Heath Waves and Human Health

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ABSTRACT

The thermal environment plays an important role in human health and well being. Extremes in temperature can cause physiological disturbance and organ damage, leading to illness or death. The increase in mortality during hot weather can be very significant. Mortality in many temperate cities, such as New York, Rome, Shanghai, and Tokyo, where hot weather is severe but infrequent, shows sharp increases in total mortality during unusually hot weather conditions. It is likely that the adverse effects of heat waves will increase with global warming. Probably intermittent regional temperature variations will have more direct effects on health than long-term climatic trends to which population become adapted. It is important to increase awareness of the potential health effects of heat waves, and every reasonable effort should be made to avoid them.

A number of interested international agencies, such as the World Meteorological Organization, World Health Organization and United Nations Environmental Programme have decided to promote and financially support several "Showcase Projects" dealing with the impact of extreme heat events on human health with the aim to develop a coherent set of warning systems, improve mitigation measures and ultimately save lives. The goal for these Showcase Projects is the development of heat watch/warning systems for several selected cities, which permit local health officials to more efficiently implement mitigation actions. In addition, guidelines will be developed for the local meteorological agencies to improve their services to the various decision-making arms of the local government, such as the media, the local department of public health, the local utility company, and many others. There are three major aspects to the project:

Research and development,

technology transfer and

local operation.

One important aspect of development is that the locality participating in the project will have significant input in the development of the system, to make certain that it is tailored perfectly for local needs. The first city selected for system development was Rome, Italy, and the first organizational meeting between the WMO, WHO, the Agency of Public Health, Lazio, the Italian Meteorological Service, and UNEP took place in early February 1999. An agreed-upon format of system development was determined. The second city selected for system development was Shanghai, China.

Analysis of the effects of heat waves in the past pointed out that the most casualties occur between the people over 65. Heat waves usually occur in synoptic situation with pronounced slow development and movement, with quite persistent leading to an intensive and prolonged heat stress for inhabitants of the cities. Just to point out one typical example: during a heat wave in 1983 from the beginning of July to the beginning of August an anticyclonic weather regime dominated. When compared to the previous years summer mortality increased significantly (1). Extremely warm air was persisting at all levels. Pressure filed was quite uniform, slightly above the normals; air mass was characterized by an elevated thermal stability, without convective mixing, leading to elevated temperature and humidity of the air at ground level. At 500 hPa level a ridge of warm air was persisting over the area of west and central Mediterranean for several consecutive weeks.

INTRODUCTION

The belief that the atmospheric environment affects human health can be traced back almost to the dawn of civilization. The seasonal exodus of the rich from the squalor of cities to the cleaner and more comfortable environment of their county estates occurred also in ancient Rome (2). During the height of summer Rome was notorious for its unhealthy conditions. The city was deserted by all but the poor. The upper class during summer months moved to their country villas in the nearby Apennines. Though the mountains are not particularly high, they are high enough to lower temperatures sufficient to make summer living quite pleasant.

Interest in the impact of weather on human health has increased dramatically in recent years, mostly due to notable tragic events - such as several hundreds and sometimes thousands of deaths during heat waves in developed and developing countries. These events are usually confined to densely populated urban areas. Urban climates are characterized by the well-known urban heat island effect, which may exacerbate the impact of weather on heat-related mortality. With this in mind, a number of interested international agencies, such as the World Meteorological Organization, World Health Organization and United Nations Environmental Programme have decided to promote and financially support several "Showcase Projects" dealing with the impact of extreme heat events on human health with the aim to develop a coherent set of warning systems, improve mitigation measures and ultimately save lives. Several meetings of a group of experts convened by the WMO have been held to establish guidelines (3, 4).

The health impact of hot weather has been studied predominantly in relation to the most serious health outcome, i.e. death. A major reason for this is that mortality data sets are readily available for a large number of urban areas. Because heat can contribute to mortality from a large variety of causes, the number of heat-related deaths is considered to be the number of deaths occurring in excess of the number that would have been expected for that population in the absence of heat wave (the "baseline" level).

Intervention plans should be best suited for local needs, through co-ordination between the local health agencies and meteorological officials. In Rome the system will be run by the local health agency (Agency of Public Health, Lazio). There are plenty of possibilities to mitigate the impact of heat wave. Health authorities will be able to reach out to children, senior citizens, anyone in poor health and those in high-risk neighbourhoods, where heat-trapping homes make people more vulnerable to very hot weather conditions. Among the most effective and important mitigation measures is certainly the issue of warnings and recommendations in the media. The information should be clear and with concrete recommendations and advice, without inducing panics and should reach everybody in the city, also tourists and occasional visitors. Media have the power to educate and inform, and they will play an extremely important role in the implementation phase of the show case project.

