mees, H.L.P., P.P.J. Driessen and H. A.C. Runhaar	2015	The Netherlands and ten cities: Chicago, Kassel, London, New York, Paris, Philadelphia, Rome, Stuttgart, Tatabanya, Toronto	8	Two interactive multi-stakeholder workshops in Arnhem & Rotterdam (63 participants), one focus group of elderly people in Rotterdam (14 participants), and a content analysis of relevant literature, reports, local

Author	Year	Country	No	Study design
				policy documents & internet sites;
Kovats, R.S. and K.L. Ebi	2006	Italy (city-level implementation), France (all 14 main cities), Spain, UK (UK Heatwave Plan for England and Wales), Portugal (country-wide), Germany (country-wide)	6	Report on heatwaves and public health in Europe
Paz, S., M. Negev, A. Clermont and M.S. Green	2016	5 Med-cities: Adelaide, Barcelona, Cape Town, Los Angeles, Santiago	5	Literature review and analysis, descriptive results
Van Loenhout, J.A. F., J.M. Rodriguez-Llanes and D. Guha-Sapir	2016	Belgium, The Netherlands	2	Desk evaluation of National Heatwave Plans and key informant interviews
Paterson, J.A., J.D. Ford, L.B. Ford, A. Lesnikowski, P. Berry, J. Henderson and J. Heymann	2012	Ontario, Canada	1	Qualitative interview study: 53 semi-structured interviews were conducted to identify adaptation efforts, barriers and opportunities for current and future interventions
Boeckmann, M.	2016	Japan	1	Qualitative study of local heat and climate change adaptation, explorative approach
Martinez, G.S., C. Imai and K. Masumo	2011	Municipalities: Kusatsu (Shiga), Kumagaya (Saitama), Tajimi (Gifu), Obu (Aichi), Machida (Tokyo) in Japan	1	Review, internet search and interviews
Kunst, A.E. and R. Britstra	2013	The Netherlands	1	Implementation evaluation, 27 questionnaires obtained from care managers of long-term care institutions in Amsterdam
Martin, J.L.	2016	Baltimore City, US	1	Description of Baltimore City Code Red Program
O'Neill, M.S., D.K. Jackman, M. Wyman, X. Manarolla, C.J. Gronlund, D.G. Brown, S.J. Brines, J. Schwartz and A.V. Diez-Roux	2010	285 US communities	1	Survey of 285 communities on local government programs to prevent health problems and reduce heat exposure
White-Newsome, J.L., S. McCormick, N. Sampson, M.A. Buxton, M.S. O'Neill, C.J. Gronlund, L. Catalano, K.C. Conlon and E.A. Parker	2014	Cities: Detroit, New York City, Philadelphia, Phoenix in the US	1	Qualitative interview study (73 semi-structured interviews with gov. & non-gov organization leaders rep. public health, general social services, emergency management, meteorology, and the environmental planning sectors)
Kosatsky, T., N. King and B. Henry	2005	Cities Toronto and Montreal in Canada	1	Description of predictive heat/health warning (alert) system and Hot Weather Response Plan

Author	Year	Country	No	Study design
Price, K., S. Perron and N. King	2013	Montreal in Canada	1	Implementation description
Knowlton, K., S.P. Kulkarni, G. S. Azhar, D. Mavalankar, A. Jaiswal, M. Connolly, A. Nori-Sarma, A. Rajiva, P. Dutta, B. Deol, L. Sanchez, R. Khosla, P.J. Webster, V.E. Toma, P. Sheffield and J. J. Hess	2014	Ahmedabad, Gujarat, India	1	Description of development and implementation of the heat-health action plan and the heat early warning system in Ahmedabad
Michelozzi, P., F.K. de' Donato, A.M. Bargagli, D. D'Ippoliti, M. de Sario, C. Marino, P. Schifano, G. Cappai, M. Leone, U. Kirchmayer, M. Ventura, M. di Gennaro, M. Leonardi, F. Oleari, A. de Martino and C.A. Perucci	2010	34 major cities in Italy	1	Description of the Italian National Program for the prevention of heat-health effects
Grewe, H.A. and D. Pfaffenberger	2011	Germany	1	Review (not specified)
Bolitho, A. and F. Miller	2016	Australia	1	Qualitative study: literature and policy review; analysis of available secondary data on extreme heat events and impacts and structured, key informant interviews with stakeholders
Berisha, V., D. Hondula, M. Roach, J.R. White, B. McKinney, D. Bentz, A. Mohamed, J. Uebelherr and K. Goodin	2017	Maricopa County, Arizona, US	1	Evaluation (an observational surveys at 63 facilities, a facility management survey with 52 managers, a visitor survey completed by 658 participants from 22 cooling centers)
Riley, K., L. Delp, D. Cornelio and S. Jacobs	2012	California, US	1	Description of an outreach and education approach, feedback from participants
Bassil, K.L. and D. C. Cole	2010	14 studies reviewed	15	Structured review
Toloo, G., G. FitzGerald, P. Aitken, K. Verrall and S. Tong	2013	15 studies reviewed	16	Systematic literature search

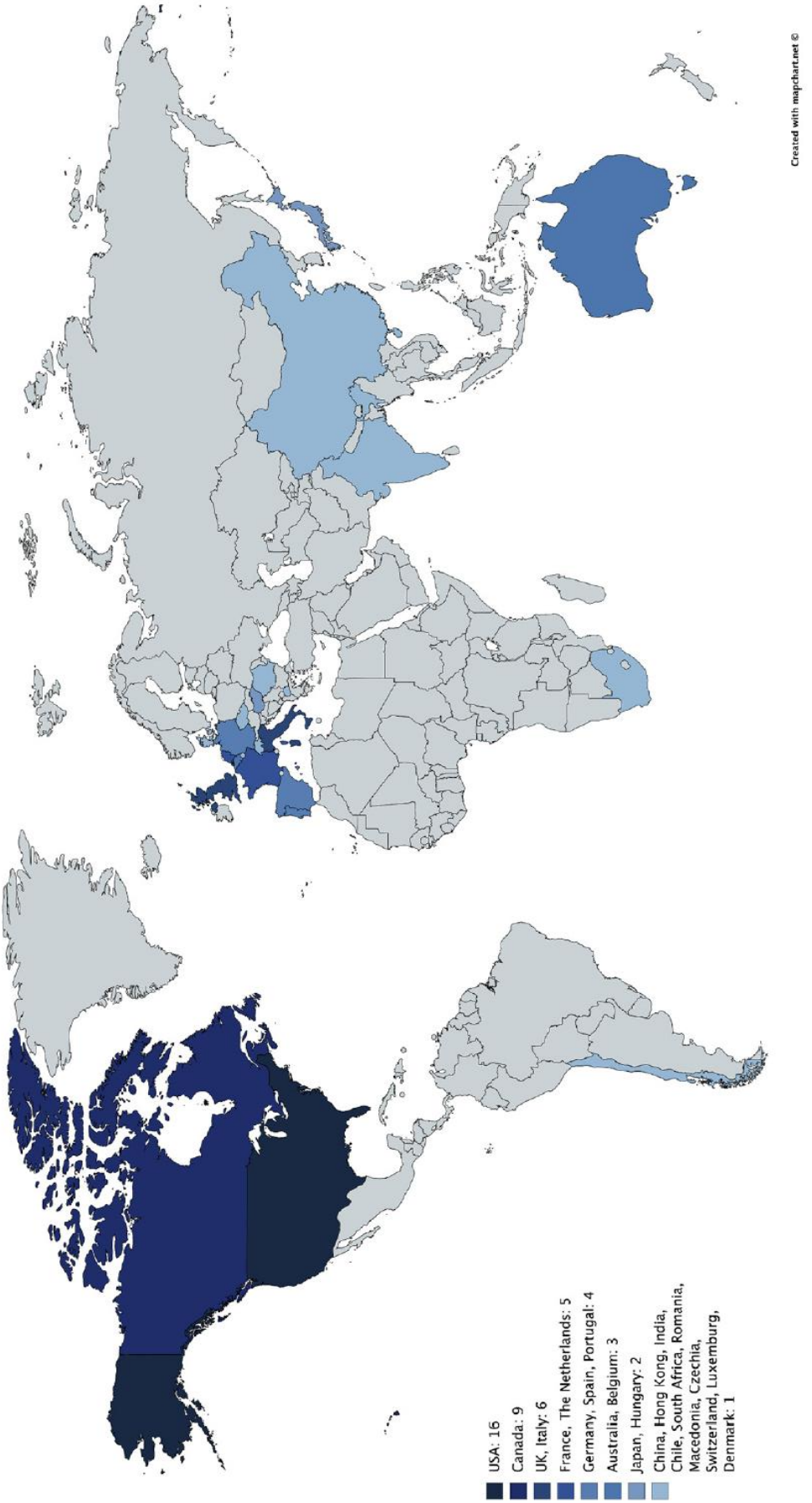

Fig. 2. World map.

