Temperature Impacts on Health, Productivity, and Infrastructure in the Urban Setting, and Options for Adaptation

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ABSTRACT

Heat waves and warming temperatures pose a serious threat for human settlements worldwide, especially in urban environments. Research shows that increased temperatures, coupled with the urban heat island effect, can have a crippling effect on both biological and infrastructure systems. As the number of people living in cities continues to increase, so does the vulnerability of target groups susceptible to the impacts of heat. In an attempt to better understand the risks involved, the author explores literature surrounding the implications of heat including morbidity, mortality, work productivity, and system failures. In addition, the author highlights potential options for adaptation, which scale from the individual level to that of policy implementation, as well as the importance of managing impacts from a multi-stakeholder perspective.

INTRODUCTION

Heat waves and warming temperatures pose a serious threat for human settlements worldwide, especially in urban environments. Establishing a better understanding of the risks involved requires an in-depth look at not only the direct effect that heat has on human health, but also the indirect costs related to losses in economic opportunities as well as infrastructure and energy security. This paper highlights the effects that temperature has primarily on urban dwellers by examining historical records of morbidity, mortality, work productivity, and system failures. In addition, it attempts to aggregate the impact that increasing temperatures will have on our economic futures and what, if anything, can be done about it. Refer to Table 1 for a summary of key findings.

At the global scale, there has been a decrease in the number of cold days and nights, and an overall increase in the number of warm days and nights (IPCC, 2012). Although warmer temperatures may decrease deaths attributed to cold temperatures, the overall impact of temperature-related

TABLE 1

KEY FINDINGS

IMPACT	REFERENCE
Mortality	
Extreme heat events are considered not only one of the most underrated weather hazards, but have, in fact, killed more people than any other disaster in the United States as well as Australia.	(Borden & Cutter, 2008; EPA, 2004; Hanna et al., 2011)
Mortality in the U.S. increased 5.04% during the first heat wave of the summer but only 2.65% during later heat waves, when compared to non-heat wave days.	(Anderson & Bell, 2011)
For every 1ºF increase in heat wave intensity, there is a 2.49% increase in risk of death in the United States.	(Anderson & Bell, 2011)
Every one-day increase in heat wave duration results in a .38% increase in mortality risk in the United States.	(Anderson & Bell, 2011)
Assuming a 2ºC increase in temperature by 2050, temperature-related years of lost life are expected to increase by 381 in Brisbane, Australia. A 4ºC increase in temperature by 2050 is projected to have an increase of 3,242 temperature-related years of lost life in Brisbane.	(Huang et al., 2012)
Work Productivity	
In 2070, leisure activity for acclimatized people will not be possible 5-14 days per year, and manual labor for 15-26 days per year in Perth, Australia.	(Maloney & Forbes, 2011)
Over the past few decades, heat stress has reduced global labor capacity to 90%. By 2050, labor capacity is projected to reduce to 80%, and by 2200 it is estimated to be 39%.	(Dunne et al., 2013)
Water loss of 1–2% of body weight can reduce labor capacity by 6–7%, however, a deficiency of 3–4% will reduce labor capacity by 22% .	(Hanna et al., 2011)
Economic Analysis	
On average, a reduction of 1% in labor capacity results in a 0.75% loss of income globally.	(Kjellstrom et al., 2009b)
Assuming a 2ºC increase in temperature results in AUD $278 million annually in costs, which is AUD $15 million more than Australia's current costs for temperature-related deaths. For a 4ºC increase in temperature, annual health costs are estimated to be AUD $393 million, a rise of AUD $130 million from baseline costs .	(Huang et al., 2013)

