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The health impacts of 2003 summer heat-waves Briefing note for the Delegations of the fifty-third session of the WHO Regional Committee for Europe

During July and August 2003, significantly above-average temperatures were observed throughout Europe, Scandinavia, and western Russia, with monthly mean temperatures exceeding the 90th percentile in each region.

The dramatic impacts on human health, particularly in France, raised many questions, for example what are the consequences of heat waves on human health, are heat-wave impacts preventable and if so how could they be prevented?

Studies on the European summer 2003 heat wave is likely to yield many lessons for the future. Such work is important to identify cost-effective interventions, including heat wave warning systems that will save lives. If current predictions on climate change are accurate, more extreme weather events such as heat waves or floods will occur in coming years. These are likely to occur at more frequent intervals and to be more severe. International collaboration is needed to better evaluate and target actions.

Attached, please find a short briefing note. For further questions, please contact Dr Bettina Menne, Email: bme@who.it; Tel: +39 06 4877546.

HEAT-WAVES: IMPACTS AND RESPONSES

Heat-waves affected large areas of western Europe during the months of July and August 2003. For instance, the period between 4 and 12 August was unique in the meteorological history of Paris,[1] the intensity, duration and minimum and maximum daily temperatures being the highest measured since 1873. Provisional data provided by the Director-General of the French Institut de Veille Sanitaire estimated an excess mortality of 11 435 people in the period 1–15 August. The Portuguese Instituto Nacional de Saúde[2] estimated that 1316 deaths were attributable to the heat-wave between 30 July and 12 August. Other countries, including Germany, Italy, Spain and the United Kingdom, were also affected, and work has begun on elaborating the information and data. The events of August 2003 have shown that the effects of heat-waves may be largely under-evaluated.

Europe has experienced an unprecedented rate of warming in recent decades.[3] In the period 1976–1999 the annual number of periods of extreme warmth increased twice a fast as expected from the corresponding reduction in the number of periods of extreme cold. In most of Europe the increase in the mean daily maximum temperature during the summer months was greater than 0.3 °C per decade in the period 1976–1999. The frequency of very hot days in central England has increased since the 1960s, with extremely hot summers in 1976, 1983, 1990 and 1995. Sustained hot periods have become more frequent, particularly in May and July.[4]

Heat-waves are rare events that vary in character and impact. They could become more frequent, intense and longer with climate change. Table 1 shows future projections of extreme events, as elaborated by the Intergovernmental Panel on Climate Change.

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[1] *Impact sanitaire de la vague de chaleur en France survenue en août 2003. Rapport d'étape, 29 août 2003*. Saint-Maurice, Institut de Veille Sanitaire, 2003 (http://www.invs.sante.fr/publications/2003/chaleur_aout_2003/rap_chaleur_290803.pdf, accessed 28 August 2003).

[2] *Onda de calor de agosto de 2003: repercussões sobre a saúde de população. Estimativas provisoras* [Heat-wave of August 2003: repercussions for public health. Provisional estimates]. Lisbon, Instituto Nacional de Saúde, 2003.

[3] Klein Tank A et al. *Climate of Europe: assessment of observed daily temperature extremes and precipitation events*. De Bilt, KNMI, 2002.

[4] Hulme M et al. *Climate change scenarios for the United Kingdom. The UKCIP02 Scientific Report*. Norwich, Tyndall Centre for Climate Change Research, University of East Anglia, 2002.