Table 6: Reviews on effectiveness

Author, year	Studies included with countries	Target group	Main findings
Bassil, K. L. and D. C. Cole 2010	Abrahamson 2008: UK1; Angus 2006: Canada; Ebi et al. 2004 US; Fouillet et al. 2008: France1; INPES 2006: US; Kalkstein et al. 2007: US; Kosatsky et al. 2009: Canada1; Kysely & Kriz 2008: Czech Republic; Nogueria et al. 2005: Portugal; Palecki et al 2001: US; Sheridan 2007: US & Canada1; Smoyer 1997: US; Smoyer 1998: US1; Weisskopf et al. 2002: US Effectiveness of public health interventions in: - public awareness and individual change in practice - change in health outcomes (morbidity and mortality) (14 studies)	Population/health outcome: elderly, intervention/response staff, general public, cardiac/pulmonary patients, elderly/health care providers and mortality/morbidity assessed in different defined groups	Indicators of awareness and practice are difficult to measure e.g. received heat-line calls decreased with summer progression likely due to less media attention, less advertising and reduced need given acclimatization - vulnerable, elderly and socially isolated may be less aware than general public - public surveys: knowledge of heat warning is often universal, but e.g. elderly and less-educated were less likely to heed advice - recall of heat alerts from radio and television broadcasts may be high and associated with increasing level of change in practice, as well as increased efforts to support vulnerable friends and family (73%) (although fewer elderly reported having been helped (63%) and only 14% reported asking for help) (INPES 2006) - variation in awareness across different demographic categories, and despite nearly universal awareness of heat advisory it did not necessarily translate into action (only 50% Kalkstein et al. 2007) - perception studies may not capture important vulnerable groups like socially isolated or homeless - in over 65 year olds knowledge of details of message of mitigation plans were less well understood, few changed practice because did not believe they were vulnerable or messages applied to them, also confusion with ozone precautions - self-perception and challenge in delivering targeted strategies e.g. people with chronic cardiac and pulmonary disease did consider themselves at-risk - elderly not concerned about heat or not taking advantages of resources - concern over whether information was reaching vulnerable populations, recommendation to focus more (i.e. women over 85 years living alone) <u>Change in health outcome</u>: number of lives saved and economic benefit of warnings assessed in Philadelphia where warning lowered mortality by 2.6 lives with operational costs at noise level, but it remains challenging to assign such tangible values. - commonly comparison between different heat wave periods, challenge greater public awareness of heat-warnings - heat-related mortality rates and ambulance services, challenge may be attributable to improvements in response - heat wave may be more severe and longer, increase in AC availability and improved response, increase in "frail elderly" population, rising poverty rates, etc.
Toloo, G., G. FitzGerald, P. Aitken, K. Verrall and S. Tong 2013	Chau et al. 2009: Hong Kong; Ebi et al. 2004: Philadelphia USA2; Fouillet et al. 2008: France1, 2; Morabito et al. 2012: Florentine-Italy; Palecki et al. 2001: Midwest USA2; Tan et al. 2007: Shanghai, China; Weisskopf et al. 2002: Milwaukee, USA2 Effectiveness heat warning in reducing health impacts (7 studies)	<u>For reducing health impacts</u> look at excess mortality for >65 age group, odds of increasing mortality among age groups 65-74 and >75	<u>Effectiveness in reducing heat-related mortality</u>: six studies asserted that substantially fewer people died of excessive heat after implementation of heat warning systems, comparing hot period without system in place with similarly hot period with a system implemented, to be considered to have an effect: other factors such as overall improvements in health care, better living conditions incl. use of AC, heightened heat awareness, use of heat insulating building materials. <u>Effectiveness in reducing heat-related morbidity</u>: no studies measured the potential impacts of system to reduce morbidity. - studies measured emergency medical service, emergency hospital admission, calls to ambulance during heat waves; overall contrasting patterns between hospital admission and mortalities during heatwaves. Cost-effectiveness (Ebi et al. 2004).
	Abrahamson et al. 2008: London and Norwich, UK1, 2; Alberini et al. 2011: 5 cities Canada1; Ibrahim et al. 2012 Victoria, Australia; Kalkstein and Sheridan 2007: Phoenix, USA2; Richard et al. 2011: Montreal Canada1; Semenza et al. 2008b Houston and Portland, USA; Sheridan 2007: 4 cities in North America1, 2; Wolf et al. 2010: Norwich UK1 Effectiveness heat warning in alerting human response (8 studies)	<u>For alerting human response</u>: elderly 72-94, community-based health profession and care providers to people aged >65, middle aged and older with heart problems, >65	<u>Human response and effectiveness</u>: warnings intended to increase awareness of risk associated with heat and provide temporary measures to safeguard the population's health, measures include opening of cooling shelters, use of "buddy" systems, distribution of hydration packs; coupled with mass media messages to warn the public, ways to protect themselves and others, and availability of facilities - very few papers addressed whether programs reach and are heeded by the target audience; <u>Awareness, perception and action</u>: does awareness lead to taking protective actions? Those who saw themselves vulnerable were more likely to take actions, those who did not consider themselves susceptible were less likely to act to protect themselves, e.g. some elderly did not consider themselves vulnerable but others of the same age group; - few people have knowledge on thermoregulation, hot temperature threshold, sweating and use of fans <u>Summer preparedness</u>: unchanged behavior is explained by the fact that many people naturally change their behavior in the summer - it could be people's "common sense" to protect themselves, but important to notice that this may have detrimental effects on vulnerable and isolated people whose conditions may deteriorate rapidly. <u>Cost and barriers</u>: especially cost of running an AC (Sheridan, 2007).

1 Studies we also found through our database search.

2 Studies were used in both reviews.

Table 4: Evaluation of effectiveness

Author, year	Effectiveness evaluation
Kovats, R. S. and K. L. Ebi 2006	Strong evidence of the effectiveness of specific measures in reducing heatwave mortality or morbidity is missing. It is not possible to directly compare the impacts of heatwaves: - heat health warning systems are extremely difficult to evaluate - there is hardly any published information on formal assessments of systems, of the effectiveness of the system as a whole or of individual interventions Recommendation for criteria for evaluation: A process evaluation of the system is recommended describe the components and operation of the system; describe the resources used to operate the system, evaluate the system for simplicity, acceptability, sensitivity, timeliness, effectiveness of individual response measures, specificity.
Grewe, H. A. and B. Blättner 2011	A systematic evaluation of European heat-health action plans is missing It is argued that considering the sustainability aspect a reduction of exposure to heat would be more effective in the long run compared to the minimization of health consequences. However short term interventions to minimize health effects are indispensable alone due to ethical reasons. Yet changes e.g. in urban development and housing insulation, would be much more effective for exposure reduction than behavioral change.
Lowe, D., et al. 2011	Evaluations of the effectiveness of predicting heatwaves, notifying vulnerable populations, and adoption of adaptation advice associated with communications are not currently available, and are urgently required to inform good practices.
Van Loenhout, J., et al. 2016	BE: The effectiveness of warning at-risk populations was not evaluated, according to a stakeholder interview. NL: not indicated in the study.
Paterson, J. A., et al. 2012	Results from the City of Windsor's heat alert and response system pilot and Toronto Public Health's efforts in evaluating effectiveness of heat messaging will contribute to a national system's best practices guidebook developed by Health Canada Health officials have voiced the need for standardized and evidence based best practices for evaluating programs.
Boeckmann, M. 2016	Evaluation of adaptation measures is challenging and not currently a regular practice; combined strategy that applies structural and community-based approaches. Suggestions for indicators include: - number of ambulance transports for heat stroke deaths related to climate-sensitive morbidity and mortality - media uptake of warning messages - increased awareness among citizens
Martinez, G. S.,et al. 2011	In terms of monitoring and evaluation we found that the effectiveness of the heat stroke prevention plan is monitored through the publication of morbidity and mortality data (3/5), as well as process indicators (2/5) including e.g. ambulance calls, number of mail service registrants, etc. Overall the reporting of heat-related outcomes and of selected indicators pertaining to the plan are common, but no formal monitoring and evaluation is carried out, either in terms of outcome or of process
Kunst, A. E. et al. 2013	The study evaluated the implementation not the effectiveness of the plan. It is notable that the implementation depend on the perceived effectiveness of recommended measures, which may strongly depend on local conditions. It is recommended that further studies should assess the cost-effectiveness of measures aimed at preventing heat-related morbidity and mortality.
