Prevention of Heat-Related Illnesses

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Extreme temperatures are known to have negative consequences on the environment and the ecosystem. Already more frequent and intense heat waves are likely to increase in the future due to a projected 0.1–0.2-degree Celsius rise in temperature by 2100. Extreme heat can lead to a spectrum of health-related conditions that range from mild to severe and include, but are not limited to, heat dehydration, cramps, exhaustion syncope and stroke; these are referred to as heat-related illnesses (HRIs).

Keywords: heat wave ; heat-related illnesses ; urban settings ; heat warning system

1. Introduction

Extreme temperatures are known to have negative consequences on the environment and the ecosystem [1]. Already more frequent and intense heat waves are likely to increase in the future due to a projected 0.1–0.2-degree Celsius rise in temperature by 2100 [2][3][4]. Extreme heat can lead to a spectrum of health-related conditions that range from mild to severe and include, but are not limited to, heat dehydration, cramps, exhaustion syncope and stroke; these are referred to as heat-related illnesses (HRIs) [5]. Without appropriate cooling strategies, extreme heat overextends the body's capability to regulate its temperature, which can then lead to cardiovascular and/or respiratory compromise, multi-organ failure, impaired coagulation, loss of consciousness, stroke and even death [6].

The World Health Organization (WHO) estimates that 166,000 deaths have occurred from 1998–2017 due to heat-related illnesses [7][8][9][10]. The 2003 heat wave in Europe increased this number alone with an estimate of 70,000 deaths, while Russia saw 56,000 deaths in the heat wave of 2010 [11]. Other parts of the world have seen similar trends due to heat waves, especially in countries closer to the equator. These countries already experience higher temperatures at baseline, making them more likely to bear the impacts of even small increases in average temperature [12]. Countries in South Asia such as India and Pakistan have experienced heat waves that resulted in thousands of excess deaths [13][14].

The WHO and World Meteorological Organization (WMO) collaborated to produce a technical guide as an aid for governments to set up an early warning system for heat waves [15]. While governments in some HICs were able to implement these, other countries, especially those in low resource settings, have not been able to set up systems to mitigate the impacts of extreme heat. In areas where governments do not have resources to drive heat response, communities must make changes to their environment and behaviors to reduce the impact of extreme heat exposure.

2. Analysis on Results

Of the 17 articles that were included in the final review, 14 articles were based in HICs, while three were based in LMIC settings. Most (10 out of 17) articles covered community-based interventions in the form of heat action plans and six were from Europe, which had been established by respective local and national governments in response to the 2003 heat wave. The studies ranged from randomized trials (n = 2), non-randomized or quasi-experimental analyses (n = 6) to observation or secondary data analyses. Variations in health outcomes reported, the assessment of knowledge, attitude and practices, sample populations, and data sources were observed (**Table 1**).

Table 1. Summary of studies on community-based heat-related interventions in urban settings.

Author	Location	Study Design	Sample Population	Sample Size	Intervention Type	Primary Outcome	Comparator (If Any)	Quality	Results
Mattern 2000	United States	Cross-sectional study	Elderly above 65 years of age	34	Health education, culturally sensitive and age-specific heat-related manual	Risk factors for heat-related mortality	Same population before intervention	Good	67% (pre-test) versus 94% (post-test) knew of a contact for assistance during hot weather
Sheridan 2007	United States	Survey	Adults 65 years and above in four North American cities	908	Heat Mitigation Plan	Knowledge	NA	Good	Post-survey, knowledge—90% Behavior modification—46%
Fouillet 2008	France	Cohort study	Whole population of France	NA	Awareness; National Heat Wave Action Plan	Excess mortality	Same population before intervention	Good	Expected excess mortality ratio was +27% whereas observed excess mortality ratio was +9%, with an estimated mortality deficit of 2065 deaths
Oakman 2010	Australia	Observational study	All individuals above 18 years of age living in the area	328	Media awareness	Knowledge, attitude and practice	NA	Good	54% changed their summer behavior Self-rated understanding of the heat health risks at 7.9 on a 10-point scale, higher than same time last year
Morabito 2012	Italy	Cross-sectional study	Elderly above 65 years of age	21,092	Heat Health Warning System (HHWS)	Heat-related mortality	Same population before intervention	Good	Reduction in mortality rate observed only for 75 years and above, only when the maximum temperature time period was considered
Schifano 2012	Italy	Pre-post intervention study	Elderly above 65 years of age	50,000 to 2.5 million in the different cities	National heat health prevention program	Heat-related mortality	Same population before intervention	Good	Reduction in elderly mortality from +36.7% to +13.3% with increase in temperature from 9 °C to 12 °C above the 25th percentile
Pascal 2012	France	Statistical modeling	NA	~11 million	Heat warning system	Relative risk of mortality	NA	Good	Implementation of heat-action days was associated with a combined loss of relative risk of mortality by −3.3% (95% CI −10.3–4.4)