Table 1. Estimates of confidence in observed and projected changes in extreme weather and climatic events

Confidence in observed changes (latter half of the 20th century)	Changes in phenomenon	Confidence in projected changes (during the 21st century)
Likely	Higher maximum temperatures and more hot days over nearly all land areas	Very likely
Very likely	Higher minimum temperatures, fewer cold days and frosty days over nearly all land areas	Very likely
Very likely	Reduced diurnal temperature range over most land areas	Very likely
Likely in many areas	Increase in heat index (combination of temperature and humidity) over land areas	Very likely in most areas

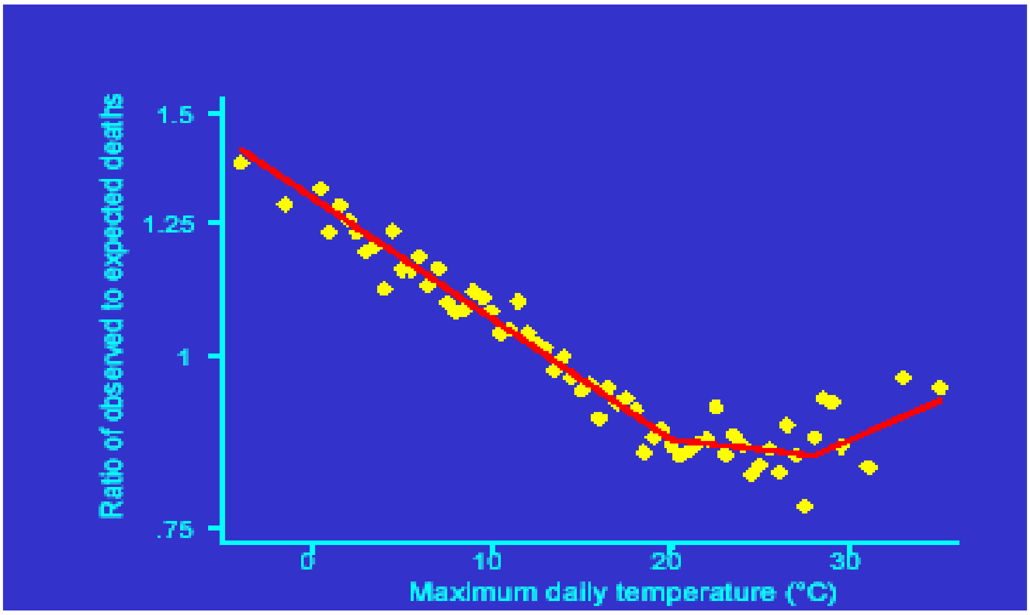
Source: Houghton JT et al., eds. *Climate change 2001: the scientific basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge and New York, Cambridge University Press, 2001.

Epidemiology

A range of epidemiological methods has been used to estimate the effects of the thermal environment on mortality and morbidity. Time series analysis has been widely used to quantify the relationship between mortality and temperature, and linear, V- or J-shaped relationships have been described. A threshold temperature at which mortality is lowest can be identified in temperate zones. Thresholds tend to be higher in warmer locations.

There is evidence that high and prolonged periods of raised temperature may have larger impacts on mortality than would be expected from the linear relationship shown in Fig. 1, probably because of the thermal stress posed by high night-time temperatures.

Fig. 1. Relationship between the ratio of observed to expected deaths and maximum daily temperature



Source: Hajat S et al. Impact of hot temperatures on death in London: a time series approach. *Journal of Epidemiology and Community Health*, 2002, 56:367–372.

High levels of air pollution, particularly due to ozone, also accompany some heat-waves.

The effects on mortality of individual heat-waves have been estimated using episode analysis. In many studies, attributable or "excess" mortality is estimated by subtracting the "expected" mortality from the observed mortality. The expected mortality is calculated using a variety of measures, including moving averages and averages from similar time periods in previous years. Estimates are therefore very sensitive to the method used to estimate the "expected" mortality.[5] Published studies have used different methods, thus making comparison difficult (Table 2).

[5] Whitman S et al. Mortality in Chicago attributed to the July 1995 heatwave. *American Journal of Public Health*, 1997, 87:1515–1518.