Mees, H. L. P., et al. 2015	The study investigates stakeholders perceptions of effectiveness: it was emphasized that effectiveness is a key consideration for the protection of vulnerable citizens. - collective effort provides the best guarantee that vulnerable citizens are actually reached. However, evaluations of effectiveness are lacking and necessity of these studies is emphasized.
Paz, S., et al. 2016	Effectiveness of the climate adaptation plans is not evaluated in this study. It is recommended that local research to improve assessments of health risks is conducted, locally-appropriate adaptation measures are identified and the implementation and outcomes of health-related climate action plans should be evaluated.
Martin, J. L. 2016	It is emphasized that it is difficult to compare heat response plans and evaluate responses to heat events because heat events vary over time and affect populations differently based on vulnerability. The article discusses Baltimore's response to the 2012 complex heat event and reviews the challenges with and strategies for evaluating the program: - this included the short time that the program has been in existence and data limitations - challenges associated with risk communication and behavior change exist as e.g. public messaging and education for those who are most vulnerable might not reach them as those are often individuals who are isolated and lack strong social networks - *"message fatigue"* can be experienced during long periods of extreme heat and residents might not always understand the cumulative effect of heat stress on the body - many residents have indicated that they do not like the idea of going to a cooling center during the day and getting comfortable only to return home where they do not have AC and becoming uncomfortable again Challenges associated with cooling center standardization and use are that residents may seek cooling relief in locations other than official city cooling centers (no data is collected from these) and there is no data regarding how many individuals are visiting the site specifically for cooling vs. regular service. Efforts to bring on additional cooling centers formally have proved difficult because of a lack of staffing at many faith-based organizations and community groups. There exists the challenges in the measuring of program effectiveness overall: morbidity and mortality data are one way of measuring, other potential metrics for measuring program effectiveness include reported changes in individual behavior and overall population behavior, but this is difficult to assess; The Red Code program is unfunded, part of the planning and qualitative evaluation each year involves examining the available resources and the direct and indirect costs to agencies who participate.
O'Neill, M. S., et al. 2009	The study points to limited evaluations available.
White-Newsome, J. L., et al. 2014	Despite efforts to identify and quantify the success and reach of the heat preparedness programs the majority of participants stated that evaluation was difficult when given the limited funding and resources. Philadelphia and Phoenix: use surveillance of heat-related deaths, emergency dispatches, hospitalizations and hospital discharges during extreme heat events to inform future preparedness plans was emphasized. Phoenix: longitudinal data collection was deemed costly, but necessary. Overall it is argued that conducting best practices assessments and relevance of comparing heat-related mortality in other cities was a way to boost evaluation efforts. Interviewees pointed to the importance of evaluating how their heat programs were being used in order to assess the efficacy of their work *"if you can't measure it you can't manage it"* Considering that in evaluating cooling centers it has to be differentiated e.g. are they used as routine vs. in response to heat Other indicators of program success were the number of individuals requesting and receiving fans in cities with fan distribution programs, participation in emergency preparedness exercise and requests for trainings, etc.
Kosatsky, T., et al. 2005	The joint program of action and research initiated in 2003 involves the evaluation of AC use, medication practices and patient hydration in chronic care centers
Price, K., et al. 2013	The study was not designed to assess whether the heat plan, as applied in 2010, was effective in reducing mortality.
Knowlton, K., et al. 2014	Continuous quality improvement efforts were applied and several issues have been identified and address, linked to what the study group consider effective elements of the project: recognition of heat as a disaster and growing health threat; interagency communication and coordination; international team coordination; data collection; budgetary concerns and political will. A program evaluation is intended and includes assessment of its effect on two main target populations: organizations involved in the public health response to extreme heat, and the general population, particularly people most vulnerable to extreme heat (ongoing when the study was published). Other evaluation activities are being planned, especially impact assessment and efficiency characterization. Impacts assessment in the general population will include: post-intervention surveys of vulnerable populations (e.g. slum households); review of emergency medical service, hospital, clinic records, and evaluation of post-intervention all-cause mortality records for the city. Self-reported rates of heat illness and prevalence of hot weather coping behaviors in slum dwellers will be compared to baseline rates collected prior to the interventions, from emergency medical service calls, visits to clinics, and hospital admissions for all-causes and heat-specific causes. Once impact evaluations have been done, efficiency and cost-effectiveness of the intervention can be evaluated.
Michelozzi, P., et al. 2010	The mortality surveillance system enables the evaluation of warning systems and prevention programs, but the critical point is that the potential effectiveness of interventions, included in the heat prevention plans, still need to be formally evaluated. Evaluation of heat prevention plans as a whole is another critical issue and despite difficulties, process and outcome assessments should be undertaken. A preliminary evaluation carried out in Italy suggests that a reduction in the impact of heat on mortality has occurred since the introduction of HHWWS and prevention programs, but alternative explanations cannot be disregarded. With reference to other literature the authors emphasize that there is a general consensus that more has to be done in terms of evaluation of heat health watch warning systems and prevention measures.
Grewe, H. A. et al. 2011	Effectiveness of most individual measures is not tested, however, measures to optimize liquid and electrolyte balance, cardio-vascular function as well as bodily heat release and heat production are linked to evidence on susceptibility and its reduction.
Bolitho, A. et al. 2016	This study does not report on evaluation of effectiveness.
Berisha, V., et al. 2017	This evaluation is the first project of this scope and magnitude to evaluate cooling centers from a public health perspective, and first step to understanding facilitators and barriers for operating a specific local climate adaptation program and evaluating the public benefit.
Riley, K., et al. 2012	The activities took place within and were informed by a socio-political and economic context that presents obstacles to the effectiveness of the heat standard and to education as a successful strategy to implement it; Overall it is difficult to evaluate the effectiveness of the campaign, in terms of changed behavior or decreased mortality and morbidity there is no sufficient data.

