A NEW GENERATION OF HEAT HEALTH WARNING SYSTEMS FOR SEOUL AND OTHER MAJOR KOREAN CITIES

Laurence S. Kalkstein
University of Miami Coral Gables, Florida USA
larryk@udel.edu

Scott C. Sheridan
Kent State University Kent, Ohio USA

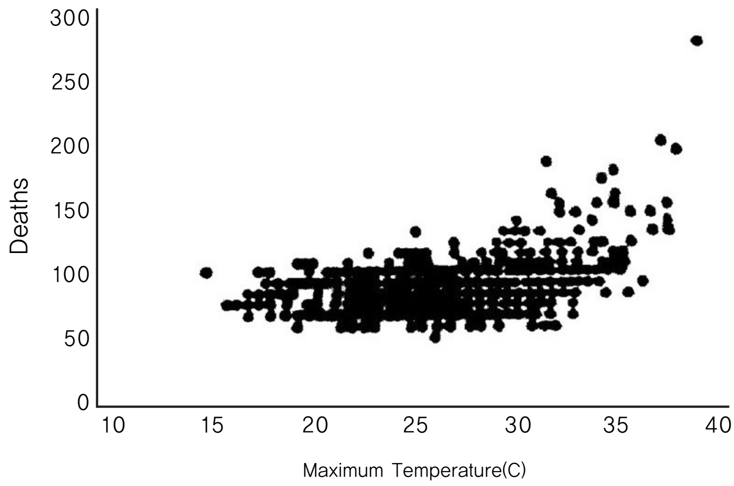
Yang Ching Au (Nicole)
Housing and Development Board Singapore

Heat is considered the deadliest of weather-related phenomena over much of the developed world. It has its most severe impact in mid-latitudes, where intense heat waves have killed thousands of people, such as the 2003 European heat event, which alone was responsible for over 35,000 deaths. The most vulnerable areas for heat-related problems are found in locales where heat waves occur at irregular intervals, and where summer climates are highly variable. Thus, cities like New York, Philadelphia, Paris, Rome, Shanghai, and Seoul have been impacted by large numbers of deaths during excessive heat events. These deaths are often difficult to identify, unlike deaths from other natural disasters such as hurricanes and tornadoes, but during excessively hot weather, deaths from most causes rise dramatically, sometimes doubling on the worst days (Figure 1). As most deaths from heat are never reported as such, heat is the "silent killer", since most of these deaths are associated with little or no physical damage.

It has only become recently recognized that heat has such a devastating impact on human health. Thus, over the last 15 years, a proliferation of techniques has been devised in an attempt to mitigate the impact of extreme heat

편집자 주

이 글의 저자인 Kalkstein 교수는 현재 국제생명기상학회(International Society of Biometeorology)의 회장직을 맡고 있으며, WMO/WHO/UNEP의 기상과 기후의 보건 영향 분야에 대한 자문위원으로 활동하고 있다. Sheridan 교수는 국제생명기상학회지(International Journal of Biometeorology)의 편집책임자(Editor-in-Chief)로 활동하고 있다. 국립기상연구소는 미국 마이애미 대학과 2007년 11월에 폭염이 보건에 미치는 영향 연구에 대한 공동연구 협력을 위하여 MOU를 체결한 바 있다.



[Figure 1] Total daily deaths during summer vs. daily maximum temperature: New York City.

on the population. We have been working with a variety of countries and agencies to develop the most sophisticated means possible to issue heat-related warnings, to assist in the development of urban plans to lessen the impact of heat, and to check the effectiveness of heat systems in major cities around the world. We are honored to have recently entered into a contract with the Korean National Institute of Meteorological Research(METRI) to develop a heat/health watch warning system (HHWS) for Seoul, and possibly for other major cities in the country, based upon our successes in other parts of the world. In this article, we will describe how the new HHWS works, its many advantages, and how we integrate with stakeholders (interested agencies) to make certain that proper plans are implemented whenever the HHWS indicates health-debilitating conditions.