Author	Location	Study Design	Sample Population	Sample Size	Intervention Type	Primary Outcome	Comparator (If Any)	Quality	Results
Takahashi 2015	Japan	Randomized controlled trial	Elderly 65 to 84 years of age	1072	Heat health warnings and distribution of water bottles	Knowledge, attitude and practice	No intervention group	Fair	Improvement in the frequency of water intake (p = 0.003) Improvement in frequency of cooling body (p = 0.002) Improvement in the frequency of taking a break (p = 0.088), Reduced activities in the heat (p = 0.093) Increase in hat or parasol use (p = 0.008)
de'Donato 2015	Europe	Quasi-Experimental	Deaths that occurred in 9 European cities	1,322,844	Heat Action Plan	Attributable number of deaths	Same population before intervention	Good	In terms of heat attributable mortality, 985, 787 and 623 fewer deaths estimated in Athens, Rome and Paris, respectively. A reduction in mortality risk associated with heat observed only in the three aforementioned cities.
Benmarhnia 2016	Canada	Quasi-Experimental	All residents of the island of Montreal	NA	Advisories and emergency public health measures	Heat-related mortality	NA	Good	Daily deaths reduced by an average of 2.52 deaths per day after implementation of the heat action plan
Nitschke 2017	Australia	Randomized controlled trial	Elderly above 65 years of age	637	Awareness; Evidence-based information leaflets	Behavior	No intervention group	Good	Intervention group had significant increases in: air conditioner use during hot weather (74.4% versus 63.4%) the use of a wet cloth on face, neck or body to cool down during heat waves (16% vs. 8%) the belief that they had enough information to beat the heat (94% vs. 88%)

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Author	Location	Study Design	Sample Population	Sample Size	Intervention Type	Primary Outcome	Comparator (If Any)	Quality	Results
Hess 2018	India	Time series analysis	People living in Ahmedabad city	Entire population	Awareness and Health Intervention, Heat Action Plan (HAP)	Risk ratio	Pre intervention period, same population	Good	Post-to-pre-HAP non-lagged mortality IRR for maximum temperature over 40C was 0.95 (0.73–1.22) and 0.73 (0.29–1.81) for maximum temperature over 45C. An estimated 2380 deaths post-intervention were avoided
Xu 2018	China	Quasi-experimental	All individuals above 60 years of age living in the area	2400	Healthcare networks	Knowledge, attitude and practice	No intervention group	Fair	Intervention groups had 0.387, 0.166 and 0.037 higher knowledge, attitude and practice scores, respectively
de Donato 2018	Italy	Time series analysis	People residing in 23 Italian cities	NA	Awareness and Health Intervention;Italian National Heat Plan	Attributable number of deaths	NA	Fair	For extreme temperatures, The attributable fraction of heat-related deaths declined from 6.3% in the period 1999–2002 to 4.1% in 2013–2016. More than 1500 heat attributable deaths spared
Liotta 2018	Italy	Non-randomized experimental study	Elderly above 75 years of age	12,207	Social intervention: The Long Live the Elderly (LLE) program to reduce social isolation	Heat-related mortality	No LLE urban areas	Good	Cumulative mortality rates of 25% (CI 95%: 23–29) and 29% (CI 95%: 17–43) in LLE versus non LLE urban areas, respectively
Martinez-Solanas 2019	Spain	Time series analysis	People living in Spain	NA	Prevention Plan;Spain's National Heat-Health Prevention Plan (HHPP)	Attributable number of deaths	Same population, pre-intervention	Good	There was a small decrease in mortality attributable to extreme heat (from 0.67% to 0.56%), which was offset by an increase in mortality attributable to moderate heat (from 0.38% to 1.21%). Most significant reduction seen among older individuals.