Table 3: List of heat health intervention studies

Author, date, country	Target group	Intervention description	Main findings
Kovats, R. S. and K. L. Ebi 2006 Italy (city-level implementation), France (all 14 main cities), Spain, UK (Heatwave Plan for England and Wales), Portugal (country-wide), Germany (country-wide) and US comparison	Not defined for individual countries, overall elderly are most at risk of heat-related mortality; social factors such as living alone, being socially isolated, no working AC, those in top floor apartments; effect of deprivation, also residents in retirement homes and nursing homes, persons with mental illness or disability that causes cognitive/ behavioral problems - Overall important risk factors are likely to be location specific	Effective heat health warning systems requires: - reliable meteorological forecasts for the population or region of interest - robust understanding of the cause-and-effect relationships between thermal environment and health outcomes at population level - effective response measures to implement within the window of lead-time provided by the warning - the involvement of institutions and civil society that have sufficient resources, capacity, knowledge and political will to undertake the specific response measures Specific interventions that have been incorporated into systems: Media announcements, telephone help-line, opening of cooling centers, alert to hospital emergency rooms, ambulance services, home outreach visits to vulnerable persons, evacuation of vulnerable persons from their homes to cooling centers, outreach to homeless, electricity and water companies cease disconnection for non-payment, fan distribution Difficult to assess which measures are implemented in what way, but a communication and public education strategy is an essential part of heat health warning systems.	There is little information when a threshold for initiating a health response should be set. Heat health warning systems are implemented at the local level, they vary widely in structure, partner agencies, specific interventions deployed. - systems are being implemented in Europe in the absence of strong evidence of the effectiveness - passive dissemination of heat avoidance advice is likely to be ineffective - systems should be linked to the active identification and care of high-risk individuals - systems require clear lines of responsibility for the multiple agencies involved - other health interventions are necessary in relation to improved housing, and the care of the elderly at home and vulnerable people in institutions - important to involve the system's end users or their advocates
Grewe, H. A. and B. Blättner 2011 Belgium, Denmark, England, France, Italy, Luxembourg, Netherlands, Portugal, Spain	Especially vulnerable groups are defined across European heat action plans: risk factors are cumulated: age, need for care, chronic disease; therefore, nursing homes are important target institutions in all countries for prevention measures and the caring professionals are especially addressed target groups of the action plans, although with different levels of obligation	The study gives an overview on heat-health action plans in Europe: Reaching vulnerable groups: In France municipalities and public health services are explicitly obliged to safeguard and monitor medical and nursing care, on department level support and control is carried out, additionally one cool room in each care institution and hospital has to be provided, via the social medical emergency care for homeless and persons in social hardship, access to homeless is provided, a list of vulnerable people is compiled annually, for that reason the French data protection law was adapted, for Paris this means a written invitation to ca. 400.000 mostly elderly citizens to register, coupled with a specific support during heat waves, in 2006 around 13.000 persons followed this invitation, after telephone screening almost 800 persons with priority need for support were identified and benefited from telephone consultation, transfer to cool places, acute medical intervention during the heatwave in the same year; England has adopted an "equality impact assessment" to identify underrepresented population groups and integrate them into further development of heat action plans, from communal responsible persons an active participation is demanded which goes beyond general recommendations, additionally in England there is a systematic record of vulnerable groups within the Primary Care System, but resonance of workers was low, heat as relevant risk was apparently still questioned and doubts on feasibility of recording vulnerable persons, unclear competence and difficulties in inter-professional work in acute situations were discussed; In Italy two procedures are in place for the mandatory registration, in the majorities of cities included in the heat action plan (more than 200.000 inhabitants) identify vulnerable groups through social and health data, criteria used are age 75 years, disease (collected through archived hospital discharge data), then social isolation (available information on marital status, or family status), intake of a defined drug group (which was based on the archive for drug description), as well as low social economic status, some cities registered vulnerable persons directly after notification from GP, social worker and other providers, but only 30% of GP participate in the notification by GP procedure. In Luxembourg over 75 year old can apply for care during a heat wave if they live alone or with a physically disabled person, if they can only care for themselves in a limited way, hardly have neighborly contacts and receive no benefits of care insurance; no information in other countries. Real-time surveillance of mortality and morbidity: differs in respective countries.	Heat-health action plans have different designs: - usually they include a warning system - targeted prevention measures in the municipal setting - surveillance systems to monitor heat-related disease incidences - the measures in Europe do not disclose medium- and long-term strategies to reduce exposure through city planning and housing (mitigation measures); long-term initiatives may still be in place but may not be thought to be part of a crisis plan for heatwaves
Lowe, D., K. L. Ebi and B. Forsberg 2011 Belgium, France, Germany, Hungary, Italy, Macedonia, Netherlands, Portugal, Romania, Spain, UK, Switzerland	Different systems identify different risk populations: elderly, chronically ill, with specific medication, homeless, obese/unfit, cognitive disability, outdoor workers, physically active, children, disabled, SES, tourists, isolated, gender, drug/alcohol dependency, refined to most vulnerable, Ramadan (1/12), institutionalized (1/12), people with fever (3/12), pregnant women (1/12)	Actions prior to heatwave: forecasting, monitoring, warning, press releases, seasonal surveillance, leaflet, pre-heat prevention, heat-hotline, information campaigns, dissemination of heat illness recognition and prevention information, disseminate via pharmacies, GPs, etc., preparing lists of persons at risk; Actions during heatwave or heatwave forecasted: heatwave alert, warnings via media, suggest public cooling areas, provide phone hotline, tracking homeless, installation and maintenance of AC common rooms in residential care, info to health care system, maximum mobilization, increase number of hospital beds and staff, extend opening hours of public AC places and pools, provide water in public places, transportation to AC rooms, active monitoring of vulnerable subgroups by GPs, social workers, volunteers (phone calls & home visits), activation of emergency protocols in care and retirement homes and in hospitals, supply food to elderly and persons at risk, protective measures for occupationally heat exposed workers; Dissemination of heat advice to vulnerable populations typically involved websites, pamphlet distribution or media campaigns (active methods in 3 out of 12, and passive in 11 out of 12).	The twelve countries show differences in heat action plans, but also commonalities such as involvement of meteorological institutions, types of indicators, actions and vulnerable groups identified. - forecasted temperatures triggering a heatwave warning ranged from 27° to 32°, within some plans, thresholds are outlined for particular regions or cities that reflect differences in acclimatization, the presence of UHI, costal experiences of heatwaves versus inland - several systems provide brochures tailored to specific vulnerable groups (tailored advice is better received than general advice), use plain language advice and visual communication, sometimes in multiple languages - majority of systems focus on improving heat health responses of residential staff and centers, novel adaptation strategies target outdoor workers/physically active work, three systems consider support measures for the homeless, including shelters, provision of caps, lockers for storing belongings and maps of drinking fountains; many action plans recommend spending two hours in an AC environment to reduce impacts of heat, outreaching to at-risk-neighbors and through voluntary services is also mentioned in some action plans - preventive strategies such as structural changes to buildings to aid passive cooling and/or protect buildings against heating up, are often considered
Van Loenhout, J. A. F., J. M. Rodriguez-Llanes and D. Guha-Sapir 2016 Belgium (BE), The Netherlands (NL)	Belgian plan: young children, elderly, socially isolated individuals and persons who perform heavy physical exercise	National heatwave plans of two adjoining countries have different warning indicators (heat definition, activation) aiming to reduce the avoidable human health consequences due to heatwaves. The Belgian plan contains information on heat-related health effects and their treatment, risk groups and aggravating factors; phase 1: informing the public, spreading an information leaflet on heat, phase 2: preparing warning and alert messages; phase 3: Informing professionals, incl. GPs, hospitals, elderly care, homecare, initiating a media campaign, initiating a call center, phase 4: intensifying previous measures, creating a crisis center	BE: 1 out of 7 participating organizations were not familiar with the plan, 2 not with the content. 2 were directly involved in warning the at-risk population, 3 indirectly and 1 not at all. 3 gave high priority to heat as a public health emergency, 3 medium and 1 no response. Regarding the successfulness in reaching the risk population 4 gave positive feedback, 1 rated partial success, 1 rated no, 1 n/a.
	Dutch plan: elderly people living in care organizations, the chronically ill, socially isolated individuals, overweight people and children	The Dutch Plan contains information on risk groups, situations, heat-related health effects, recommendations to prevent heat stress and communication strategies towards vulnerable groups; phase 1 watchfulness: preparing for a hot period, raising awareness among employees, phase 2 pre-warning: Informing national organizations, and regional information points, checking whether preparation for a warning phase are in order; phase 3 warning: Press release for general population, sending warning message to intermediaries, creating a regional information point;	NL: 2 out of the 6 participating organizations were not familiar with plan, 1 not with the content. 3 were directly involved in warning the at-risk population, 1 indirectly, 1 not, 1 did not respond. 3 gave high priority to heat as public health emergency, 2 medium, 1 low. Regarding the successfulness in reaching the risk populations, 2 gave positive feedback, 1 rated partial success, 1 n/a, 1 does not know, 1 gave no response.