mortality remains uncertain. Part of this uncertainty stems from the lack of a universally accepted definition for heat wave. Varying thresholds for temperature and duration of heat waves hinder proper comparison and synthesis of results, which in turn restricts the ability to monitor such events (Anderson & Bell, 2011; Nairn & Fawcett, 2013). What is agreed upon is that increased temperature and exposure to heat are associated with increased rates of mortality and morbidity (Basu & Samet, 2002; Huang et al., 2011; IPCC, 2007; Kovats & Ebi, 2006; McGeehin & Mirabelli, 2001). Past events show how heat can have a crippling effect in urban settings. The 1995 heat wave in Chicago resulted in over 500 heat-related deaths (Whitman et al., 1997). In the summer of 2003, Europe's heat wave claimed 70,000 lives (Robine et al., 2008), 15,000 in France alone (Fouillet et al., 2006). Current statistics for 2013 indicate that 760 people in England (Whipple, 2013) and 1,453 in India (The Hindu, 2013) have suffered from heat-related mortality this year alone. Target groups most susceptible to heat include the elderly (Green et al., 2001); laborers and those working outside (Hanna et al., 2011; Kjellstrom et al., 2009b); the poor and socially isolated (Curriero et al., 2002; Rey et al., 2009; Jabeen & Johnson, 2013); those with poorly constructed houses (Chapman et al., 2009); those lacking air conditioning and living on the top floor (Curriero et al., 2002); and urban dwellers (Harlan & Ruddell, 2011).

High ambient temperatures can place tremendous stress on the human body. During periods of heat exposure, the body responds with thermoregulatory functions, sweating being the primary mechanism. If core body temperature exceeds 37°C for sustained periods, hyperthermia can ensue. Thermal comfort is controlled primarily by six parameters, which include: (i) air temperature, (ii) radiate temperature, (iii) humidity, (iv) air velocity, (v) clothing worn, and (vi) the person's activity (Parsons, 2003). While the first four parameters are conditions of the thermal environment and cannot be altered, the last two parameters are behavioral characteristics that can be modified. This presents an opportunity for reducing risk by changing behaviors. Furthermore, establishing a better understanding of the health impacts and economic costs of heat exposure will help to catalyze management and reduction of heat exposure for vulnerable populations.

MORBIDITY AND MORTALITY

Extreme heat events are considered not only one of the most underrated weather hazards, but have, in fact, killed more people than any other disaster in the United States as well as Australia (Borden & Cutter, 2008; EPA, 2004; Hanna et al., 2011). In terms of its effect on human morbidity, elevated temperatures are associated with increased rates of renal, cardiovascular, and respiratory disease, along with heat stroke, hyperthermia, and nervous system failure (Baccini et al., 2008; Hansen et al., 2008). In addition, evidence indicates that heat impairs decision-making, physiological functioning, mood, and behavior (Bi et al., 2007; Hanna et al., 2011).

Despite the physical strain that excessive heat can have on the body, humans prove to be highly resilient in the realm of hazards. In environments with high ambient temperatures, people are able to acclimate themselves in order to cope with the heat. However, this takes time and recurrent exposure (Hajat et al., 2010; Hanna et al., 2011). The process of acclimation may explain why the impacts of high temperatures are greater during the first heat wave of the summer compared to subsequent heat waves that same summer. In a study conducted by Anderson and Bell (2011), mortality increased 5.04% during the first heat wave of the summer but only 2.65% during later heat waves, when compared to non-heat wave days. This leaves individuals who are not able or choose not to expose themselves for a specific amount of time that is required to acclimate (i.e. tourists, those using air conditioning, seniors, and the immobile) vulnerable to heat exposure.

While it is apparent that the timing (mentioned above) of heat waves plays a role in mortality risk, analyzing recent heat waves in the United States highlights the impact that intensity and duration have as well. For every 1ºF (0.6°C) increase in heat wave intensity, there is a 2.49% increase in risk of death. Furthermore, every one-day increase in heat wave duration results in a 0.38% increase in mortality risk (Anderson & Bell, 2011). Although these current impacts are significant, what can we expect in the future in a world committed to a 2.4ºC increase in temperature (Ramathan & Feng, 2008)? In attempting to show the impact temperature has on mortality in Brisbane, Australia, Huang et al. (2012) projects how temperature-related years of lost life will increase significantly by 2050 if global temperatures continue to rise without any response in adaptation. Temperature-related years of life loss is an indicator of premature mortality. It accounts for fatal cases by the age at which deaths occurs, giving greater weights to deaths at younger ages. Assuming a 2ºC increase in temperature by 2050, temperature-related years of lost life are expected to increase by 381. A 4ºC increase in temperature is projected to have an increase of 3,242 temperature-related years of lost life. Additionally, applying the threshold of AUD $40,000 per year of life, as Huang et al. (2013) did, generates significant future health costs. Assuming a 2ºC increase in temperature results in AUD $278 million annually in costs, which is AUD $15 million more than the current costs for temperature-related deaths. For a 4ºC increase in temperature, annual health costs are estimated to be AUD $393 million, a rise of AUD $130 million from baseline costs (Huang et al., 2013).

