PHASE

Public health Adaptation Strategies to extreme weather events

SCIENTIFIC SUMMARY for Public health
Health effects of Heat

What is known on the health effects of heat

High temperatures and heat waves have a detrimental effect on human health. Evidence has grown since the '90s, firstly from studies conducted in the US and Europe while more recently evidence has also been published from other areas of the world with very diverse climatic and socio-economic conditions.

Heat effects are immediate or with a delay of 1-3 days and greater for respiratory and cardiovascular causes. In high economic developed countries the short-term mortality increase is due to the anticipation of deaths of very frail people, the so-called harvesting effect. Effects on mortality are greater than those on morbidity. Greater effects, with peaks in excess deaths have been reported during exceptional heat waves events such as the 2003 heat wave in Europe.

Time series modelling techniques have become more sophisticated in recent years and have permitted to study the temperature-mortality relationship in a more flexible way simultaneously taking into account the possible delayed effects.

It is important to consider that susceptibility factors vary over time and are heterogeneous in different settings based on local population characteristics (proportion of elderly, social-economic level, health care services, etc).

Few recent studies, from the US and Europe, suggest a decrease in the heat effect in the elderly in recent years, possibly related to individual and community level adaptation (increased awareness on health risks, implementation of warning systems and prevention plans).

Multicentre studies suggest stronger effects of extreme temperatures in the cities less acclimatized to heat. This factor is important when considering future climate change scenarios which predict an increase in mean temperatures and higher frequency of extreme events for Europe.

Subgroups of the population most at risk

Among people most at risk to the adverse effects of heat waves epidemiological studies have identified the elderly, young children, people living alone, subjects with pre-existing chronic disease (table1). A number of studies suggest women are at greater risk than men.

Poor health, both physically and mentally, has been shown to increase susceptibility to high temperatures. The evidence of increased sensitivity to high temperatures among persons with respiratory diseases such as asthma or chronic lung diseases, is quite extensive. An increased vulnerability to elevated temperatures is also reported for those with cardiovascular and cerebrovascular disease. People suffering from diabetes also have an increased risk of dying during heat waves. A history of mental illness has been associated with increased risk of heat-related mortality. In addition, depression, mental disorders, and circulatory disorders of the brain are conditions shown to significantly increase the risk of dying in a day with high temperatures.

Infants and pregnant woman are also at higher risk during heat waves, but most studies focus on mortality which is less relevant for these groups.

Heat wave increases the risk of death among people with impaired health status, but the risk also increases with the degree of dependence. Patients who are hospitalized, living in a nursing home or are being confined to bed all have an increased risk of dying on heat wave days .

Certain medications, especially diuretics and psychotropic drugs have been found to be associated with increased risk of mortality and morbidity during heat waves. Subjects on antidepressants and antipsychotics have also been associated with increased risks of mortality.

Table 1. Susceptibility factors to heat and strength of the evidence from scientific literature.

Susceptibility factor	Susceptible subgroup	Strenght of evidence
Age	Children (age 0-4)	+
	Elderly (65+) and very elderly	+++
Gender	Women	++
Socioeconomic status	Low-income, low education level	+
	Living alone	+
Health condition	Cardiovascular disease (e.g. heart failure)	+++
	Respiratory disease (e.g. COPD)	+++
	Diabetes mellitus	+
	Mental disease (e.g. depression)	+
	Neurological disease (e.g. dementia)	+
	Renal disease	+
Pharmacological treatment	People assuming psycotics, neuroleptics, diuretics, etc.	+++
Environmental conditions	urban residence, building characteristics, air pollution	+
Other risk factors	Pregnant women, occupation in hot environment (e.g.furnaces,agriculture)	++

What the PHASE project adds

Temporal variation in the effect of heat in 9 European cities: period comparison before and after 2003.

In Europe, after the 2003 heat wave evidence on the adverse effects of extreme temperature on mortality has grown and heat prevention plans have been widely adopted. However, there is limited evidence of the temporal variation in the effects potentially associated to changes in exposure and adaptation measures introduced.

A period analysis conducted on the effects of high temperatures on mortality, before (1996-2002) and after (2004-2010) summer 2003, was conducted in 9 European cities (Athens, Barcelona, Budapest, Helsinki, London, Paris, Rome, Stockholm, Valencia) by age, cardiovascular and respiratory causes. Results show that the mortality risk associated to high mean temperature has decreased in Athens, Rome and Paris in the recent period among the elderly and subjects with cardiovascular disease possibly due to prevention measures targeted to these subgroups of population. Conversely, an increase in the heat effect was observed in cities with milder climatic conditions previously not exposed, more evident in Helsinki and less in Stockholm.

In conclusion, although mortality risk associated to high temperature has decreased, extreme temperatures still have a significant effect on mortality in European cities and cannot be underestimated.

Annual variation in the effects of extreme temperatures.

