by Dan Sandink

Reducing heat-wave risk through active and passive measures

Extreme temperatures have been shown to result in increased incidences of mortality and morbidity. Cities across the world have been subject to extreme heat events that have resulted in perhaps hundreds of thousands of deaths in the 21st century. Estimates of the number of deaths caused during the western European heat-wave of 2003 range from 25,000 to 70,000. A heat-wave in the U.S. in 1980 resulted in 5,000 to 10,000 deaths, and a 1988 event in the U.S. resulted in 10,000 deaths attributed directly to extreme heat. The Canadian Disaster Database reported six heat-event disasters in the country since 1900, all of which resulted in a number of deaths. The most severe of these events occurred in 1936, when 1,180 deaths occurred across the country. A 2009 heat event in Vancouver and the Fraser area resulted in 134 deaths.

Under changing climate conditions, an increase in occurrence of death as a result of extreme heat is expected. To counteract these hazards and vulnerabilities, there have been attempts to mitigate the impacts of heat-wave incidents on vulnerable populations, through both "active" and "passive" risk reduction options.

Internal Vulnerability Factors

Heat-wave vulnerability can be high for children, pregnant women, people of low socioeconomic status, those with chronic health conditions including diabetes, and mobility and cognitive constraints. However, older adults, including those over the age of 65, are considered particularly vulnerable to heat-waves. Increased vulnerability of this age group may result from higher likelihood of pre-existing medical conditions (e.g., cardiovascular and respiratory illnesses, diabetes), limited mobility, impairment of thermoregulatory capacity, and reduced ability to perceive changes in temperature. Social isolation is often identified as a significant risk factor, and is related to living alone; being single, widowed, or divorced; and not leaving home on a daily basis. Sweat production can also be inhibited in elderly individuals, as some pharmaceuticals can impair this response to heat. Elderly individuals also tend to have lower fluid intakes as they often exhibit a decreased sense of thirst.

External Vulnerability Factors

Acclimatization to higher temperatures due to the geography of a city affects the vulnerability of populations to high temperatures. Physiological adaptations may occur for populations living in warmer climates, and acclimatization in these areas results in a requirement of higher temperatures to cause heat-related mortality. Timing of heat-waves can also affect risk, and the impacts of heat-waves that occur in April or May can be more severe because people have not had the chance to acclimatize to hot weather over a summer season. Individuals living in cities are at greater risk compared to rural residents, largely due to urban heat-island (UHI) effects.

Active Options for Reducing Risk

Mortality from heat events is largely preventable through relatively simple measures, including increasing fluid intake and accessing air conditioning. Active programs encourage these types of behaviours and activate immediately before or during heat-wave events. Active options often take the form of heat-health warning systems, which are based on monitoring of weather systems to predict extreme heat and warning residents of upcoming periods of hot weather. In Canada the Clean Air Partnership has reported that Toronto, Halton Region, Oakville, Peel Region, Markham, Hamilton, Kingston, London, and Montréal have implemented these types of programs. Interventions associated with these systems may include mass-media announcements, website-issued bulletins, opening of cooling centres, and direct communication with vulnerable populations including home visits. Common actions that are advised through active programs during heat-health alerts include avoiding the outdoors or sun, keeping hydrated, staying in or seeking out air conditioned environments, proper use of fans, avoiding overexertion, dressing appropriately, and checking on elderly or vulnerable neighbours.

DAN SANDINK has been Manager, Resilient Communities and Research at the Institute for Catastrophic Loss Reduction <www.iclr.org> since 2008. At ICLR, Dan's work has focused on urban flooding, individual disaster risk perception and behaviour, and climate change adaptation.

Table 1

Example Passive Mitigation Options

Passive option	Measure
Building materials and design	Green roofs
	Increased albedo
	LEED building compliance
	Shade trees around buildings
	Improved home insulation
Land use change	Urban forestry
	Pervious surfaces
	Community gardens
Transportation systems	Improve public transit
	Pedestrian, bike friendly transit
Other approaches	Reduce waste heat
	Community design to promote social interaction

S. Harlan and D. Ruddell (2011). "Climate change and health in cities: Impacts of heat and air pollution and potential co-benefits from mitigation and adaptation." *Current Opinion in Environmental Sustainabilitv. 3.* 126-134.