Table 2: Mortality attributable to selected heat-waves in Europe, 1976–1995

Heat-wave	Attributable mortality
1976, United Kingdom	9.7% increase for England and Wales and 15.4% increase for Greater London. Almost two-fold increase in mortality rate in geriatric hospital inpatients (but not other inpatients)
1981, Portugal	1906 excess deaths (all causes, all ages) in Portugal, 406 in Lisbon in July, including 63 deaths from heatstroke
1983, Italy	65 deaths from heatstroke during heat-wave in Latio region. In Rome 35% increase in deaths in July compared to July 1982 in those aged ≥65
1987, Greece	2690 heat-related hospital admissions with 926 deaths; estimated excess mortality >2000
1995, United Kingdom	8.9% increase in all-cause mortality (768) in England and Wales, and 15.4% increase (184) in Greater London

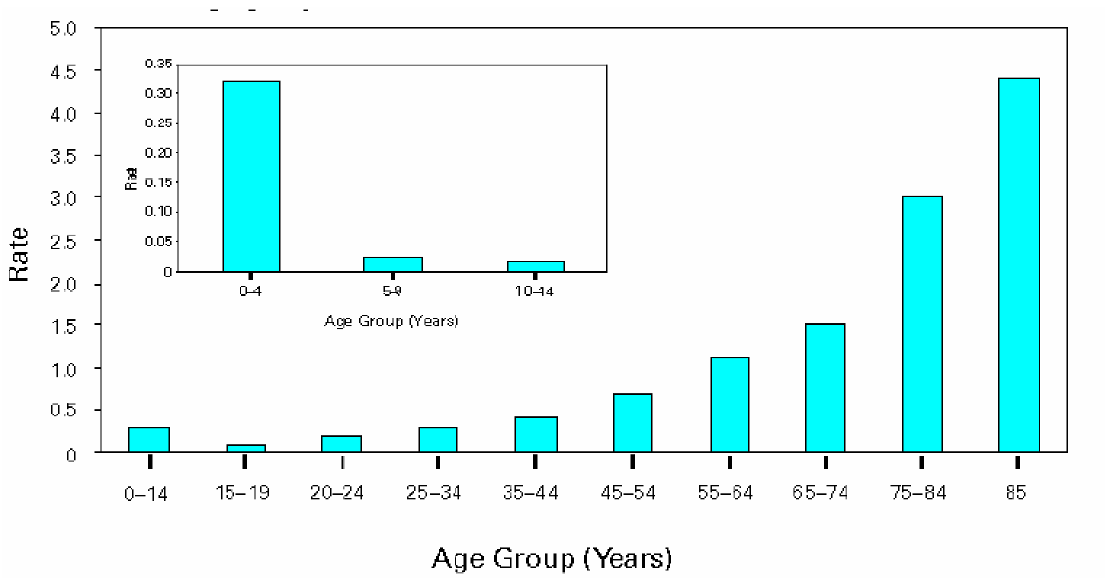
Source: Kovats RS, Koppe C. Heatwaves: past and future impacts. In: Ebi K, Burton I, Smith J, eds. *Integration of public health with adaptation to climate change: lessons learned and new directions*. Lisse, Swets & Zeitlinger, 2003.

Most epidemiological studies have been carried out in the United States, and confirm the risk of heat stress, particularly for the elderly and especially those in hospital or long-term care.

Epidemiological studies indicate that there is no significant difference in risk between men and women. Studies vary, however, in the age at which the vulnerability is shown to increase. Most population-based time series studies show an effect in adult age groups,[6] with the effect being comparatively greater in those aged over 65. As these studies use predetermined groups for the "elderly", there has not been a more detailed examination of the actual age at which vulnerability increases in different populations.

[6] Sierra Pajares Ortiz M et al. Daily mortality in the Madrid community during 1986–1991 for the group between 45 and 64 years of age: its relationship to air temperature. *Revista Española de Salud Pública*, 1997, 71:149–160.

Fig. 2. Average annual rate* of heat-related deaths as a result of weather conditions, by age group, United States, 1979–1997



*Per 1 million population.
† Underlying cause of death attributed to excess heat exposure classified according to the *International Classification of Diseases, Ninth Revision* (ICD-9), as code E900.0 "due to weather conditions (deaths)."