Building on the previous analyses, the annual variation of the heat effect was analyzed in 9 European cities (Athens, Barcelona, Budapest, Helsinki, London, Paris, Rome, Stockholm, Valencia) during a 20 -year period (1990-2010). This analysis assesses variations between summers (due to exposure differences) and changes in the trend over time. A significant reduction in the effect was observed in Rome and Athens and an increase in the effect was observed in Helsinki and Stockholm. This methodology enables to detect years with an exceptional high mortality associated to temperature extremes (Barcelona (2001), Paris (2003) and London (2003)). There was no evidence of a change in the mortality risks related to high temperatures in Budapest and Valencia.

This more detailed analyses confirmed results from the period analysis, identifies extreme years and when (year) there was a change in the trend. These results are important for evaluating the impacts of climate change and the role of public health actions in helping populations to adapt.

Cohorts susceptible to heat waves

The risk of mortality among cohorts of persons with specific pathologies previously associated to heat was investigated in Rome and Stockholm during the summer periods of 2000-2008. The relationship between heat waves and all-cause mortality was investigated through time series modelling, adjusting for time trends. Cohorts of subjects were identified on the basis of previous hospital discharge records for congestive heart failure, COPD, diabetes, survivors of MI and psychiatric disease and for the total 50+ population.

In Rome the cohort specific increase in mortality ranged from 7% among survivors of myocardial infarction to 25% in the COPD cohort. In Stockholm the range was from 11% for the congestive heart failure cohort to 28% for the psychiatric cohort.

Case studies of risk of preterm birth associated with high temperatures during the last month of gestation

The aim of these studies was to explore the potential effect of elevated temperatures on the risk of preterm birth in Stockholm (Sweden) and Valencia (Spain) and in Italian cities. All singleton births that took place during the warm season (May-September) in Stockholm (1996 – 2006) and Valencia (2006-2010) were included. The effect of heat was estimated for different temperature variables, daily maximum (Stockholm) and maximum apparent temperature (Valencia) and for temperature values from the 50th, 90th and 99th percentiles of the warm season up to 4 weeks before delivery. Additionally, three temperature-interval-specific estimates were obtained for changes between each of these temperature values. We took into account the pregnancies at risk adjusted by the gestational age distribution of the set in each day. The risk of preterm birth increased up to 20% when maximum apparent temperature exceeded the 90th percentile two days before delivery in Valencia. In Stockholm a more delayed effect was obtained.

The effect of high temperature on the probability of preterm birth was also analyzed in six Italian cities in the period April to October from 2001 to 2010. A positive relative risk was observed comprised between +1.03 (95% CI 0.98-1.10 - lag 3-6) in Turin and Palermo (95% CI 0.95-1.10 - lag 0-2) and +1.09 (95% CI 0.90-1.32 - lag 0-1) in Bologna when comparing the 75° and the 90° percentile of maximum apparent temperature distribution. Association was significant only in Rome; RR: 1.06 (95% CI 1.03-1.10 - lag 0-2). The analysis of effect modification conducted for Rome showed a higher association between temperature and preterm risk in younger women (<20yrs) and among those with previous chronic diseases and a lower association among women older than 37 yrs, with higher education level and with obstetric pathologies during pregnancy. A further analyses was conducted on the association between heat waves and preterm birth risk in the Rome cohort for the same period. We found a RR of 1.19 (IC95% 1.08-1.32) for a day of heat wave compared with a day without a heat wave.

In Italy results from studies conducted on preterm births served to develop a guidance leaflet for pregnant women on the risks related to heat and the prevention measures to adopt during heat waves. This was then adopted at national level by the Italian Ministry of Health.

In conclusion, the exposure to elevated temperatures was associated with an increased risk of preterm birth in the last month of gestation. Different city-specific patterns of the effect of temperature were observed showing the potential heterogeneity in population characteristics and climate.

Case study of the effect of heat on child hospital admissions in Valencia

A case study was carried out to examine the effect of heat on hospital admissions in children aged 0-14 years in Valencia during the period 1996-2009. Outcomes were total hospital admissions, admissions for respiratory causes and for gastrointestinal infections. A seasonal (May-September) time series design was applied to estimate the effect of high temperatures and heat wave episodes.

The study showed an association between high temperatures and hospitalizations in children. An effect of high temperatures on total, respiratory and gastrointestinal infection admissions, the latter had the greatest effect estimates. Regarding heat waves, several definitions were tested, and all were consistent in showing an adverse impact on child hospitalizations on heat wave days compared to non-heat wave days.

Survey of prevention plans and identification of susceptible subgroups

An overview of existing heat plans in countries included in PHASE was provided including heat warning systems, health surveillance systems, specific prevention measures and methodologies for the selection of susceptible subgroups from registries, GP and social service notifications. Case studies are a valuable tool for providing information on the components of a heat plan in place at the European level for other countries that want to implement heat plans and can select the most appropriate measures based on local infrastructures and characteristics.