Table 2

Vulnerability Addressed by Risk Reduction Measures

Vulnerability Type	Vulnerability Factor	Mitigation Type	
		Active	Passive
Internal	Drug effects	Addressed through warnings (+)	Not addressed (-)
	Social isolation	Visits to vulnerable populations (*)	Increased community engagement/contact (+)
	Socioeconomic status	Not addressed (-)	Housing conditions, community design addressed (*)
	Access to A/C, cooling	Short-term access to cooling centres (*)	Reduced ambient temperatures, reduced need for A/C (+)
	Housing	Not addressed (-)	Addressed (+)
	Access to transportation	Short-term access to cooling centres (*)	Improved public transit (+)
	Pre-existing conditions, chronic disease, fitness, dependency	Not addressed (-)	Addressed through improved public transit, community gardens (+)
External	Acclimatization	Not addressed (-)	Reduced ambient temperatures (*)
	Urban Heat Island	Not addressed (-)	Addressed (+)
	Community design	Not addressed (-)	Addressed (+)

(-) indicates that factor is not addressed; (+) indicates that factor is addressed;
(*) indicates that factor is partially addressed.

Passive Options for Reducing Risk

There are many passive options that are available to mitigate the impacts of extreme heat (see examples in Table 1). These measures are especially valuable in dense urban areas to mitigate UHI impacts, and can also serve to increase health through access to nutritious food, increase physical activity, and increase social engagement.

When used throughout an urban area, green roofs can reduce localized air temperatures and provide cooling capacity within buildings. Use of highly reflective building materials is a further option to reduce UHI effects, and these materials have been shown to reduce ambient air temperature by 1-3.5°C in some cases.[1] Specifically, the impact of the use of highly reflective materials has been explored in Los Angeles, California, where use of such materials reduced average local temperatures by 1.5°C and by as much as 3°C when combined with other strategies, such as urban forestry.[2] Leadership in Energy and Environmental Design (LEED) includes various factors, including high-albedo and green roofs that can also serve to mitigate UHI impacts.

Urban forestry is a further option that can reduce UHI effects. Trees can shade urban surfaces and through evapotranspiration and can dissipate energy that would otherwise be absorbed into urban surfaces and re-emitted at night. Indeed, it has been reported that increased canopy cover can reduce local air temperatures by 1-3°C.[3] Further, increasing vegetation through urban forestry and green roofs can provide multiple additional benefits, including reduced ground-level ozone, reduced reliance on air conditioning, and provision of a range of additional social and ecological benefits. Pervious surfaces, which serve to absorb stormwater rather than shed it into stormwater management facilities like storm sewer systems, also serve multiple purposes, including lowering air temperature through evaporation of water.

Waste heat from industrial processes, automotive sources, buildings, and air conditioning has also been identified as a contributor to UHI. For example, a study in Tokyo, Japan found that waste heat generation by air conditioners increased local temperatures by 1-2ºC.[4] Efficient building design and improved public transportation systems can assist in reducing waste heat in urban areas. The placing of shade trees around buildings can significantly reduce reliance on air conditioning, and can offset cooling costs by 25 to 80 percent in some circumstances.

Improved public transportation systems have been cited as long-term

1 M. O'Neill, R. Carter, J. Kish, C. Gronlund, J. White-Newsome, X. Manaroola, A. Zanobetti, J. Schwartz (2009). "Preventing heat-related morbidity and mortality: New approaches in a changing climate." *Maturitas, 64*, 98-103; A. Synnefa, A. Dandou, M. Santamouris, and M. Tombrou (2008). "On the use of cool materials as a heat island mitigation strategy," *Journal of Applied Meteorology and Climatoloy, 47*, 2846.

2 B. Stone (2005). "Urban heat and air pollution: An emerging role for planners in the climate change debate." *Journal of the American Planning Association, 71*, 13-25.