Source: Centers for Disease Control and Prevention. Heat-related deaths – four states, July–August 2001, and United States, 1979–1999. *Morbidity and Mortality Weekly Report*, 2002, 51:567–570.

The dramatic consequences of the heat-wave in France – in terms both of excess deaths and of the overloading of the undertaking system – and the strong political and media reaction stimulated the Institut de Veille Sanitaire to launch a national and international enquiry with a view to discovering the magnitude of the "epidemic".

Table 3 show the preliminary results of requests for information on the 2003 heat-waves by the Institut de Veille Sanitaire (to national contact institutions) and the WHO Regional Office for Europe (to PHEWE and cCASHh partners). Further results are expected.

Table 3. Preliminary information provided to the Institut de Veille Sanitaire and the WHO Regional Office for Europe on the health effects of the 2003 heat-waves

Country	Meteorological information	First results		Enquiries started	Heat health warning system	Evaluation of the system
		Source	Results			
Belgium		Institut Scientifique de Santé Publique	–	No, if started there is a possibility of the results in six months	No	–
France	4–14 August, 9 days with temperature over 35 °C; maximum temperature 39.5 °C, minimum temperature 23.4 °C	Institut de Veille Sanitaire	11 435 excess deaths[a]	Yes, a survey has been carried out in 13 French cities	No	–
Germany		Robert Koch Institut and Deutscher Wetterdienst		Yes, first results should be available in September	No	No
Italy (Rome)	9 June to 2 July and 10–30 July, long intense heat-waves	Agenzia di Sanità Pubblica ASL/RM/E	639 excess deaths[b]	Yes	Yes	System was pre-tested for three years, but implementation started only on 1 July 2003
Italy (Turin)		ARPA/Piemonte		Yes, first results should be available in September	Under development	
Portugal	30 July to 13 August, intense heat-wave with high ICARO[c]	Instituto Nacional de Saúde	1316 attributable deaths[d]	Community survey carried out	Yes in Lisbon, ICARO	Yes
Spain		Agencia de Salud Pública and Instituto de Salud Carlos III, Madrid	–	Yes, national evaluation started, first results in mid-September	No	–

[a] Excess mortality refers to the difference between the number of deaths observed on a given day and the corresponding smoothed average value for the period 2001–2002.

[b] Excess mortality refers to the difference between the number of deaths observed on a given day and the corresponding smoothed average value for the period 1995–2002 (mean daily mortality 43.5).

[c] ICARO = Importância do CAlor: Repercussão sobre os Óbitos. Information is available on http://www.onsa.pt.

[d] A mean value of expected deaths is calculated by using the mean value of observed deaths in the previous periods (1–14 July, 15–28 July, 1–28 July).

Source: Impact sanitaire de la vague de chaleur en France survenue en août 2003. Rapport d.étape, 29 août 2003. Saint-Maurice, Institut de Veille Sanitaire, 2003 (http://www.invs.sante.fr/publications/2003/chaleur_aout_2003/rap_chaleur_290803.pdf, accessed 28 August 2003).

Additional work is needed to understand morbidity patterns, vulnerable populations, the differences between cities and countries, and how the high mortality and illness could have been at least partly avoided.

In order to understand morbidity patterns and intervention measures, the physiological aspects of temperature regulation are briefly described in Box 1.