Implications for Public health (key public health messages)

Key public health messages for heat include:

- The effects of high temperatures and heat waves on health are extensive and will increase in Europe under future climate change predictions
- Public health attention should be focused towards specific actions to reduce the health effects among susceptible subgroups especially the elderly, subjects with chronic illness, young children, pregnant women.
- Research should focus on identifying susceptible subgroups and finding the best outcome indicators to estimate the effects (eg. Children: ER visits, GP visits; chronic disease patients: medical prescriptions, hospital admissions etc)
- The temporal variation in the effects of heat due to adaptation (introduction of prevention plans) and changes in the pool of susceptibles should be regularly monitored.
- Communication campaigns are a key tool for both the public, front line responders and health care services to increase awareness and help response and adaptation.
- Due to the potential interaction between air pollution and heat waves common warning systems should be developed and policies to reduce air pollution levels should be triggered especially during heat waves
- Adequate planning and a multi-sectorial approach is required to effectively minimize the health effects of heat.

Preparedness and response tools necessary to define a Prevention Plan

A Heat prevention plan should include:

1. A Heat Warning system based on the temperature-mortality of local populations, and not solely on absolute values of temperature, where possible.
2. Guidelines or guidance documentation should be defined where specific prevention measures and emergency actions are modulated on the levels of risk issued by warning system.

3. Information campaigns for the general public and at risk subgroups, health care professionals and front-line workers. Effective communication strategies for the different stakeholders should be identified to provide relevant, timely, accessible and coherent information on risks, available prevention measures and social/health care services.
4. The identification of at risk subgroups using population registries, Health service records and/or medical profession notifications is an important component to identify susceptible people. Guidance documents need to be developed also on the basis of specific susceptible subgroups. Recently identified at risk groups like children and pregnant women need to be accounted for. In Italy, a new leaflet for pregnant women was developed based on PHASE findings.
5. "Good practice" interventions should be chosen taking into account available resources and infrastructures as well as susceptible subgroups that need to be included in prevention measures. Sustainability and cost-effectiveness of interventions should be the guiding principles for decision-making. The evaluation of specific interventions, as in the Lazio Region for GP active surveillance, can serve to evaluate effectiveness of prevention measures and monitoring of at risk subgroups.
6. Surveillance of health outcomes (mortality surveillance system, hospital admissions registry, GP notifications, ambulance calls, number of telephone calls). Attention should be focused on how to define a significant increase in events. The expected number of events should be based on a mean value defined considering a sufficient number of years to be stable and take into account for population changes in more recent years as well weekly and monthly trends in the health outcome considered (eg. Decline in summer months, higher number of visits beginning of the week and less on weekends). Near-real time notifications can help identify emergency situations and plan health service response planning. Simple method to calculate excess mortality during heat wave days was developed within PHASE as operational tool.
7. Emergency contingency plans should be defined and integrated across Institutional bodies, especially environmental services, health and social services, civil protection and local and national policy makers, energy and transport sectors.
8. Medium and long-term mitigation measures should also be implemented by local municipalities and at the national level.

References and hyperlinks to published results:

- Åström DO, Forsberg B, Rocklöv J. Heat wave impact on morbidity and mortality in the elderly population: a review of recent studies. Maturitas. 2011 Jun;69(2):99-105. doi: 1016/j.maturitas.2011.03.008. Epub 2011 Apr 8. Review
- Michelozzi P, de' Donato FK, Bargagli AM, D'Ippoliti D, De Sario M, Marino C, Schifano P, Cappai G, Leone M, Kirchmayer U, Ventura M, di Gennaro M, Leonardi M, Oleari F, De Martino A, Perucci CA. Surveillance of Summer Mortality and Preparedness to Reduce the Health Impact of Heat Waves in Italy. Int J Environ Res Public Health. 2010 May;7(5):2256-73. Epub 2010 May 6
- Rocklöv J, Forsberg B, Ebi K, Bellander T. Susceptibility to mortality related to temperature and heat and cold wave duration in the population of Stockholm County, Sweden. Glob Health Action. 2014 Mar 12;7:22737. doi: 10.3402/gha.v7.22737. eCollection 2014.
- Schifano P, Lallo A, Asta F, De Sario M, Davoli M, Michelozzi P. Effect of ambient temperature and air pollutants on the risk of preterm birth, Rome 2001-2010. Environ Int. 2013 Nov;61:77-87. doi: 10.1016/j.envint.2013.09.005. Epub 2013 Oct 5.
- Schifano P, Cappai G, De Sario M, Michelozzi P, Marino C, Bargagli AM, Perucci CA.Vulnerability to heat wave-related mortality: a follow-up study of a cohort of elderly in Rome. Environ Health. 2009 Nov 12;8:50.
- http://www.phaseclimatehealth.eu/