The premise behind these heat/health systems is solid knowledge of the actual heat-health relationship at each locale that a system is implemented. Thus, the threshold conditions that induce an adverse health response need to be identified. Of great importance is the fact that these thresholds vary across space, which strongly suggests that the systems must be location specific. For example, people in New York react very differently to heat than citizens of Seoul, not only because the climate is different but also because of the different urban structure and demographics of each city. In the past, similar thresholds have been used across large areas with disregard to this concept. The system for Seoul is specific to that city only, and different thresholds for issuing heat warnings will be necessary in other cities, even in Korea. Another interesting finding in our research is that thresholds which induce a negative health impact on people actually vary during a season in the same city. Thus, thresholds in our HHWS are often different for June and August in the same city. We have found that it takes less heat to increase mortality early in the summer season than later, partially because we acclimatize to heat as the season progresses. In addition, many susceptible people die early in the summer from heat, leaving less to die later in the season. Since the HHWS is based on determining thresholds of human health tolerance to heat, rather than being simply a comfort index, these thresholds must vary as the season progresses, even in a single city.

Another unique aspect of our system is the use of air masses, rather than simple weather variables like temperature and humidity, to evaluate heat health relationships. Air masses are large homogeneous bodies of air, which when present, exhibit distinctive meteorological characteristics. For example, a moist tropical (MT) air mass is always associated with hot, humid conditions, little nighttime temperature relief, partly cloudy skies, and sometimes an afternoon thunderstorm. A dry tropical (DT) air mass is even hotter during the day, but less humid, with clear skies and usually no precipitation. Both of these air masses are associated with elevated mortality in most mid-latitude cities, but their impacts vary spatially. In some cases, DT air may cause little harm and MT air masses can be worse; in other cities, the opposite could be true.

The use of an air mass based approach is key to identify the impact of heat on human health. We don't respond independently to the meteorological elements of temperature, humidity, and wind. Instead, we respond to the combination of these weather elements as they represent themselves within an air mass. We are thus sensitive to the simultaneous impact of all weather elements within a mass of air, and this is the reason why we first develop a daily "air mass calendar" for each day during the summer season using various statistical techniques to determine the differential impacts of weather on human health. To read more on how we develop this calendar, go to http://www.as.miami.edu/geography/research/climatology/IJOC_Sheridan_2002.pdf which describe the techniques in detail

Daily mortality data for Seoul was provided by the METRI so we could develop relationships between daily weather and variations in deaths. During a heat wave, deaths in mid-latitude cities can increase markedly, as illustrated in Figure 1. This is particularly true when looking at daily air mass type and increases in mortality (Table 1). It is clear that, during certain air mass intrusions, mortality can increase significantly; for example, in Seoul, an average DT air mass day leads to an increase of almost 7 deaths, which represents a 7 percent increase in mortality. It is impressive to think that a certain set of meteorological conditions can induce such a negative response in human health. The increase varies across months; in July during DT air mass intrusions, average daily mortality in Seoul can increase by over 30 individuals. When compared to other cities, residents of Seoul are rather sensitive to heat. Some other cities are even worse; for example, in Rome, an average DT air mass day yields a 14 percent increase in mortality, and in Shanghai, a typical MT+ day is associated with a 16 percent rise. Obviously, in many cities there are significant daily mortality increases during particularly oppressive air mass days, and DT and MT+ air masses must therefore be isolated when they are forecast, since they obviously can contribute to important negative health issues when they occur.

Although most days within the "oppressive" DT and MT+ air masses lead to increased mortality, these impacts also vary from day to day, depending upon meteorological and other variations within the day. For example, an MT+ air mass with a particularly high minimum temperature may cause more deaths than a similar air mass day with a lower minimum temperature. Often even more important, it may be necessary to have three or more days in a row of an oppressive air mass before any negative health outcome can occur. In Seoul, for example, on the first day of a DT air mass, there are only 2 or 3 excess deaths, on average.

〈Table 1〉 The impact of heat on human mortality in various cities around the world, including Seoul. "Deaths" represent the daily average increase in mortality during the air mass intrusion, and "percentage" is the percent increase in daily average mortality that this increase represents.