Box 1. Physiological aspects of temperature regulation and heat illness

The body temperature regulation centres in the brain attempt to keep body core temperature within healthy limits. At rest this is around 37 ºC, but with exercise the temperature can increase to 38–39 ºC without any detrimental effect to health, as long as the thermoregulatory system is within its control range. In order to stay within the control range, the body needs to balance heat production by the body and possible other heat gains (e.g. solar radiation) with heat loss. Heat production is the result of metabolic activity, required to perform activities. As the body is not 100% efficient in this, the major part of the released energy is given off as heat. The body can lose this heat by convection (warming of air or water around the body), by conduction (contact with solids, such as the floor), by respiration (air inhaled is usually cooler and dryer than exhaled air) and by evaporation of sweat.
Skin eruptions, heat fatigue, heat cramps, heat syncope, heat exhaustion and heat stroke are classical heat illnesses. Most heat illnesses (with the exception of skin eruptions and heat cramps) are in essence symptoms of varying severity of failure in the thermoregulatory system. The least severe form is heat syncope, caused by a failure of the circulation to keep up blood pressure and supply oxygen to the brain. As soon as the patient is horizontal, the system recovers quickly. When the muscle pump is active (e.g. during exercise), blood pressure can be kept up longer and body heating may progress further, together with the high cardiovascular stress leading to heat exhaustion. In such cases, if the high heat load from exercise and/or climate is not removed this may progress into heat stroke, where the extreme body temperature (above 40.5 ºC) will lead to damage to cellular structures and the thermoregulatory system and a high risk of mortality. This is typically diagnosed in fit young adults who continue exercise despite feeling unwell, for example during competitions. Heat stroke has a high case-fatality ratio and rapid onset. Complications of heat stroke include adult respiratory distress syndrome, kidney failure, liver failure and disseminated intravascular coagulation.[7] Deaths from heat stroke may be underreported because it is similar to other more familiar causes of death, particularly coronary or cerebral thrombosis, once the body is no longer hot itself or in a hot environment.[8]
There are many factors that might facilitate the occurrence of heat-related illness and mortality. Vulnerability to heat in old age occurs because of intrinsic changes in the regulatory system or because of the presence of drugs that interfere with normal homeostasis. As homeostasis is impaired, elderly people may not be aware that they are becoming ill because of high temperature and therefore may not take action to reduce their exposure.

[7] Donoghue ER et al. Criteria for the diagnosis of heat-related deaths. *American Journal of Forensic Pathology*, 1997, 18:11–14.

[8] Keatinge WR et al. Increased platelet and red cell counts, blood viscosity, and plasma cholesterol level during heat stress, and mortality from coronary and cerebral thrombosis. *American Journal of Medicine*, 1986, 81:795–800.

Several studies have shown that the elderly in institutions, such as residential care homes, are particularly vulnerable to heat-related illness and death.[9] With the elderly having a reduced sweating capacity, it is essential that the sweat they produce evaporates.[10] This does not happen if ambient water vapour pressure is high. Short-term heat acclimatization ordinarily takes from 3 to 12 days, but complete (long-term) acclimatization to an unfamiliar thermal environment may take several years.

For less fit people, such as the elderly, heat illnesses can occur at low levels of exercise or even in the absence of exercise. Low fitness levels lead to a low cardiovascular reserve and thus to low heat tolerance. In addition, a number of other predisposing factors can accelerate the development of high body temperatures. As with fitness, these mostly affect the sweating system (reduced cooling), skin vasodilation (reduced heat movement from core to skin) or cardiovascular reactivity (problems with supply to vital organs and with blood pressure). Even in less severe exposures, however, these processes in reaction to heat can also affect health through other pathways. In general, increased sweat production in heat can lead to two types of problem: dehydration and hyponatraemia (excessive intake of liquid).

During a heat-wave, a number of factors might facilitate the start of heat illness:

- dehydration owing to reduced food and liquid uptake or disease;
- alcohol abuse;
- use of drugs such as diuretics, ß-blockers, anticholinergics, digitalis and barbiturates, especially combined with hypertension;
- acute diseases such as diarrhoea, fever, infections or skin burns; and
- chronic conditions such as mental illness, adiposity and hypertension.

Preventing and managing the effects of heat – policy directions

Preventing the effects of heat requires individual measures, emergency planning and reduction of heat stress in the indoor and outdoor environments.[11]

Individual measures

In the prevention of heat and heat-related illnesses, the functioning of the relevant systems in the body should be directly addressed. Immediate measures can be taken to reduce heat load (less and better clothing, cool environment, etc.) but the ultimate goal is maintenance of the natural defence systems (rehydration, fitness, acclimatization and reduction of excess weight).