Paterson, J. A., J. D. Ford, L. B. Ford, A. Lesnikowski, P. Berry, J. Henderson and J. Heymann 2012 Ontario, Canada	Elderly homeless but not specifically indicated	The study looks at cc adaptation to manage adverse health outcomes, the following information only relates to heat wave adaptation. The interviewed health officials are concerned about how extreme heat could exacerbate existing health issues or create new health burdens (71%). Overall adaptation is taking the form of mainstreaming cc into existing public health programs. To manage extreme temperatures, the City of Ottawa uses multi-stakeholder extreme weather prevention and response strategy to maximize capacity for public protection, especially for those most vulnerable (e. g. elderly, homeless). Peel and Ottawa plan to use or have implemented syndromic surveillance of heat related hospital visits during extreme heat alerts to monitor burden of illness in hot weather. The Windsor-Essex Public Health Unit with the City of Windsor implemented a heat alert and response system and conducted a heat health vulnerability assessment to identify vulnerable groups, thresholds for issuing heat alerts and indicators of effective responses.	Effective messaging and communication of the health risks associated with cc is found to be challenging because: - inter-jurisdictional differences on use of triggers to inform alert and warning systems and conflicting messages to the public on extreme heat and smog days are significant issues - difficulties exist in promoting public responses because cc has not yet resonated in communities - effective messaging is difficult in diverse communities and the public lacks a clear perception of personal risks and/or confuses concepts of adaptation and mitigation - monitoring adequate responses of vulnerable groups is challenging - effective health warning systems may not translate to adequate responses and interventions locally
Boeckmann, M. 2016 Japan	Specifically older people targeted, and construction workers and school children taking physical education classes outside in the heat.	A portfolio of measures to reduce vulnerability to adverse effects of extreme temperature events. Very specific behavioral change advice such as the use of AC, increased fluid intake and staying indoors; awareness raising and sharing information, different channels for communicating range from radio and TV, text messages and website downloads, to leaflets and other print media. There is a strong social and civil society component in local heat adaptation efforts: individualized adaptation examples are given where the community is mobilized to check on older persons. A special role is assigned to community volunteers *"Minseh-in"*, structural measures: access to public cooled spaces, free provision of cooling towels and "heat stroke measure items" and financial support to purchase AC units. Use of smart technology, automated ACs. Most measures are reliant on government funding.	High awareness of health risks from heat but challenges were found which constrain implementation: - lack of funding and prioritization (e.g. earthquake and tsunami considered more dangerous) - question of responsibility - communication between different actors - constrained space (e.g. for urban greening) - role of social capital in preventing heat-related illness is contested, potentially shifts the blame of harm or inaction to those at risk
Martinez, G. S., C. Imai and K. Masumo 2011 Municipalities: Kusatsu (Shiga), Kumagaya (Saitama), Tajimi (Gifu), Obu (Aichi), Machida (Tokyo) in Japan	The elderly were explicitly addressed in most heat disorder prevention plan	All five local governments had locally run heat-health preventive systems in place encompassing different heat disorder prevention activities, they were categorized along the WHO heat-health action plan elements. The plans were operated under different lead bodies, the heat related health information plan provided for distribution of leaflets, prevention guidelines, heat stroke seminars, public education campaigns, announcements, etc. routinely, and on alert days: behavioral advice issued according to risk level (4/5), email service (cell phone and PC) for registered addressees (4/5), warning in City government website (3/5), fax to registered organizations, institutes, work places (2/5), Advisories in local radio broadcast, TV stations, etc. Considering care for vulnerable people element different activities were listed: targeted distribution of informative leaflets, portable heat measurement devices and special "cooling" scarves, senior resident halls and clubs invited to register in heat alert email service, active outreach to the elderly who live alone by social workers, Minsei (civil volunteers) visit seniors on regular basis during hot spells (3/5), newspaper deliveries inform the city if they find pile of accumulated newspapers in mail box (2/5), general local support system for senior residents, including heatstroke prevention. Free 24/7 tele-assistance communication devices; however some plans do not include specific provisions for health care facilities and/or social services, others are invited to prepare for hot spells and register in heat alert service. Registration of private citizens in the warning distribution lists is voluntary, rather than based on cross-referenced census from health centers and/or social services; Local volunteer networks play a major role in dissemination of information and active outreach to vulnerable subgroups, particularly the elderly.	This review aimed to showcase selected examples of activities and is not as rigorous or representative as a comprehensive assessment, the most important characteristic findings: - the heat-health information provisions constituted the most developed dimensions of the plan, with a wide range of communication strategies and channels, the use of email and cell phone notifications to register participants is a major component within most plans - registration for private citizens in the warning distribution list is voluntarily, rather than based on a cross-referenced census from health centers and/or social services - health education activities besides alert notifications, leaflets and instructions are a common strategy, but not consistently part of a local heat stroke prevention plan - local volunteer networks play a major role in dissemination of information and active outreach to vulnerable subgroups ("social capital" - preparedness of the social and healthcare systems are commonly not an explicit component of the plan - only a subset (the elderly) of all groups vulnerable to heat-related morbidity and mortality were explicitly addressed in most heat disorder prevention plans, leaving out the homeless, mentally ill, handicapped, the socially isolated and other subpopulations known to suffer during heat waves
Kunst, A. E. and R. Britstra 2013 Amsterdam, The Netherlands	National Heat Plan identified: the elderly people in general, people with chronic illnesses, obese people, socially isolated people, and residents of institutions as risk groups. For the evaluation study: institutionalized people	The national heat plan provides for specific measures to be implemented, for residents of long-term institutions the plan recommends cooling measures both at the level of institutions (such as use of sunshades and ventilation) and at the level of individual residents (such as intensified care and behavioral adaptation). Institutional level cooling measures: lowing sunshade between 12.00 and 16.00, lowering sunshade already at sunrise, in the evening and at night natural or mechanical ventilation, closing the windows when outside temperature exceeds inside temperature, etc. Individual-level cooling measures: Offering passive fluids by placing water jugs during the day, extra round of drinks with active offering of fluids, soup or juices, avoiding sun exposure during 12.00 and 16.00, simulating wearing loose clothing and help changing if necessary, stimulating and helping residents to move to cooled rooms, adjusting daily schedule, reducing frequency and intensity of activities and therapies, stimulating and helping residents to splash their face, neck and wrists, consulting a physician when residents are taking medication, stimulating covering the head during sun exposure, etc.	The study evaluated the implementation of the plan, analyzed to what extent care managers acknowledged the importance of cooling measures recommended for the institutions at large; - Most institutions had a heat protocol, virtually all of which had been developed in the three years preceding the study. - Outdoor sunshades were used most often to protect residents against heat (93% of all institutions) - Prevalence of cooling facilities such as air conditioning and rooftop cooling had increased, but remained low (41%) - Care managers confirmed the importance of most of the 23 cooling measures recommended by the National Heat Plan, with some exceptions - Only 41% regarded consulting physicians on medication use to be 'very important' - Most care managers did not foresee large problems with the implementation of the recommended cooling measures - Barriers mentioned related to shortage of and expertise among personnel (negligence, lack of knowledge), also lack of awareness by residents, and the need to respect residents' independence.
Mees, H. L. P., P. P. J. Driessen and H. A. C. Runhaar 2015 The Netherlands and a review of ten cities: Chicago, Kassel, London, New York, Paris, Philadelphia, Rome, Stuttgart, Tatabanya, Toronto	Stakeholders judge the socially isolated elderly who live independently as the most vulnerable but also the most difficult group to reach Most of the cities heat health warning systems and response plans mention vulnerable citizens in the formal planning documents, only three cities have elaborate descriptions about activities for the protection of vulnerable citizens	Analysis of local governance arrangements to protect vulnerable citizens against extreme heat, looks into 10 cities heat stress policies: Heat stress policies in the cities show different approaches to identify, reach out to and protect vulnerable individuals. Identification of vulnerable citizens and addressing them: - in most cities assessment and geographical mapping - heat lines are set up (all cities) - registration: in Paris CHALEX database is established, registered citizens are called every other day by the public social services; - several interactive arrangements, where public (health) authorities collaborate with health practitioners and social/community workers, i.e. in Philadelphia, USA. - a nursing team does home visits following heat-line calls, network to also provide telephone assistance (Philadelphia, Kassel) - city based buddy system (community volunteers who pay visits to vulnerable citizens, Philadelphia). - Toronto, active outreach is organized - Rome, registered citizens are actively contracted, using existing networks of social services, general practitioners and volunteers. There was only one measure directly targeting vulnerable citizens: local authorities designated public places (such as swimming pools, libraries, senior centers, hotels) as cooling centers	Most cities include socio-economic factors that may lead to increased sensitivity, exposure or reduced adaptive capacity. - all cities have an early warning system and response plan - two cities have a dedicated plan for the protection of vulnerable citizens - active intervention of the public health or social service towards vulnerable citizens - public authorities install or subsidize AC for low income vulnerable elderly people - several cities turn public buildings into cooling centers - all cities activate a media campaign for the general public - active phone calls are made in Paris, Kassel, London and Toronto, home visits only carried out in Philadelphia and Rome
Paz, S., M. Negev, A. Clermont and M. S. Green 2016 5 Med-cities: Adelaide, Barcelona, Cape Town, Los Angeles (LA), Santiago	Mediterranean-climate urban populations are defined as particularly vulnerable to cc due to synergetic reasons: the concentration of poor, the climate and projected cc, as well as the urban design and infrastructure. The plans aimed to reduce vulnerability by different means: Adelaide: reducing exposure of vulnerable populations, by providing shelter; Barcelona: mapping of vulnerable areas regarding health impacts; exposed workers; LA and Santiago: identify vulnerable populations, propose longer-term plans; Cape Town, eliminating informal settlements, providing electrification	Rising temperatures, heat waves, heat stress and the heat island effect was identified as local risk by all 5 cities and heatwave management appear in all cities while the specific tools differed. The heatwave management for Adelaide comprised emergency management procedures and an extreme heat strategy as well as urban design adaptation such as water sensitive urban design and increased vegetation. For Barcelona heatwave management included an emergency program for extreme heat, it provided for adaptation measures to protect exposed workers from increasing climate conditions (especially heat-related health risks) and an early warning system. In terms of urban design, the UHI was established as criteria in drafting new development plans. In Cape Town climate action plans incorporated increasing awareness of how to manage heat-related stress and other climate-related illnesses, the design and implementation of "Heat-Health" action plans, including plans in respect of emergency medical services. A nation-wide cc and atmosphere monitoring system. The heatwave management in LA provides for the public health agency to issue heat alerts, guidance to schools, ensuring appropriate resources (i.e. cooling centers) available to the public. Furthermore, the establishment, improvement and maintenance of mechanisms for robust rapid surveillance of environmental conditions, climate-related illness, vulnerabilities, protective factors and adaptive capacities as well as increasing the tree canopy. In Santiago heatwave management consists of the monitoring system WebGIS and adaptation of the monitoring system and emergency plans by including cc related health effects in risk management practices. In terms of urban design green standards in new development projects and increased green spaces are cited.	The study does not investigate the implementation of climate adaptation plans but rather their existence. It is noted that many cities do not have such plans, and of those that do, their plans differ in scope and a great gap exists between plans in strategies and comprehensiveness regarding adaptation to health impacts.