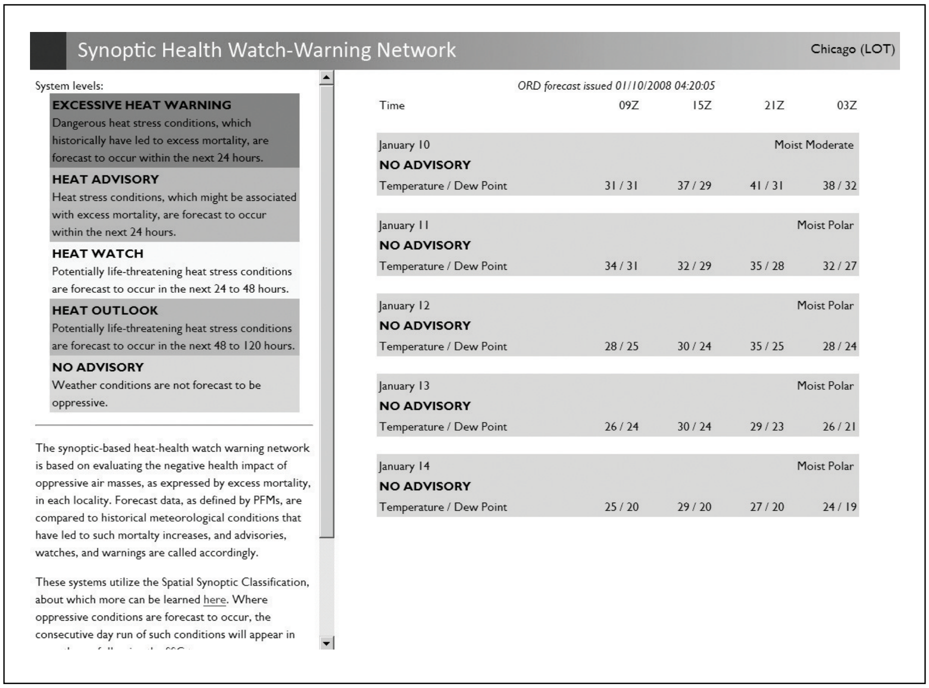
City	Mean increase in mortality, DT days		Mean increase in mortality, MT+ days	
	Deaths	Percentage	Deaths	Percentage
Seoul	6.9	7	6.7	7
Chicago	5.2	5	7.4	7
Washington	0.9	4	1.7	7
NewOrleans	None	None	3.7	9
Rome	6.2	14	5.0	12
Shanghai	None	None	42.4	16
Toronto	4.2	11	4.0	10

However, after 5 or more consecutive days of the air mass, the average daily increase in deaths approaches 40. Thus, the first day of an offensive air mass may not trigger a "warning" from the system, but the fifth consecutive day most certainly would. Thus, it is necessary to develop full relationships between daily mortality and a number of variables, both meteorological and non-meteorological, within the oppressive air masses to establish estimates of the number of people expected to die that day from the stressful conditions.

Using forecast data from METRI, we can actually estimate heat-related mortality for several days before the excessive heat event actually occurs. This is where the HHWS becomes an important piece of information for weather forecasters, so they can have the most reliable information available to call heat/health related warnings. We have devised password-protected websites, such as the one for Chicago, USA illustrated in Figure 2, to provide guidance to forecasters when they should call excessive heat warnings. The colored bars on the left side of the system page are related to the increasing negative impact of the heat, and with increasing numbers of estimated heat-related deaths, the level of warning is heightened accordingly.

Although it is most important to devise an accurate warning system that informs the public and decision-makers about the times when the negative health impact will be most severe, it is equally important to have in place a set of intervention measures to lessen the potential catastrophic impacts. The development of intervention measures requires two steps: first, to identify those "stakeholders", both private and public, that must reach out to vulnerable populations and attend to them during the most severe times of an excessive heat event, and second, to coordinate activities that these stakeholders pursue to try to save lives. The stakeholders and their concomitant activities vary from city to city; often the stakeholders form a "heat task force" in a city, which permits proper coordination among the local weather service, health department, emergency managers, utility companies, and other similar stakeholder agencies. Although this varies dramatically from city to city, the opening of air conditioned shelters, attending to the elderly and homeless, and setting up call centers to advise people what to do during a heat emergency are some of the necessary steps that cities take when an excessive heat warning is called.