Although these estimates are country specific, in this case Brisbane, Australia, assessing future health impacts and expenditures is necessary for adaption. Accurately doing so, however, can prove difficult. Determining the magnitude of heat-related morbidity and mortality is challenging due to a number of uncertainties and weakness in underlying health data. First, there exist varying criteria for determining heat-related deaths (CDC, 1995; Donoghue et al., 1997). Lack of a standardized definition may even result in heat not being listed on death certificates as the cause or contributor to mortality (Basu et al., 2002). This has led to the notion that such impacts are widely underestimated (Shen et al., 1998).

INFECTIOUS DISEASES

One pathway affecting transmission of infectious disease is climatic conditions, which includes temperature (Bennett & McMichael, 2010; Patz et al., 2007). While there are links between warming temperatures and range expansion for infectious diseases, the impacts it will have on biodiversity and human health are not fully understood (Altizer et al., 2013; Harvell et al., 2002; McMichael et al., 2006). With this, however, research does suggest that higher temperatures, within a given threshold, do affect vectors and pathogens. Dengue virus, cholera, salmonella, and mosquitoes carrying malaria and Japanese encephalitis are all known to proliferate faster in warmer temperatures (Bi et al., 2007; McMichael et al., 2006). Also, increased heat in Bangladesh was linked to greater risk of water-borne diseases, including typhoid and diarrhea, due to increased water shortages (Jabeen & Johnson, 2013). In the United States, a widespread outbreak of West Nile virus (WNV) occurred in 2012 when 5,674 cases were reported (CDC, 2013). In an attempt to understand what caused the outbreak, researchers analyzed the last two outbreaks of WNV in Dallas, Texas, and determined that each was preceded by unusually mild winters followed by a wetter, earlier spring (Chung et al., 2013).

The impacts of infectious disease can be detrimental to the financial stability of households. Productivity declines as a result of lost workdays. This, coupled with medical costs, can place enormous pressure on families. Areas with endemic disease often face both social and economic costs at the macro level. High rates of child mortality may result in changes to the population-age structure and lower rates of academic achievement, as well as lost opportunities in tourism, trade, and foreign investment (Bennet & McMichael, 2010; Patz et al., 2007; Sachs & Malaney, 2002). According to Gallup and Sachs (2001), countries where malaria is pandemic have a 1.3% lower economic growth rate per year, even after taking income, health, and location into account. Furthermore, countries that reduced malaria by 10% saw a rise of 0.3% in annual economic growth.

WORK PRODUCTIVITY

As mentioned above, increased temperatures can directly and indirectly affect one's physical health, but what impact will this have on productivity and work capacity? Consequences of elevated temperatures in the work force range from poor decision making, psychological distress, diminished labor capacity, and increased risk of accidents (Hanna et al., 2011; Ramsey, 1995; Tawatsupa et al., 2010). Heat stress in humid environments, specifically, can have an enormous impact on labor capacity. Dunne et al. (2013) estimated that over the past few decades, heat stress has reduced heavy labor capacity to 90%. By 2050, labor capacity is projected to reduce to 80%, and by 2200 it is estimated to be 39%. Dunne et al.'s estimates were based on empirical data to derive a formula which they then used. Furthermore, while these estimates are a global assessment for acclimatized populations, one cannot assume that reduced labor capacity is distributed evenly. Populations living in the tropics and mid-latitudes with increased humidity will be affected disproportionally to those living at higher latitudes. According to the models produced by Kjellstrom et al. (2009b), losses in labor productivity for South Asia by the 2080s will amount to 7.5%. In Delhi, the capacity to perform at a heavy labor intensity for extended hours is very low, with 20% labor capacity remaining by mid afternoon (Kjellstrom et al., 2009a). In hot environments, sweat loss can lead to dehydration and, therefore, diminish work capacity if the body does not replace lost fluids. Water loss of 1–2% of body weight can reduce labor capacity by 6–7%, however, a deficiency of 3–4% will reduce labor capacity by 22% (Hanna et al., 2011). The risk of dehydration for individuals raises questions regarding water access and vulnerable communities that have decrepit infrastructure. Maloney and Forbes (2011) modeled the effect that increased temperatures will have on the human heat balance in 2070. Their results show a significant increase in the number of days where outdoor activity is not possible due to risk of hyperthermia. Not only will this affect leisure activity, but also severely impact the economic and health sectors. Table 2 illustrates their results.