The Centers for Disease Control and Prevention[12] have developed guidelines on preventing and managing heat, which include the following advice.

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[9] Sierra Pajares Ortiz M et al. Daily mortality in the Madrid community during 1986–1991 for the group between 45 and 64 years of age: its relationship to air temperature. *Revista Española de Salud Pública*, 1997, 71:149–160.

[10] Havenith G. Temperature regulation and technology. *Gerontechnology*, 2001, 1:41–49.

[11] Koppe C et al., eds. *Heatwaves: impacts and responses*. Geneva, World Health Organization (Health and Global Environmental Change Series, No. 2) (in press).

- Drink more fluids (nonalcoholic), regardless of your activity level. Don't wait until you're thirsty to drink. Warning: If your doctor generally limits the amount of fluid you drink or has you on water pills, ask him how much you should drink while the weather is hot.
- Don't drink liquids that contain caffeine, alcohol, or large amounts of sugar – these actually cause you to lose more body fluid. Also, avoid very cold drinks, because they can cause stomach cramps.
- Stay indoors and, if at all possible, stay in an air-conditioned place. If your home does not have air conditioning, go to the shopping mall or public library – even a few hours spent in air conditioning can help your body stay cooler when you go back into the heat. Call your local health department to see if there are any heat-relief shelters in your area.
- Electric fans may provide comfort, but when the temperature is higher than 35 °C, fans will not prevent heat-related illness. Taking a cool shower or bath, or moving to an air-conditioned place is a much better way to cool off.
- Wear lightweight, light-coloured, loose-fitting clothing.
- NEVER leave anyone in a closed, parked vehicle.
- Although anyone at any time can suffer from heat-related illness, some people are at greater risk than others. Check regularly on: infants and young children, people aged 65 or older, people who have a mental illness, those who are physically ill, especially with heart disease or high blood pressure.
- Visit adults at risk at least twice a day and closely watch them for signs of heat exhaustion or heat stroke. Infants and young children, of course, need much more frequent watching.

If you must be out in the heat

- Limit your outdoor activity to morning and evening hours.
- Cut down on exercise. If you must exercise, drink two to four glasses of cool, nonalcoholic fluids each hour. A sports beverage can replace the salt and minerals you lose in sweat. Warning: If you are on a low-salt diet, talk with your doctor before drinking a sports beverage. Remember the warning in the first "tip" (above), too.
- Try to rest often in shady areas.
- Protect yourself from the sun by wearing a wide-brimmed hat (also keeps you cooler) and sunglasses and by putting on sunscreen of SPF 15 or higher (the most effective products say "broad spectrum" or "UVA/UVB protection" on their labels).

Emergency planning

Current evidence indicates that government services and health agencies might underestimate the health risks. Heat-waves are often accompanied by power failures, and failures to the water supply. Heat-waves should be included in emergency planning at local and national levels.

Knowledge should be made available on social factors, such as the living conditions of the elderly and the numbers of elderly, mentally ill and other vulnerable people. It

[12] *Tips on preventing and managing heat*. (http://www.cdc.gov/nceh/hsb/extremeheat/heattips.htm, accessed 28 August 2003).

is essential to understand the level of support that is currently provided, by families and by social and health care systems, to the elderly and other populations at risk.

The capacity of hospitals and other health facilities to treat patients with heat-related illness and conditions that are aggravated by heat needs to be evaluated. Studies are also needed to assess the behavioural responses to hot weather.

Heat health warning systems

In many cities across the world, the meteorological services provide a "heat warning" when a certain temperature or temperature/humidity threshold is surpassed. Warnings are given on different scales. The warning is transmitted to the public by the media between one and three days in advance. In many countries, the health or civil protection authorities are informed separately. In most countries no specific interventions are made or advice is given, other than a passive warning to the general public and to the local public health agencies.

