HUMAN HEALTH IMPACTS OF HEAT ISLANDS: SOME KEY ISSUES

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It is now widely accepted that heat is the major weather-related killer within temperate climate cities, and during extreme heat waves in vulnerable urban areas, hundreds of people can die, as they did in Chicago in 1995 (Whitman et al., 1997). However, there are still numerous uncertainties involving the precise impacts of heat on the urban population. This presentation attempts to discuss and answer some of these uncertainties.

One common question that arises is, "How many people actually die from the heat?" This is an important query because it is difficult to quantify and separate those deaths attributed to heat from deaths that have been precipitated by other environmental factors, such as pollution. In addition, there is a "mortality displacement" factor to consider; would many of the vulnerable (often ill or elderly) people who died from heat have died shortly afterward from other causes?

Our research has shown that mortality displacement is a significant aspect of heat-related mortality. We estimate that 20-40 percent of the deaths that occurred during a heat wave would have occurred shortly afterward, within a month or two after the heat wave (Kalkstein, 1993). Although this is a significant proportion, it is even more noteworthy that 60-80 percent of heat-related deaths would *not* have occurred shortly afterward, indicating that the heat event considerably shortened the life of many individuals. Thus, heat-related mortality must be dealt with as a major health problem within the developed world.

The impact of pollution in exacerbating the number of heat-related deaths is a second important issue. A number of people believe that it is actually the high pollutant concentration during a heat wave, rather than the heat itself, that is creating the health problems. Our research has indicated otherwise (Kalkstein, 1995). We evaluated elevated mortality in Philadelphia during two sets of air mass conditions: air masses that are associated with the most stressful heat (defined as moist tropical – MT and

dry tropical – DT), and all other air masses that are mainly benign from a meteorological standpoint. Within both sets, we divided days into pollutant quintiles, ranging from the quintile with the greatest concentrations of ozone and particulate materials through the lowest ("cleanest") quintile. If pollution was the major driver contributing to elevated mortality during the stressful air masses, we would expect mean mortality to decrease within these air masses, from the dirtiest through the cleanest quintile. On the contrary, mean mortality remained elevated through all the quintiles, regardless of pollutant concentration. This suggests that, when the weather is already stressful, pollution has little impact on excess mortality. It also suggests that there is not a synergistic relationship between meteorology and pollution when the weather is stressful. However, the results obtained using this procedure for the benign air mass days were different. In this case, there was a clear increase in mortality from the cleanest through the dirtiest quintiles. This suggests that, when heat stress is not a factor, there is a clear pollution effect on mortality. However, in general, the pollution impact is much less dramatic than any meteorological impact that occurs during extreme heat.

Another question frequently asked about heat-related mortality relates to the effectiveness of air conditioning in mitigating negative health outcomes. It appears that air conditioning does have a positive effect in reducing such deaths when individuals have access during stressfully hot conditions. A study has shown that, during a period when air conditioning use greatly increased among the general population (1960s through today), the mean annual death rate has declined more rapidly when hot, oppressive air masses are present than when benign summer air masses are present (Kalkstein, 1997). A calculation of the death rate differential between the two groups of air masses suggests that the greater availability of air conditioning has reduced heat-related mortality by approximately 26 percent in New York.

However, there are two caveats to this finding. First, many of the most vulnerable people who are poor or infirm still do not have access to air conditioning. Thus, they cannot receive any benefit from its general societal presence. Second, it is possible that air conditioning may be actually contributing to the "urban heat island effect". A recent project has indicated that, during the presence of hot, stressful air masses, the disparity in maximum and minimum temperatures between urban and nearby rural areas has increased, especially during the 1960s and 70s (Scott, 2001). The timing

is noteworthy; this period coincides with the dramatic increase in air conditioning use in urban areas. In fact, in Manhattan, where approximately 30 percent of the airshed up to 100 m represents air conditioned buildings, this exacerbation of the heat island in the 1960s and 70s seems most pronounced. Although this is purely circumstantial, certainly the possibility of air conditioning's role seems to be logical. First, much of the heat within the air conditioned space must be displaced outside. Second, the sheer amount of air conditioning machinery now present in major urban areas must contribute significantly to urban heating.

This theory requires further testing, and it is important to determine the "distance decay" of this air conditioning impact if it in fact does exist. For example, would this "Manhattan effect" have an impact in the Bronx, a poor section of New York City about 10 km away? If so, how can we avoid this problem, especially because air conditioning is a life-saver for many people during hot weather? We propose that a study of this type should be performed in a city where air conditioning is generally less important, or has become more important only recently. Toronto would be a good possibility.

Finally, a question arises about the effectiveness of roof treatments and other cooling initiatives to improve indoor climate and reduce the urban heat island effect. There are many efforts going on in this arena. We have been working with the city of Philadelphia to determine if their efforts in constructing reflective roofs on townhomes is actually creating a cooler indoor climate for people without the benefit of air conditioning. Preliminary results indicate that the reflective roofs do reduce indoor temperatures by a degree or two during the hottest air masses, particularly moist tropical air. Although this may seem to be an insignificant amount, it is plausible that even a two degree decrease could mean the difference between life and death for those who are unable to leave an un-air conditioned apartment. We are working further through the EPA's Heat Island Reduction Initiative to determine if "cool roofs" and tree planting programs are actually effective in saving lives during oppressive weather.

Regardless of the outcome of these initiatives, it is strongly suggested that "heat watch/warning systems" be implemented in as many vulnerable cities as possible to provide warning to citizens, health practitioners, and other decision-makers when oppressive weather is forecast (Kalkstein et al., 1996). Approximately 15 such systems are presently in operation in the United States, Canada, China, and Italy, with more planned. These systems

must be designed in a manner that isolates the impact of oppressive weather on each individual urban area, as urban structure, demographics, and variable climate play a differential role in each city. In addition, cities must develop a cogent mitigation plan which is put into place every time the system issues a warning or emergency.

The increased awareness of the negative impact of heat has been a welcome development in the medical and meteorological community. We see continued sophistication in understanding the meteorological/pollution/health relationships during heat waves, and encourage continued research in this area.

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