TABLE 2

RISK OF HYPERTHERMIA IN PERTH, AUSTRALIA, NOW COMPARED TO 2070

		Present year	Year 2070
In shade	Acclimatized	1 day/ 10 years	1 day/ year
	Unacclimatized	1 day/ 5 years	9 days/ year
At rest, exposed to sun	Acclimatized	1 day/ 5 years	8 days/ year
	Unacclimatized	4 days/ year	36 days/ year
Moderate activity	Acclimatized	1 day/ 2 years	17 days/ year
	Unacclimatized	13 days/ year	58 days/ year
Physical Labor	Acclimatized	4 days/ year	34 days/ year
	Unacclimatized	31 days/ year	94 days/ year

Source: Adapted from Maloney & Forbes, 2011.

In order to prevent overheating, workers must self-pace themselves by working less or by reducing labor intensity (Hanna et al., 2011; Kjellstrom et al., 2009b). In either case, work productivity is reduced. When temperatures exceed 85ºF (29.4°C) in the United States, workers with high exposure to climate reduce their labor on average by one hour (Zivin & Neidell, 2010). According to Kjellstrom (2009), automobile factories in India attempt to offset lost productivity by employing additional workers and accepting fewer orders in factories. However, this increases costs, and therefore, limits economic potential for both workers and employers, as noted by Kjellstrom et al. (2009b), who claims that a reduction of 1% in labor capacity results in a 0.75% loss of income.

IMPACTS OF HEAT IN THE URBAN SETTING

The impacts of increased temperatures constitute a greater risk for individuals living in the urban environment, due in part to the urban heat island effect. Because cities are packed with buildings, roadways, and other dark surfaces, they contain a high thermal mass and absorb large amounts of solar radiation. Densely packed buildings prohibit ventilation, and lack of green space and vegetation limits shading and evapotranspiration (EPA, 2008). This, coupled with air pollution, causes temperatures in cities to be higher than surrounding rural areas (Oke, 1982; Aniello et al., 1995). Urban sprawl further exacerbates the issue by not only expanding the range of the urban heat island, but also the intensity of its effect (Frumkin, 2002). In addition, urban sprawl makes individuals reliant on automobiles for transportation, thus increasing pollution/emissions. Densely packed cities are beneficial in that they promote active transportation, such as walking or biking. However, what happens when temperatures get so hot that people are unable to commute due to heat-related health risks? Moreover, how will people who work outside compensate for lost income? While policies and safety nets are in place for some countries, many people are forced to rely on personal resourcefulness.

INFRASTRUCTURE AND SYSTEM FAILURES

Aside from the impacts that elevated temperatures have on human health, its effect on infrastructure poses potential challenges for cities. Excessive heat has the ability to strain water and energy systems, transport networks, utilities, and housing settlements. Last year, a weak monsoon in India caused temperatures in the country to be higher than normal. Low hydroelectric generation could not keep up with the power demand resulting in the country's largest electrical blackout in history. Approximately 670 million people were left without power when the grid collapsed (Yardley & Harris, 2012). In the United States, there are reports of airplanes getting stuck in asphalt that had softened as a result of intense heat, along with train derailments as a result of heat-related kinks in the rail tracks (Wald & Schwatz, 2012). High ambient temperatures can decrease the efficiency of electrical transmission and distributions systems and can create possible cascading effects (DOE, 2013). Nuclear power plants have had to request permission to continue operating after elevated water temperatures in the cooling pond exceeded 100ºF (37.8ºC) (Wald, 2012).

On days of extreme heat, most people remain indoors in order to stay cool. The built environment, however, can have adverse effects on health. Poor indoor conditions, resulting in increased rates of allergies, asthma, and respiratory disease, currently cost the United States economy billions of dollars (Fiske, 2000). As future temperatures are projected to increase, the indoor environment will soon play a more crucial role than ever before, forcing us to address its effect on our health. Current research bridging the effects of climate change on human health in the indoor environment remains limited (Institute of Medicine, 2011). However, information on the cost-effectiveness and health benefits of improved building insulation is emerging. Chapman et al. (2009) estimated that the benefits for installing insulation in a house were $3,374 compared to the costs of $1,800. Savings came from avoided costs in the health and energy sector, including decreased lost-work days as well as the benefits of reduced emissions. However, further research is needed to determine future impacts of a changing climate on the indoor environment. Effective policy decision-making requires such research, as does involvement from multiple sectors.