The level of technology in the call centers can have a significant impact on the effectiveness of the heat alert system and corresponding intervention measures. Call centers are strategic points of contact where heat information and related health advice are disseminated to the



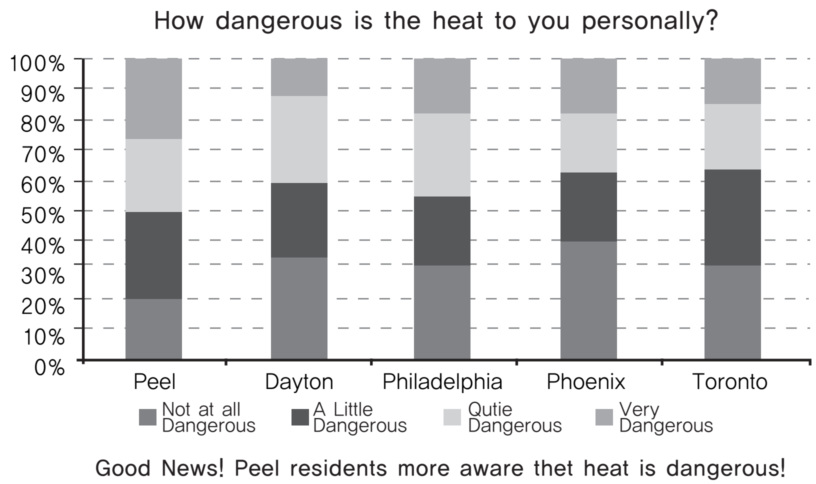
[Figure 2] An example of the HHWS page (this one for Chicago, USA), that is password protected. The information provided on the page includes warning level, forecast weather conditions, air mass type, and an estimate of heat-related deaths on severe days.

public who do not have ready access to the internet who need an interactive form of contact. When a caller chooses not to wait for his/her call to be answered, an automated voice message system can be activated, prompting this person to leave a name and contact number so that someone can get in touch as soon as the information line is available.

An automated dial-up service that provides information to particular groups of people, such as seniors alone at home, may be useful. These vulnerable groups need specific types of information conveyed and worded in certain ways that less vulnerable groups do not. For instance, an elderly may not be educated and may not understand what a heat wave is or what it can do to his health. He may not know why it can kill him or understand why he needs to take certain measures like going to an air conditioned shelter, or not switching on a fan in an unventilated room. This service does not require the person to call in, and can be used without increasing resource requirements. Nurses may be stationed at each call-center to provide expert support in complex situations

The final important issue in the development of a new HHWS is effectiveness checking. We have already done much of this for a number of cities in the United States and Canada, and plan to follow up after the new system in Seoul is implemented during the summer of 2008. Effectiveness is evaluated in many ways. For example, are the citizens aware of whether a heat warning has been called? Do they understand what to do if such a warning is in place? Do they perceive that they are vulnerable to the negative impacts of heat (much of our work shows that people lack understanding of the dangers of heat, and consider themselves generally not vulnerable)? We have devised questionnaires that have been administered to individuals in various cities to see how they perceive the dangers of heat; an example question is shown in Figure 3. Such an activity is desirable for Seoul as well after the HHWS has been operating there this summer, to see if the message is getting across.

We look forward to working closely with the METRI and other government agencies in the country to develop our state-of-the art HHWS. As this essay has hopefully demonstrated, the development of such a system is complex, with aspects relating to estimating negative health impacts on a day-to-day basis, disseminating information in a proper manner, organizing stakeholders who deal with intervention measures, and evaluating the quality of the system and the population response.



[Figure 3] One of the questions on our questionnaire evaluation for various communities in North America. Over 50 percent of residents in these urban areas underestimate the impact of heat upon their health, even in an exceedingly hot desert city like Phoenix, USA.