Martin, J. L. 2016 Baltimore City, US	The heat plan defines vulnerable populations susceptible to extreme heat in Baltimore, including the elderly, homeless people, substance abusers and outdoor workers	Baltimore has an extreme heat plan in place that establishes a coordinated multi-agency approach to providing cooling relief for vulnerable populations in Baltimore City and seeks to educate the public regarding the risks posed by extreme heat. It is an emergency preparedness and response program and is intended to respond to extreme heat. The City Code Red program includes public information, active outreach activities and heat awareness efforts through press releases, mass media, outreach and social media platforms. Efforts aim to target the most at-risk populations and to remind support networks to help protect vulnerable residents. The city also provides energy assistance to city residents to apply for subsidies to help with the cost of heating and cooling bills as part of the Maryland Energy Assistance Program. On Code Red days the city opens cooling centers at its Community Action Centers and city-run senior centers. Individuals in the cooling centers are also offered bottled water, and bottled water is also provided to homeless individuals by homeless outreach teams and the Salvation army on Code Red days. A key component of the program is weather monitoring and surveillance looking at forecasted temperatures, heat index, and air quality.	The summer 2012 was the third warmest summer on record in the US and the 8-month period from Jan to Aug was the warmest on record. The heat response measures deployed: opening additional cooling centers (total of 22); water and ice distribution sites were set up (used by over 5,600 individuals); twp emergency shelters were opened to house those without power (used by 6 residents); Community Emergency Response Teams reached out to neighborhoods without power; additional outreach by neighborhood leaders; calls to residents through its Reverse 911 system to inform them of the heat emergency and opening of additional cooling centers, and to remind them to call 311 for more information; live calls to senior clients to provide additional information regarding emergency services and to check on welfare; also healthcare facilities and facilities serving vulnerable populations were contacted to identify facilities without power and instructed to report power status and health concerns related to the power outage. Bio-surveillance measures were also in place for a week following the storm tracking for instance asthma ED visits, and emergency calls were tracked across a variety of categories, including asthma, cardiac arrest, chronic obstructive pulmonary disease (COPD), respiratory distress, dehydration, dizziness/vertigo, and syncope fainting.
O'Neill, M. S., D. K. Jackman, M. Wyman, X. Manarolla, C. J. Gronlund, D. G. Brown, S. J. Brines, J. Schwartz and A. V. Diez-Roux 2009 285 US communities were surveyed	The paper identifies determinants of vulnerability to heat-related health effects including: biomedical (underlying disease status); sociodemographic (income, age, race); and community (AC access, vegetation). Biomedical criteria have limited explanatory power for population patterns of risk during hot weather. Community-level factors, including social and physical aspects of neighborhoods, communities, and cities, also affect vulnerable and merit attention because community and population-level interventions may yield large public health benefits.	The survey inquired into the actions US cities are taking to monitor and alleviate the effects of excessive heat events, so to prevent health problems and reduce heat exposure - administered to 285 communities 70 responded (25%) and a total of 30 had established preventive programs. The survey results suggest that many US communities are not adequately prepared to prevent the effects of hot weather on the health of residents, and several are not undertaking activities to reduce heat exposure and emission of the greenhouse gases that contribute to global climate change.	Heat Health Prediction and Risk Assessment surveyed: - Regularly review weather forecast information for the purpose of preparing for excessive heat events (36%) - Maintain current and accessible record of facilities and locations that may house vulnerable individuals (29%) - Develop quantitative estimates of potential health impacts related to hot weather (13%) - Have established criteria for identifying heat-attributable deaths and illness (9%) For specific Notification and Response: - Coordinate public distribution and broadcast of heat exposure symptoms and heat tips (31%) - Increase outreach efforts to vulnerable populations (e.g. elderly, homeless) (31%) - Designate public buildings or specific private buildings with AC as public cooling centers (30%) - Extend hours of operation at community centers with AC (30%) - Suspend utility shutoffs (11%) - Provide current records of locations that may house vulnerabel individuals to social services (9%) - Operate informational phone lines to be used to report heat-related health concerns (21%) - Arrange for extra staffing of emergency support services (19%) - Establish provisions to transport the homeless to cooling shelters (13%)
White-Newsome, J. L., S. McCormick, N. Sampson, M. A. Buxton, M. S. O'Neill, C. J. Gronlund, L. Catalano, K. C. Conlon and E. A. Parker 2014 Cities: Detroit, New York City, Philadelphia, Phoenix in the US	Detroit: seniors, homeless, persons with medical conditions, new immigrants, high-rise structures New York City: homebound, those without AC, seniors, immigrant populations, living in high-rise buildings Philadelphia: seniors, those living in row homes Phoenix: seniors, homeless, tribal communities	The heat health warning system in place in the four cities provided some guidance for warnings, but local circumstances, in addition to the forecasted weather conditions, would sometimes affect whether a city would activate an outreach program, regardless of the warning system recommendation. Detroit adopted an "in-the-field" program like the Gatekeeper Program where utility service providers go out in the field to look at sites and provide assistance, other NGOs created processes to help homeless and new immigrants with heat and cold, and Detroit Homeland Security and the Emergency Medics have created a list of people who cannot be moved for heat and adopted a shelter-in-place practice; Community Emergency Respose Team-program (CERT), media outlets, smart message; New York: there is a unified command system to organize around emergencies, social service programs and case managers are contacted, list of most vulnerable clients is updated. Then transporting homebound seniors to cooling centers; youth were enlisted as messengers to help educate the local elderly about heat related health risk; then there is partnership with the US Postal Service Carrier Alert program, if a person doesn't pick up mail in 3 or 4 days the nearby community based organization is sent in to see if the person is well; then Notify NYC program, and partnership with union for doormen, maintenance and people who stand at desk in buildings; also sending out CERT teams, also installation of ACs in senior homes, etc. Philadelphia: the business-hour hotline "Philly 311" becomes a heat-line in a heat emergency, and calls can be directed to medical professional, who will determine whether or not an intervention is necessary, if so, a sanitarian will be sent. Then fans and AC distribution program, websites with cooling centers, so-called *block captains* checking on elderly residents on their blocks, also home-based outreach to residents which receive assistance from agencies and NGOs, also to assess safety and uncover potentially dangerous behavior. Use innovative communication and engagement with groups that are vulnerable to heat but often go unaddressed in response measures. Phoenix: facilities licensed through state agencies such as assisted living facilities and group homes are contacted, large AC distribution program, and cooling centers for homeless, and outreach activities to drive with vans out to the camps of homeless, volunteers distribute ice chest water, Gatorade and hygiene kits; or outreach teams to bring resources or take them to emergency room or refuge location, specific group are homeless with mental health problems identified, youth education program.	Local context impacted heat preparedness as well as political will and resource access, main obstacles: 1. Financial constraints: lack of funding, lack of resources e.g. programs distributing ACs to low-income households realizing afterwards that energy bills could not be afforded and no use of AC; also very bad housing and difficult-to-predict nature of heat emergencies 2. Cooling center challenges: many barriers to their use exist including: stigma ("it is only for seniors or homeless individuals"), hygiene, health and safety, access (transport), difficulty with evacuating one's home (emotionally or physically jarring, "people are not going to leave their pets"). 3. Communication challenges: the lack of public awareness, providing appropriate evolving messages, no internet access, extreme heat events are not perceived as serious, "too many warnings could result in the public's desensitization", messaging to 50% illiteracy rate population (Detroit) coupled with cognitive decline of aging; also communicating with two specifically isolated populations: people who were once institutionalized but are now in neighborhood-based housing, and homeless population. Moreover, focus on indirect risks, someone with AC might not want to go outside get medicine, or stay inside because of the heat. 4. Need for evaluation efforts to execute heat programming
Kosatsky, T., N. King and B. Henry 2005 Cities Toronto and Montreal in Canada	Homeless, under-housed, and frail, isolated, seniors, e.g. also aboriginal population	Toronto has instituted a two-level alert and emergency response - key to the program: media alerts and community partnerships to aid vulnerable people. Fact sheets are disseminated, heat "alert" press release posted - vulnerable clients are contacted during heat waves, providing advice on how to lessen heat stress - places for people to cool off are identified, increased access to public (swimming) pools - relaxed restrictions on homeless people staying in parks overnight and outreach to vulnerable members of community (homeless, under-housed, frail, isolated, seniors, aboriginal population). - Red Cross provided a Heat Information Line, following paramedic visits at home; cooling centers including overnight capacity, bottled water, snacks, AC space, street patrols Montreal's (Quebec) issued public advisories based on temperature thresholds - instituted a program of research and action to inform the population and to identify and mitigate population vulnerabilities - priority areas: include hospitals and nursing homes, few of which had AC - in the community, local health centers target their vulnerable elderly clients requiring follow-up during heat waves based on the identification of factors such as dehydrating medications, social isolation, and lack of access to a nearby cooling room	Toronto: In the summer of 2001 the Hot Weather Response Plan was put to test: 6 heat alerts and 3 heat emergencies were called, 401 persons called the Heat Information Line during the emergency days: of these, 28 were referred directly to emergency responders, and 23 received a home visit. Approx. 1700 people visit the cooling centers and 20-36 stayed overnight at the cooling centers open 24 hours. Extensive media coverage was carried out. In 2002 heat alerts were called on 15 days, and 2 days reached heat emergency conditions, during the 2 emergency days 1800 people used the cooling center. Montreal: in 2001 Montreal experienced a similar heat wave as Toronto but had not opened cooling centers. No further information on other implemented interventions.