Author	Location	Study Design	Sample Population	Sample Size	Intervention Type	Primary Outcome	Comparator (If Any)	Quality	Results
Scortichini 2018	Italy	Time series analysis	Residents in 23 Italian cities	NA	National heat health warning system. Time mortality surveillance systemIdentification of susceptible individuals and treatment	Mortality rateAttributable number of deaths	Same population, pre-intervention	Fair	The effect of extreme temperature reduced after all cities implemented the heat action plan (RR 1.23, 95% 1.15–1.32). Attributable number of deaths reduced from 6.3% to 4.1% (1200 units) during periods of extreme temperature

The chosen articles elaborate on (1) the establishment of heat action plans and (2) education and awareness campaigns while accommodating age and need-appropriate dissemination of heat-specific preventive actions as effective interventions in reducing the burden of heat-related illnesses.

Heat action plans were implemented mostly in high-income countries across Europe, in Canada and in Japan, and comprised of activities including, but not limited to, establishing a heat monitoring system, also known as the heat health watch warning system, informative campaigns for the general population, the mobilization of health care professionals, volunteers, social workers and trained caregivers in the surveillance and management of individuals with known vulnerabilities, as well as the provision of required infrastructure to cope with extreme temperatures. One study reported the implementation and evaluation of a heat action plan in a low- and middle-income country, India [16].

Some studies conducted awareness sessions within the community settings that contained guidelines on preventing heat stress, providing information on high-risk population groups (vulnerable groups such as children and the elderly) and provisions for resources to use to prevent heat illness, among other topics, aiming to improve the community's knowledge, attitudes and perceptions towards the prevention of heat stress. Like heat action plans, these studies were also administered in high- and middle-income countries such as China, the United States and Australia, but the medium used to disseminate the information differed from study to study, as highlighted below, with varying efficacy.

3. Current Insights

Heat prevention programs were seen to focus on the development and implementation of heat action plans that required multi-sectoral engagement. The studies highlight the fact that local, regional, and national governmental agencies need to take ownership of heat action plans and lead other relevant institutions such as health care facilities, community homes, volunteer and social networks, among others, to manage multiple components of a multi-pronged heat action plan.

Another important aspect in the prevention of HRIs and successful heat prevention plans is the regular surveillance of variable temperatures throughout the year. Prior knowledge of impending extreme temperatures can facilitate the initiation of prevention strategies as well as early installment of programs such as relief camps. We encourage more collaboration of governments with the World Meteorological Organization to determine appropriate heat health warning systems to better classify and forecast heat emergencies on a more consistent and reliable basis [17].

While this entry provides a menu of sorts on the packages of interventions that can be created to have a mitigating effect on the impact of extreme heat on human health, the lack of evidence around the effectiveness of these interventions in low-resource settings cannot be undermined. It is worthwhile to investigate the real-time impact of such interventions in low-resource settings as well as conduct studies to tease out the most beneficial package of interventions that are most effective, both in health outcomes and cost structures.

4. Conclusions

For heat prevention plans to be implementable and successful, they need to be cost-effective, easy to maintain, ideally should not rely on a mass effort from people and should be specifically structured to meet the local needs and resources of the community. Most robust programs and their associated effectiveness as well as cost-effectiveness studies are

needed, specifically in low-resource settings, to mitigate the effect of extreme heat conditions as well as understand the health and economic impacts of such interventions in the long term.