THE OPTIONS FOR ADAPTATION

Because heat has a significant effect on human health and research suggests we are committed to at least a 2.4ºC increase in temperature (Ramathan & Feng, 2008), a variety of coping and adaptation mechanisms must be explored. Furthermore, varying political, social, and environmental conditions influence whether or not a specific measure is effective. What may prove successful in one area may be impractical in another. Careful analysis of the various options is required, in addition to evaluating existing adaptation measures.

CHANGING BEHAVIORS

Possibly the most cost-effective measure for coping with elevated temperatures is the decision to change behavior. In parts of the world, intense heat has already forced communities to adapt by altering work schedules, attire, and even social settings. For example, siestas, or periods of rest, are taken during the hottest part of the day when work productivity is low. Also, the 2022 World Cup will be held in Qatar where temperatures can reach 50ºC in the summer. Due to obvious health risks for both players and spectators, many support the decision to hold the tournament in the winter (Gibson, 2013). Doing so would completely alter the sport's summer tradition but may be the only practical solution if countries with extreme temperatures continue to host such tournaments. In Bangkok and parts of India, night markets are set up to allow individuals to shop when temperatures are less severe. In an attempt to completely escape the heat during the daytime, the Philippines, Thailand, and Singapore have all built underground malls. When determining if certain behavioral changes are practical in a given region, it is necessary to account for political motives, social customs, and economic feasibility. Effective change is only possible with community support and adequate funding, and thus, cannot be scaled across countries.

AIR CONDITIONING: THE GOOD, THE BAD, AND THE UGLY

When temperatures become uncomfortably high, the initial reaction for many is to use an air conditioner. Doing so has the obvious benefit of immediate heat relief, but also reduces humidity, and thus, the possibility of transmission of infectious diseases and mold (EPA, 2012). However, air conditioning is neither a sustainable option nor is it a feasible strategy for poor communities (Brown & Walker, 2008; Luber & McGeehin, 2008). In addition to high utility costs required to operate these units, air conditioning is not practical in developing countries where there is a lack of basic infrastructure and where electricity may already be limited. Furthermore, air conditioning prevents people from acclimating, leaving them vulnerable to heat stress and other related health risks (i.e., when they do go outside, lose power, etc.). On a larger scale, air conditioners exacerbate the urban heat island effect by emitting heat in response to its cooling effect while at the same time increasing emissions. Additionally, they have shown to strain the power grid, leading to load shedding and blackouts (Maller & Strengers, 2011).

URBAN INGENUITY: DESIGN, PLANNING, AND TECHNOLOGIES

Another viable route for improving adaptive capacity in hot urban settings is through urban planning and design. Building orientation, design, and materials can be applied in ways that minimize the impact of excessive heat (Haung et al., 2013). Ventilation indoors as well as between buildings can be promoted through urban planning and design. Building materials, such as straw bale, have exceptional structural capacities as well as insulation properties that can handle thermal stress of hot and cold temperatures (NEES Consortium, 2005). Exploration of alternative design options is critical and must involve both modern innovation and traditional practices that rely on resourcefulness. In Dhaka, Bangladesh, Jabeen et al. (2010) explored coping strategies against heat at the household level. Roofing materials for many houses consist of corrugated iron sheets, making indoor temperature extremely hot. To reduce heat exposure, low-income households use substitute insulation material consisting of old clothes, cement bags, styrofoam, bamboo mats, and packing boxes as well as cover courtyards with leafy vines known as "creepers." In addition, poor families trade off between a light and fan in order to keep utility costs down.

Green Space and Vegetation

The importance of green space and incorporating it into urban planning and design is equally important when addressing health management in hot, humid cities. Not only do trees and green spaces provide shade and improve air quality, they also help to lower temperatures through evapotranspiration (Huang et al., 2013). Urban vegetation can also help mitigate certain hazards, including flooding and runoff (Sanders, 1986). Lastly, green space plays a role in a community's perceived health. The more access a person has to green areas, the greater their perceived general health. Socially isolated individuals benefit more from the presence of green space, possibly due to the social cohesion that these areas foster (Maas et al., 2006). While the benefits of green space are noteworthy, the costs should be explored as well. In urban settings, land holds a high monetary value and the space needed for green areas means lost economic opportunities. Furthermore, in a warmer climate, will people want to spend time outside or will they, instead, choose to stay indoors? Additional research is needed to explore the benefits and costs of green spaces and their influence on the economy, perceived health, and hazard mitigation.