Price, K., S. Perron and N. King 2013 Montreal in Canada	The elderly, institutionalized people, persons suffering from mental illness, young children	The Montreal heat response plan was designed to ensure the surveillance of weather and health indicators during the summer season and to coordinate actions to be undertaken during this period to reduce morbidity and mortality due to heat, particularly when weather thresholds are reached or an increase in health indicators is observed. The plan serves as a guide to health and social service network to develop their own local heat plan for the people they serve. The plan comprises 5 levels which define different actions to be taken: the normal level, seasonal watch, active watch, alert level and intervention level. In the beginning of July 2010, Montreal experienced a heat wave that lasted 5 days. During this period, health indicators such as total mortality, prehospital emergency transports, deaths occurring in the community, calls to the health information line and hospital admissions were monitored by the Montreal public health surveillance system and the Urgences-santé. The intervention level was onset in July 2010 and many actions were performed ranging from: - mass media communication (information in the media, call for awareness issued to health care professionals) - surveillance of dehydration symptoms in patients - involvement of local health departments in order to identify vulnerable individuals - opening of AC shelters, extension of pool opening hours - door-to-door campaign by municipal partners to identify people suffering from heat and in need of assistance Interventions also involved hospitals and long-term care, pre-hospital emergency care, boroughs and cities in the island of Montreal, police and fire departments. For Montreal it was thus decided that there would be specific communication campaign during heat waves that targets individuals with mental illnesses (in addition to communication campaign already in place targeting the elderly and young children); Additionally, further preparation work with local health and social service centers, community organizations and psychiatric hospitals.	During the heat wave there were 304 reported deaths from all causes in Montreal residents, of which 106 were probably or possibly heat-related. Two major underlying health conditions were identified in heat-related deaths: cardiovascular problems and mental health illness. Often, numerous underlying health conditions were present in an individual. When analyzing the 32 reported community deaths for people with mental illness, many of these people lived alone, and 14 out of 21 for whom information was available were contacted 24 hours prior to their death by health care professionals, family members, neighbors or friends. For heat-related deaths during the heat wave 2010, 93 occurred in the community (88%) and 13 occurred in long-term health care facilities and hospitals (12%), the total deaths occurring at home or in the community were twice the normal expected value. Individuals approx. 70 years of age and suffering from cardiovascular disease were at higher risk. But there exists vulnerability of individuals with mental illness in Montreal and of those who were drug- and alcohol-dependent, Individuals with mental health illness who died during the heatwave were also younger, averaging approx. 60 years of age; Family, friends and professionals may have been less aware that individuals with certain mental illness were particularly vulnerable during a heatwave.
Knowlton, K., S. P. Kulkarni, G. S. Azhar, D. Mavalankar, A. Jaiswal, M. Connolly, A. Nori-Sarma, A. Rajiva, P. Dutta, B. Deol, L. Sanchez, R. Khosla, P. J. Webster, V. E. Toma, P. Sheffield and J. J. Hess 2014 Ahmedabad, Gujarat, India	Factors putting certain populations in Ahmedabad at higher risk: those in areas with high population density, who have compromised safe water access, experience high ambient temperatures and have low prevalence of protective measures such as AC; Particularly those in the city's migrant slums, other poor communities, the elderly and the young, outdoor workers such as construction laborers, municipal police officers, rickshaw drivers - due to a combination of their prolonged heat exposure, poor underlying health status, and lack of access to coping mechanisms such as AC	Two interventions are central to the early warning system effort: the Heat Action Plan: which was developed as an administrative tool that would define different levels of emergency for the city and clarify activities among the plan participants for each level (focusing on community outreach to building public awareness, initiating simple early warning, capacity building among health care professionals), and the Extreme Heat Early Warning System, issuing forecasts of extreme heat a little over a day in advance; both interventions were accompanied by preparatory activities, interagency coordination was facilitated and an interagency communication plan was developed. Examples of interventions: For outdoor workers water and shade is provided and works shifts were altered to cooler hours; water tankers was provided to slum dwellers and non-essential water use was limited, power to critical facilitators/vulnerable groups was maintained, bus stops as sites of shade and water distribution was used, temples and libraries were opened as cooling centers, information was given to school students and potential change in summer holiday schedule was prepared, parks, zoos, swimming places extended their opening hours. The pilot plan was initiated and several outreach activities were part of the action plan launch, including billboards around the city with instructions and distributing pamphlet (produced in both English and Gujarati) as well as developing a radio campaign in local languages and installing electronic temperature displays to alert communities. Heat Alert dos and don'ts: behavioral advice: during heat wave: - drink water, chaas (buttermilk), and other liquids (no soft drinks) - stay out of the sun - find a place to cool down - wear light clothing - check in with friends & families And symptoms to watch for are listed (heat rash or cramps, heavy sweating and weakness, headache and nausea, lack of sweating despite heat, red, hot and dry skin, muscle weakness or cramps, nausea and vomiting).	Results relate to the intervening steps that occurred prior to the implementation of the Heat Action Plan and the Extreme Heat Early Warning system.