BACKGROUND INFORMATION

The impact of the heat wave greatly depends on the ability and willingness of the population to take into account recommendations and develop adaptive strategies. People living in hot regions successfully cope with excessive heat through adaptations in lifestyle, physiological acclimatization and adoption of a particular mental approach. Cultural or social adjustments, including design of houses for conditions of sustained heat are the most effective ways to adapt to a very hot climate. Individual lifestyles, clothing habits and occupational conditions also influence the exposure levels. Heat stress can be aggravated by inappropriate behaviour or, conversely, can be ameliorated by the use of more adaptive capacities, as awareness of the effect of heat increases. This is manifested in habits, customs.

A distinction should be made between the heat stress for a population and that for an individual. Population is looked upon as expressing an average adaptive capacity. The individuals with a low adaptive capacity suffer first and foremost from heat load of any magnitude. The relative degree of risk associated with heat load is particularly high for individuals with failing functions of the cardiovascular, respiratory, renal, endocrine or immune systems, for those with immature regulatory systems, such as infants and children, and for those with reduced adaptive regulatory functions, such as elderly and physically handicapped.

Within certain limits of mild heat stress and physical activity, thermal comfort can be maintained by appropriate thermoregulatory behavioural responses, and physical and mental work can be pursued without deteriment. Heat acclimatization will develop after several days of heat exposure and this will help to alleviate the effects of heat stress. However, severe heat stress can result in deterioration in health including heat illness, with effects ranging from mild reversible cardiovascular disturbances to severe tissue damage and death. Of primary concern are certain high-risk groups in whom even mild heat stress may produce abnormal heat strain and heat-related disorders.

The initial physiological adjustments to heat, involving changes in cutaneous vasodilatation and fluid balance, often produce mild swelling of the feet or ankles. Syncope can be precipitated by a sudden change in posture or by venous stasis in the legs during prolonged standing. Skin disorders, such as prickly heat and skin rashes, may occur when sweat is allowed to accumulate on unventilated skin. Sweat losses are not always completely replaced and result in dehydration. Heat exhaustion and heat intolerance can, in extreme, lead to heat stroke, which is characterized by hyperthermia with core temperatures of 41 °C or more, central nervous system disorders leading to convulsions and coma, and often marked anhidrosis, with a hot dry skin. For the physically unfit and vulnerable increased cardiovascular strain is the main threat imposed by environmental heat.

Heat waves present special problems in urban areas because of the retention of heat by buildings, if ventilation for cooling at night is inadequate. The number of casualties increases with duration of exposure. Forced air movement, using fans, is generally beneficial, but may be associated with increased thermal discomfort, when the ambient temperature exceeds 38° C. Early behavioural signs of prolonged heat stress in densely populated areas include increasing discomfort, social intolerance, irritability, and industrial accidents. Among the indirect effects of heat wave could be included the effects on sleep patterns.

DEVELOPMENT

The following steps have been used in the development of the Rome system:

Determine historical relationships between heat-related mortality and weather using the most efficient climatic modeling possible.

Develop a means to forecast weather conditions which lead to increases in heat-related mortality over the next 48-hour period.

Develop a set of intervention plans so the city may mitigate the health damage when the system indicates that an advisory should be issued.

Once the system is operating, develop a method to check the effectiveness of the system in actually saving lives.

The Rome system, like the others in the Showcase Project, was developed at the University of Delaware, with cooperation from local agencies; in Rome, these are the Agency of Public Health, Lazio and the Italian Meteorological Service. Agency of Public Health, Lazio provided a daily set of Rome mortality data for a 12-year period from 1987 through 1998, subdivided by age (greater than or less than 65 years of age) and gender. It appears that virtually all causes of death increase under stressful weather, so it was unnecessary to divide the data by cause of death. The mortality data were standardized in a fashion to remove any non-meteorological noise. For example, in Rome it is clear that an exodus of citizens occurs during August, when Italians frequently leave the city to take vacation. Thus, the standardization must account for such variations before any mortality/weather relationships can be developed.