3 O'Neill et al, note 1, supra.

4 Y. Ohashi, Y. Genchi, H. Kondo, Y. Kikegawa, H. Yoshikado and Y. Hirano (2007). "Influence of air-conditioning waste heat on air temperature in Tokyo during summer: numerical experiments using an urban canopy model coupled with a building energy model." *Journal of Applied Meteorology and Climatology 46*, 66–81.

means of reducing the impact of heat-wave events. Aside from reducing waste heat by decreasing vehicle use, public transit that supports pedestrianism and cycling can increase physical activity and may contribute to reduction of chronic diseases like diabetes. Similarly, community gardens provide opportunities to increase long-term health through increased nutrition and exercise, which may decrease rates of lifestyle diseases like diabetes and can also reduce social isolation.

Which Measures Are More Effective for Reducing Vulnerability?

In comparison to passive options, active options may not be as effective in reducing underlying factors that result in vulnerability, especially when long time frames and external vulnerability factors are considered (see Table 2).

Some active programs provide information on the impacts of drugs in inhibiting physiological responses to heat events, a factor that is not addressed through passive programs. Further, active programs often include visits to or contact with vulnerable populations during or immediately before heat events. The experience of residents during the 1995 Chicago heat-wave, where those who were contacted by city social services staff and educated about heat-wave risks had lower risks of mortality, indicates that short-term social contact can reduce risk.[5] Increased incidence of listening to the radio and reading newspapers to educate oneself about heat risks was also associated with reduced mortality risk in Chicago in 1995. However, social isolation is addressed through passive programs that include urban design that increases social interaction and community gardens.

Socioeconomics are also not addressed through response-oriented active options. While socioeconomics are not directly addressed through passive programs, factors associated with low socioeconomics – such as community design that increases the UHI and poor housing conditions – are addressed through passive programs. Though active programs are often designed to increase access to air conditioning, access is generally provided only over a short time period through cooling centres. Further, it has been argued that some aspects of air conditioning, including inhibiting physiological adaptations to heat and generating excess waste heat may exacerbate vulnerability[6] – thus, reliance on air conditioning to reduce heat-wave exposure may not be an ideal long-term strategy. Passive programs can permanently reduce ambient temperatures and include building measures that reduce reliance on air conditioning. Further, while housing issues (e.g., insulation, passive cooling) are not addressed in response-oriented active options, a number of passive options address these issues, including LEED design, increased albedo, and improved insulation.

Active programs generally include improved public transportation during heat-wave events (e.g., transportation directly to cooling centres); however, passive programs include permanent improvements in transit. Improving public transit has additional benefits, especially in the case of promotion of transit that includes pedestrianism and cycling, as these measures can increase physical activity and help reduce prevalence of health factors, such as chronic disease, that increase vulnerability to heat-wave events. In comparison, long-term health and chronic diseases are not addressed through active programs.

Conclusion

Heat-waves are a significant cause of death and morbidity across the world, and the impacts of heat events are likely to increase due to changing frequency, severity, and intensity of heat-waves caused by climate change. Passive programs are designed to address the root causes of vulnerability. The effectiveness of passive programs is augmented by their multiple additional benefits – all of which will be required for both mitigation of climate change and adaptation to inevitable impacts of climate change. For these reasons, passive options are being applied throughout North America, often without the express purpose of mitigating heat-health risk, but for their multiple benefits. However, the main weaknesses of passive options are their costs and the long time frame required for implementation. Thus, active programs have been implemented to fill that heat/health risk reduction gap. From an emergency management perspective, it is important that communities do not rely exclusively on heat/health warning systems, and rather work to implement long-term passive systems in combination with active systems. MW

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5 J. Semenza, M. McCullough, D. Flanders, M. McGeehin, and J. Lumpkin (1999). "Excess hospital admissions during the July 1995 heat-wave in Chicago." *American Journal of Preventative Medicine, 16*, 269-277.

6 S. Hajat, M. O'Connor, and T. Kosatsky. (2010). "Health effects of hot weather: From awareness of risk factors to effective health protection." *Lancet, 375*, 856-863.

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