Michelozzi, P., F. K. de' Donato, A. M. Bargagli, D. D'Ippoliti, M. de Sario, C. Marino, P. Schifano, G. Cappai, M. Leone, U. Kirchmayer, M. Ventura, M. di Gennaro, M. Leonardi, F. Oleari, A. de Martino and C. A. Perucci 2010 34 major cities in Italy	There are two methods to identify and register at-risk subgroups: 1st method is used in 17 cities: population registries and data from health information systems, age, gender, civil status, number of family members and median population income for each census block of residents, and coupled with data on past hospitalizations, individual characteristics, classified into risk categories from low to very high; 2nd method, adopted in 6 cities: is based on the direct notification of GPs and social workers, taking into account demographic, health characteristics and living conditions	Since 2004, the Italian Department for Civil Protection and the Ministry of Health have implemented a national program for the prevention of heat-health effects during summer, comprising: - city-specific Heat Health Watch Warning Systems D3 (level 0/1/2/3) - a local network for the distribution of the warning bulletin and national prevention guidelines - local registries of at-risk subgroups of the population - a rapid "real-time" mortality surveillance system and - evaluation of warning systems and prevention activities targeting susceptible subgroups. Prevention activities to be implemented before the onset of summer, and actions to be activated during the pre-alerting days and during alarm/emergency periods. Each year, an education campaign on the risks of heat is carried out and information on preventive measures is available on the Ministry of Health website. Informative flyers are distributed to centers for the elderly, public places, local pharmacies, health centers and to GPs. During the summer, a national help-line, managed by medical personnel and trained operators, is activated to provide information on practical measures to reduce health risks during heat waves, on the occurrence of at-risk conditions, and about social and health services available in each city. Furthermore, during heat wave episodes, advice on heat stress avoidance is disseminated via the media. At the local level, training courses and workshops addressed to GPs, nurses, health care and social workers are organized to raise awareness of risks related to extreme heat waves and to prepare both institutions and personnel to mitigate the impact on health. - a telephone help-line or tele-monitoring, scheduled home visits, and delivery of pharmaceuticals provided by social workers or volunteers; AC spaces have been implemented in social centers for the elderly and residential care homes and opening hours are prolonged to provide relief for at-risk individuals. Health prevention activities involve hospitals, nursing homes, GPs and medical staff; emergency protocols, including measures such as postponing non-urgent surgeries, discharge planning during high risk periods, staff rotation restrictions, mobilization of at-risk patients to AC rooms; - active surveillance of high and very high risk patients by GPs, medical and social personnel; dedicated telephone line triggering a network of health and social services in case of an emergency: home visits, modulation in pharmacological treatment, home-based treatments, special attention towards at-risk patients	The Italian heat prevention plan has reached a national coverage to include 93% of the residents aged over 65 years living in major urban areas (2010). Regarding the level of implementation of specific measures and the local heat-prevention plans in Italian cities during the summer 2008 it was found that: 75-100% implemented: - a written local prevention plan - an educational campaign - a telephone help-line 50-75% implemented: - educational programs for social and health workers - health surveillance of susceptible individuals - local register of susceptible individuals - emergency protocols +<50% implemented: - availability of air-conditioned places (units in health and social centers)
Grewe, H. A. and D. Pfaffenberger 2011 Germany	Factors: exposure and susceptibility (biological, psychosocial, behavioral) Group: aged people in nursing homes, care dependency can hamper or rule out deliberate influence on thermal environment as well as behavioral adaptation during heat exposure.	Preventive approaches: Constructional measures: insulation, sun protection, AC Situative measures: reduction of exposure through room cooling, shading, relocation Nursing and medical measures that target the susceptibility of residents to heat - optimization of the electrolyte status, fluid status, function of the cardiovascular system, bodily heat release and bodily heat production of the body	Constructional measures would be the most efficient way for reducing exposure during heatwaves. Situative measures: ventilation during cooler night hours, shading of windows, utilization of air-conditioning or self-initiated seeking of cooler locations may be difficult for people in need of care with limited mobility or cognitive changes; also limited capacity to communicate thermal comfort or discomfort; external assessment of potential hazard and choosing measures reducing exposure as well as their implementation and evaluation. It was found that no protective effect of using fans can be guaranteed. Nursing and medical measures: cooling measures such as frequent washing by carers are effective, reduction of thermal isolation during heat exposure is limited in terms of clothing and contact with surfaces (e.g. if immobile, bedridden, etc.); sufficient hydration with electrolyte replacement is essential, this requires close collaboration of medicine and care with regards to initial risk assessment, monitoring of liquid status, electrolyte status, and body temperature and therapy. Thereby important is the surveillance and possible adjustment of existing medication (e.g. high amount of medication, often drug groups with proven effect on morbidity and mortality of elderly during heat stress). It is recommended that liquid and electrolyte status is checked and kidney functions (incl. creatinine clearance) as well as cardio-vascular parameter are checked prior to each individual therapy decision.
Bolitho, A. and F. Miller 2016 Australia	Multi-stress nature of heat vulnerability, affecting people's health and well being, financial situation, mobility, social relations, and access to basic services heat as emergency: focusing on preventing loss of life and severe health impacts	After the 2009 prolonged high temperatures and catastrophic bushfires, a National Strategy for Disaster Resilience was designed in 2009 at the federal level. Heatwaves can trigger an emergency situation if essential services such as energy supplies, public transport, and ambulance services break down, however they are not officially recognized as emergencies. On a state government level, a Victorian Heatwave Strategy 2007 resulting in the Heatwave Plan for Victoria 2009-2010 was developed. At the local government level, local heatwave plans were undertaken around 2009. The City of Melbourne, as part of the Summer Sense programme, provides general public information on how to keep cool during hot weather as well as who might be particularly at risk of hot weather, but does not seek to explain why these differences in vulnerability occur.	Extreme heat reveals deep-rooted social inequalities associated with access to quality housing, the availability of social services, social isolation, mobility and energy poverty. Social effects of extreme heat identified by stakeholders: - social isolation resulting from reduced social interaction (reduced home visits from family, carers, and service providers, reduced social visits and participation in activities outside the home; absence of family during hot periods due to coincidence of hot weather with holiday periods) - reduced mobility due to inaccessibility and discomfort of public transport (unshaded stops, no AC, etc.) - increased dependency on relatives, friends, and carers to assist with mobility, bathing, shopping, visits to health professionals and other appointments - stress on relationships and irritability - increase in domestic and street violence - impaired wellbeing, such as poor sleep, tiredness, and lethargy - energy stress, due to expenses of running AC
Berisha, V., D. Hondula, M. Roach, J. R. White, B. McKinney, D. Bentz, A. Mohamed, J. Uebelherr and K. Goodin 2017 Maricopa Country, Arizona, US	Cooling centers target vulnerable community members, such as seniors, low-income families, and homeless persons who may not have access to AC or other cooled spaces	Evaluation of 53 cooling facilities in Arizona. The cooling centers were evaluated on the basis of their operations, services, costs, utilization, capacity, accessibility, communications strategies and populations served; objective information on facility type, location, visibility, accessibility, capacity, utilization and amenities was collected; The cooling centers have the aim to provide an accessible cooled space for the community during heat waves provided free bottled water - a lot of facilities were categorized as community, senior or religious centers; others were operating within government office buildings, private business spaces, non-profit organizations, parks and recreation buildings, homeless shelters, or other venues; - other services within the cooling centers were access to restrooms, vending machines, food and snacks, electrical outlets, wireless Internet access, indoor recreation or play areas, and books, magazines or games, social services included community adult education, child care/childhood education, employment and financial services, and religious services	Most cooling centers operated in facilities that already provided health or human services for the community - facilities tended to operate the cooling center during normal weekday hours of but with summer overnight temperatures often >80°F individuals were left vulnerable to night time heat stress - only 3 facilities opened on weekends - 78% visited cooling center to use the primary services provided rather than seek refuge from heat, up to 2,000 individuals used cooling centers each days, appeared to reach some of the region's most vulnerable populations: unemployed, without permanent residence, no reliable access to home AC and/or chronic medical condition; half of respondents did not believe high summer temperatures would put their health at risk
Riley, K., L. Delp, D. Cornelio and S. Jacobs 2012 California, US	The campaign targeted outdoor workers, given the seasonal nature of hot weather conditions and the importance of acclimatization, fatalities occur often among workers in agriculture. Overall, work-related heat hazards disproportionally impact immigrants and minorities	The goal of the state-wide campaign was to raise awareness of the heat illness standard among employers, workers, and worker advocates in targeted high-hazard industries such as agriculture and construction, and ultimately prevent heat illness among all workers in outdoor settings. In the study first a needs assessment was conducted and educational materials was developed and a social marketing campaign targeted worker communities in 5 languages; then trained workers, community members, and employer representatives about employer obligations to provide water, shade, breaks, training and an emergency response plan; additionally other outreach and educational efforts; The intervention mainly focused on education as a means to address workers health concerns. Labor Occupational Safety and Health Program lead in Southern California, 3 health promoters conducted outreach to community organizations, co-facilitated education and training, 70 community organizations sponsored staff members, community and worker leaders to participate in Train-the-Trainer courses to become peer trainers, 159 peer trainers participated in courses then educated workers, thousands of workers in workplaces and community received information, resources, and/or training from peers.	Safe work practices to avoid heat illness seem straightforward (e.g. drinking water frequently, taking rest breaks in the shade, and recognizing and responding to early symptoms), but factors at multiple levels constrain their adoption: - negative incentives of the piece-rate system - low-wage and non-English-speaking workers share an increased risk of heat illness due to factors common to the immigrant experience - limited knowledge of their legal rights - lack of resource materials in their native language or at the appropriate literacy level - economic demands to support family members in their native countries - many fear employer reprisals in the form of job loss or potential deportation and have a basic mistrust of government entities There is a need for a standard in employer's commitment.