Technology and Innovation

Excessive heat is already a problem for many cities around the world. Researchers attempt to combat increased temperatures through various mechanisms, including technological innovation. While some of the science and engineering being put forth does not seem cost-effective, other strategies have more potential. The 2022 World Cup will be held in Doha, the capital of Qatar. Because it is a city known for its extreme temperatures, scientists and engineers are looking at ways for reducing heat-related risks. They designed a solar powered artificial cloud that can be maneuvered via remote control. The lightweight carbon structure will provide shading to players and fans in the stadium as it hovers over the arena (Liggett, 2011). While this design displays ingenuity, is it worth US $500k, and more importantly, can it be replicated in additional cities? A more practical application when addressing heat may come from nanostructured photonic materi-als, as described in Rephaeli et al. (2013). Scientists at Stanford developed a new type of cooling structure that works in full sunlight. Buildings are able to passively cool themselves, even during high daytime solar radiation. Test results show that the structure can achieve a net cooling power of 100 W/m2. This implies that a single-family household can offset its air conditioning needs by 35% if the radiative cooling panels cover just 10% of the roof (Rephaeli et al., 2013). Because it does not require electricity to use, it can be used off the grid, thus, harnessing great potential for developing countries.

POLICY: ACTIONS, PLANS, AND RESPONSE

In order to promote effective risk management strategies, decision makers need to know the actual burden of temperature-related morbidity and mortality. Politicians and society are less likely to promote legislation that consists of preventative measures (Huang et al., 2013). This is due, in part, to the notion that the rewards of passing such legislation are not immediately apparent and require time to manifest. Therefore, a more impactful strategy is the implementation of co-benefit policies. By promoting active transportation, fewer automobiles will be used. This will not only decrease emissions and minimize the impact of the urban heat island, but will also carry over health benefits from reduced pollution and active transport (Harlan & Ruddell, 2011).

Warning Systems

As with any other natural hazard, warning systems for heat waves and the various effects of increased temperatures are vital for mitigating health risks. Data from requested ambulance vehicles, helplines, and fire department dispatches are routinely gathered and readily available. Some suggest that this information can be used to monitor the initial effects of heat waves in order to prevent a larger disaster (Hajat et al., 2010). Although warning systems play a vital role in reducing mortality, they need to be linked to policies and decision-making. Also, educating the community on possible heat-related risks, symptoms, and management is equally important (Hanna et al., 2011; Kovats & Ebi, 2006).

Response Plans

Although some claim that response plans are necessary (Bernard & McGeehin, 2004), more focus should be placed on preventative measures and early warning systems. Evidence shows that the effects of heat reach their maximum very quickly (Huang et al., 2012), allowing little time for effective response. Instead, there needs to be effective leadership and decision-making. This is only feasible if there exists collaboration between emergency management, public safety, and health departments (Bernard & McGeehin, 2004).

MOVING FORWARD

Urban centers are hubs for resilient ingenuity and technological innovation. While they pose a greater risk for vulnerability and system failures, they also allow opportunity for collective action and scientific advancement. Theories surrounding adaptive capacity can be put forth and tested, applying various sectors and stakeholders. This applies particularly to the field of hazard mitigation. Increased heat in the urban setting cannot be managed by one group, but rather, requires the involvement of architects, urban planners, engineers, politicians, climate scientists, health officials, and local communities.

According to the United Nation's *World Economic and Social Survey* (2013), 6.25 billion people will be living in cities by 2050, eighty percent of whom will reside in developing countries. As urbanization continues to grow, it becomes imperative that cities establish policy frameworks that enable better access to basic services and policy education. By failing to do so, marginalized populations will remain vulnerable to not only social and economic systems but also to climate impacts, including extreme heat events. Furthermore, the impacts of climate change need to be included in health policies and risk management. Failing to do so limits preparation and response capacities for both individuals and city organizations.

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