Three different climatological modeling procedures were tested to determine the best means of relating variations in summer weather to the standardized mortality data. The procedure which produced the most robust results, and best highlighted weather-induced changes in mortality was a synoptic climatological methodology called the Spatial Synoptic Classification (SSC). The SSC classifies each day into one of eight air mass types: (a.) dry polar (DP); (b.) dry moderate (DM); (c.) dry tropical (DT); (d.) moist polar (MP); (e.) moist moderate (MM); (f.) moist tropical (MT); (g.) moist tropical plus (MT+), (h.) the most oppressive subset of MT; (i.) transition (TR).

The system accounts for numerous meteorological parameters, as well as their variation throughout the day, and a synoptic approach allows for a determination of the entire umbrella of air over us at any given time, rather than just an evaluation of individual weather parameters. Of course using human body energy balance models superior results can also be achieved.

When evaluating mean total mortality for Rome during the summer it is clear that two air masses in particular, MT+ and DT, have a mean mortality which is statistically significantly higher than the other 6 air masses. DT and MT+ comprise approximately 11 percent of all summer days in Rome. DT contains the highest temperatures of any air mass, and the least cloud cover. MT+, while lower in afternoon temperature, has the highest dew point of any air mass. Both of these air masses typically have very high overnight temperatures.

Typically, the air masses which contain the highest mean daily mortality also contain the highest daily standard deviation of mortality as well. Hence, following the initial identification of these "offensive" air masses, tests are performed to discern which within-air mass parameters on offensive air mass days are most closely linked to mortality. The parameters include meteorological factors, such as maximum and minimum temperatures within the offensive air mass on that particular day, a sum of cooling degree hours, and mean daily cloud cover. Several important non-meteorological factors are also evaluated, such as the number of consecutive days of the offensive air mass (three or four straight days of DT air are very detrimental to human health), and the time of season the offensive air mass day occurred (an MT+ day occurring in June kills more people than a similar MT+ day in August, and this must be accounted for). The parameters which show a statistically significant relationship with mortality variability within the offensive air mass are identified using stepwise linear regression, and the developed algorithm can then be used to estimate excess mortality on days when weather emergencies are declared.

The identification of the oppressive air masses and the subsequent formulae comprise the central part of the heat/health watch-warning system. It was proposed that the forecast of an offensive air mass within the next 48 hours will trigger a warning of ATTENTION, indicating that conditions will soon be conducive to health problems if the forecasted offensive air mass arrives. If an offensive air mass is forecast within the next 24 hours, and if the formulae predict excess deaths from the heat above the selected threshold, an ALARM will be issued by the Agency of Public Health, Lazio to warn of these dangerous conditions.

Construction of the system represents only one part of an effective heat-health alert plan. It also requires close coordination with the local meteorological service, who issues the weather forecasts necessary to operate the system. In the case of Rome, the Italian Meteorological Service is providing 48 hour forecasts daily with all the meteorological variables necessary to determine the day’s air mass type and to calculate the formulae if the air mass is offensive. The forecast data are fed into a password-protected website that is available to Agency of Public Health, Lazio, and each morning, the website automatically determines whether an offensive air mass is predicted over the next two days, and if so, calculate the number of excess deaths.

INTERVENTION PLANS

Intervention plans should be best suited for local needs, through co-ordination between the local health agencies and meteorological officials. In Rome the system will be run by the local health agency (Agency of Public Health, Lazio). One very important remaining tasks is the development of the proper measures to lessen mortality once a warning for elevated mortality has been issued by the local health agency/meteorological service team. Health and other agencies and organizations could conduct a series of intervention activities, including:

Media announcements, which provide information on how to avoid heat-related illnesses during oppressive weather.

Promotion of the "buddy" system, media announcements encourage friends, relatives, neighbours, and other volunteers to make daily visits to elderly persons during hot weather.

Activation of "Heatline", which provide information and counselling to the general public on avoidance from heat stress.

Home visits, department of Health field teams make home visits to persons requiring more attention than can be provided over the hotline.

Nursing- and personal care boarding- home interventions. When a warning is issued, the department of Public Health contacts these facilities to inform them of a high-risk heat situation, and offer advice on the protection of residents.

Halt of utility service suspensions. The local electric company and water department halt service suspensions during warning periods.

Increased medical emergency staffing. The Emergency Medical Service increase staffing in anticipation of increased services demand.