A survey in the European region has shown that only two cities have comprehensive Heat Health Warning Systems (HHWS), these are Rome (Italy) and Lisbon (Portugal). These cities use a synoptic approach that identifies air masses that have been associated with adverse effects on mortality in that population. HHWS are also under development for Barcelona, Budapest, London and Paris. Little is currently known about the effectiveness of such a system in reducing heat-related mortality, but it seems unlikely that merely providing the information to the public on impending heat-waves will in itself reduce heat-related deaths significantly. Active community-based implementation of warning systems to ensure that vulnerable elderly people are reached and that appropriate advice is given is likely to be necessary. Implementation may therefore vary according to local circumstances, and there is a need for multi-centre evaluation of potential implementation strategies.

Reduction of heat stress in the indoor and outdoor environments

In European countries, people spend the vast majority of their time indoors, at home and at work. The indoor environment has been investigated in relation to indices of thermal comfort. Perceptual scales have been developed to evaluate thermal comfort in an individual. In temperate climates, the optimum indoor temperature is between 18 °C and 24 °C.[13] In general, recommendations have focused on maintaining minimum indoor temperatures and reducing the impact of cold rather the potential impact of heat.[14] In the United States, heat warnings are used to advise people to stay in cool homes, which means homes that are either well constructed or air-conditioned. Where these are not available, people are advised to move to buildings where thermal comfort is provided.

Temperatures are higher in urban areas. This is due to many factors, including less radiant heat loss in the urban canopy layer, lower wind velocities and increased exposure to

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[13] *Health impact of low indoor temperatures*. Copenhagen, WHO Regional Office for Europe, 1987 (document ICP/RUD 003/m01).

[14] *Indoor environment: health aspects of air quality, thermal environment and noise*, 2nd ed. Geneva, World Health Organization, 1990 (document WHO/EHE/RUD/90).

radiation. Local and regional climates are modified significantly by urbanization and other land-use changes. One of the best known phenomena of the urban climate is the "urban heat island", whereby the temperature increases with an increase in the number of inhabitants and the building density. Heat-waves present special problems in urban areas because buildings retain heat at night if ventilation is inadequate. During heat-waves, inhabitants of urban areas may experience sustained thermal stress both day and night, while those in rural areas often obtain some relief from thermal stress at night.[15] Little is known about the effectiveness for human health of certain urban planning measures, but it is assumed that urban planning plays an important role in primary prevention.

The activities of the WHO Regional Office for Europe in the area of extreme weather events

WHO set up its European programme on global change and health in 1999. The programme coordinates and participates in a number of research activities, such as cCASHh and PHEWE. This includes evaluation of the burden of disease of extreme weather conditions and evaluation of measures, strategies and policies to best prevent the effects of heat stress in human beings.

Although heat-waves have been intensively studied in the United States, this is a relatively new field in the European Region. Very few case studies are currently available to allow the proper evaluation of cost-effective interventions, its magnitude and the social consequences.

Conclusion

Prompt, appropriate action can prevent heat-related deaths. Studies on heat-waves in Europe in the summer of 2003 are likely to yield many lessons for the future. Such work is important in identifying cost-effective interventions, including heat-wave warning systems that will save lives. If current predictions on climate change are accurate, more extreme weather events such as heat-waves or floods will occur in the coming years. These are likely to occur at more frequent intervals and to be more severe. International collaboration is thus needed to better evaluate and target actions.

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[15] Jendritzky G, Grätz A. Das Bioklima des Menschen in der Stadt. In: Helbig A, Baumüller J, Kerschgens MJ, eds. *Stadtklima und Luftreinhaltung*. Heidelberg, Springer, 1999:126–158.

[16] *Climate change and adaptation strategies for human health in Europe (cCASHh)* (http://www.euro.who.int/ccashh, accessed 3 September 2003).