Daytime outreach to the homeless. The agency for homeless services activates intensive daytime outreach activities to assist the homeless on the street.

Among the most effective and important mitigation measures is certainly the issue of warnings and recommendations in the media. It is extremely important to give the population all the necessary information when the heat load will increase over the threshold and how to act. The information should be clear and with concrete recommendations and advice, without inducing panics and should reach everybody in the city, also tourists and occasional visitors.

There are two steps: the first one just before the operational start of the project in order to promote the project and its aim and to educate people. The second one during the operational phase, the media are the most effective mean to reach the whole population.

Several articles in newspapers and magazines should appear in late spring and early summer explaining the purpose of the mitigation measures to be undertaken in order to avoid adverse effects of heat wave. It should be clearly pointed out which are the most vulnerable groups. Press release and press conference should coincide with the very start of the operational phase each year. It is important to involve both the meteorological and health authorities and the city administration to give more credibility and a complete information to the public. It shouldn't be too difficult to attract the due attention of the media, while weather and climate affect people's safety, livehood and leisure activities and weather information is included in almost all daily newspapers, radio and TV programs.

Press realises should be issued after each of the heat wave episode, assessing the impact and the severity of the heat wave. The same articles used by the print media will also provide ideas for the shorter television and radio pieces popular with broadcasters. Viewers do not want a lecture on meteorology but rather basic information, with concrete advice and tips. Radio networks and the print media are also effective channels for communicating weather information and warnings. Newspapers also serve an important function in educating and informing the public about the ways to prevent the most severe impacts of heat waves. They issue warnings of severe weather i.e. heat wave.

Beside the immediate measures carried out during the heat wave, media could rise the general awareness that also long term measures should be carried out to attenuate the effect of heat island in cities. Planners, local authorities, architects and urbanists should join their efforts to make the conditions during the oppressive weather conditions less stressful.

ADDITIONAL TOOLS

A numerical model describing intensity and space variations of heat island could help individuate the most endangered quarters and to improve mitigation measures. For the city of Rome at the University La Sapienza (5) one such model has been developed. In a typical summer day, the sea breeze is an effective temperature regulator process normally present at noon and gradually disappearing in the evening. Nevertheless heat waves and severe discomfort for the population are critical in summer and the proposed energy budget model may provide an interesting tool for interpreting the occurrence of extreme urban temperatures in reference to the general synoptic situation. The model results for a typical summer day indicate that a temperature difference between town and rural areas appears in late afternoon, during the night and on early morning; the intensity of the computed heat island being represented by a temperature difference of about 4 °C. In the case of Rome the wind threshold at which the heat island effect becomes negligible is 5 m/s.

CONCLUSIONS

Since now two show case watch warning systems were developed, one for Rome and the other one for Shanghai. Some specific protocol issues should be discussed in the next future, for example: should we work on morbidity as well as mortality, should the possible synergistic effects of air pollution be considered and should we study a single episode to determine more precisely what is happening?
Also the comparison of results obtained with different methods (like: synoptic method, the energy balance model, which is with no doubt a superior tool for describing heat load) should be carefully studied.
Several Heat Watch Warning Systems have been developed at the University of Delaware for cities in the USA (6). On the web one can find some interesting examples for Public Heath information systems, for example:

http://news.bbc.co.uk/hi/english/sci/tech/newsid_1034000/1034598.stm

http://www.nws.noaa.gov/er/lwx/heat.htm

http://www.ci.mil.wi.us/citygov/health/heat

http://www.epa.gov/globalwarming/publications/actions/philadelphia.html

Further systems are being developed or are in the planning stages. It is clear that there is a great demand to deal with the problem of heat and its impact on human health, and with the possibility of a climate change and an associated increasing frequency of stressfully hot conditions, it is even more imperative that vulnerable cities be prepared to deal with the heat.

Plans are under development for the best approach to assist in building the capacity for local systems worldwide. WMO will continue to participate in multiagency projects of this kind, and as a rapporteur for WMO on climate/health issues, I am proud to be playing a part in this important initiative. The primary goal of the next generation of Showcase Projects will be the development and distribution of guidance materials and programs to transfer techniques worldwide. In addition, workshops will be planned to permit health officials and meteorological experts from developing countries to coordinate their activities and to learn how to operate such systems. Outreach to local responsible agencies will increase as the Showcase Project matures, and it is hoped that systems such as the ones under development in Rome and Shanghai will some day be commonplace in large urban areas around the world.

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