Heat Waves in Italy: Cause Specific Mortality and the Role of Educational Level and Socio-Economic Conditions

P. Michelozzi · F. de'Donato · L. Bisanti · A. Russo · E. Cadum · M. DeMaria · M. D'Ovidio · G. Costa · C. A. Perucci

Introduction

Record temperatures were observed across Europe during the summer of 2003. There is debate among experts as to whether the high temperatures observed in recent years are a normal fluctuation in the climate or a sign of global warming characterized by wider temperature variations and an increase in climate extremes. The full impact of climate change on health still remains unclear, and an accurate analysis and quantification of the possible effects, both in the short and long term, still has to be carried out (1,2). Although interest on the impact of heat on mortality is increasing, it is clear from summer 2003 that most European countries were unprepared to cope with this emergency.

The relationship between weather, temperature and health has been well documented throughout the literature, both during the winter and summer seasons. The relationship between mortality and temperature graphically presents a "U" or "V" shape, with mortality rates lowest when the average temperature ranges between 15 – 25 °C and rising progressively as temperatures increase or decrease. In relation to hot weather and the effects of high temperatures on mortality, the literature has concentrated on the effect of extreme temperatures, often denoted as "heat waves", which are known to enhance deaths from cardiovascular, cerebrovascular, and respiratory conditions (3,4). The increased frequency and intensity of heat waves may lead to an increase in heat-related deaths with the greatest impact on urban populations, particularly the elderly and the ill.

The report presents an evaluation of the health impact of heat waves recorded during the summer of 2003 (June 1st – August 31st) in three major Italian cities (Rome, Milan and Turin). The analysis aims to analyse the impact of heat waves on cause-specific mortality and to analyse the role of demographic characteristics and socio-economic conditions that may increase the risk of mortality.

Data and Methods

The dataset for each city is comprised of daily mortality counts among the resident population by age, sex, and cause of death. Temperatures (mean, maximum, minimum), and maximum apparent temperature (Tappmax an index of human discomfort based on air temperature and dew point temperature) ($T_{app\text{-}max} = -2.653 + 0.994Ta + 0.0153(Td^2)$) (5) during the summer period are also considered. The latter index combines two meteorological variables that have been shown to have an impact on human health, namely temperature and humidity.

Expected daily mortality was computed as the mean daily value from a specific reference period, respectively 1995 – 2002 for Rome and Milan, and for the period 1998 – 2002 for Turin. The daily mean expected value was smoothed using a smoothing spline. Daily excess mortality was calculated as the difference between the number of deaths observed on a given day and the smoothed daily average. Confidence limits were determined assuming a Poisson distribution.

In Rome, excess mortality by socio-economic level was evaluated for the census tract of residence using a deprivation index based on a series of components, namely education, occupation, unemployment, the number of family members, overcrowding and household ownership data (6). In Turin the level of education was considered as socio-economic indicator.

Results

During the summer of 2003 Tappmax was higher than the mean for the reference period in all cities; the greatest increase was observed in Milan with +16 %, with peak values in August that recorded the highest monthly mean since 1838. In Rome temperatures registered a 13 % increase, while Turin a +11 % increase was observed during summer 2003 (➔ *Tab. 1*).

The definition of a heat wave has to be site specific in order to reflect local conditions; in fact an international definition of heat waves currently does not exit. In this article heat waves are defined as days with Tappmax >90th annual percentile and for the first day an increase of 2 °C compared with the previous day. This definition was elaborated on the basis of the literature reviewed and on the relationship observed between temperature and mortality. Three major heat wave periods occurred in Rome, while in the north of Italy two heat waves occurred; a minor one at the beginning of the summer (mid June) and a major one in August (2nd – 18th).

The results of the analyses indicate record excess mortality during the summer 2003 heat waves. A strong association between daily mortality and temperature was observed; with peaks in mortality corresponding to peaks in temperature or with a lag of 1 – 2 days following the peaks (➔ *Fig. 1*). The heat waves recorded between June and August 2003 are associated with significant health effects; a total of 944 excess deaths were observed in Rome (+19 %), while in Milan and Turin 559 (+23 %) and 577 (+33 %) excess deaths were recorded respectively (➔ *Tab. 1*). In Rome, excess mortality was observed throughout the summer, but predominantly during the three heat waves. The first heat wave (June 9 – July 2) was associated with an increase in mortality of 352, a total of 319 excess deaths occurred during the second heat wave period (July 10 – 30), and 180 excess deaths during the third (August 3 – 13) (➔ *Fig. 1*). In the northern cities, excess mortality was mainly concentrated in the first part of August, when weather conditions were more extreme (➔ *Tab. 2 and 3*). In Milan, 141 excess deaths were recorded during the first heat wave (9 – 20 June) and 380 excess deaths during the second heat wave (5 – 18 August) (➔ *Fig. 1*). In Turin, 76 excess deaths were recorded during the first heat wave (20 – 27 June) and 257 excess deaths during the second heat wave (3 – 14 August) (➔ *Fig. 1*).

When subdividing by age group, excess mortality increased dramatically with age, with the greatest impact observed in the old (75 – 84 years) and very old (85+ years) age groups. In the latter group, mortality increased by 65 % in Turin, 46 % in Rome and 40 % in Milan (➔ *Tab. 2*). When stratifying by age group, there probably is some residual confounding related to gender, in that a larger proportion of females are in the older age groups. In fact, when stratifying by gender, the increase in mortality seems to be greater among females, probably reflecting both the higher proportion of females in the elderly population (➔ *Tab. 2*) and their possible higher susceptibility.

The analyses of cause-specific mortality illustrate how the greatest excess in mortality was observed for the central nervous system, cardiovascular, respiratory diseases and metabolic\endocrine gland and psychological illnesses (➔ *Tab. 3*). In Rome, the highest excess was registered for disorders of the central nervous system (+85 %) and respiratory diseases (+39 %). When subdividing by age group, the excess, for both causes, was greatest in the old (+123 %, +52 %) and very old (+100 % and +45 %) age groups. In Turin the greatest increase in mortality was observed for metabolic\endocrine gland disorders (+143 %), central nervous system (+122 %) and respiratory diseases (+57 %). Milan registered the greatest excess in mortality for disorders of the central nervous system (+118 %), followed by respiratory diseases (+82 %)

and metabolic\endocrine gland disorders (+68 %). Cardiovascular disease registered an increase only in Rome (+24 %) and Turin (+41 %) (*Tab. 3*).

Results show that the socio-economic level is an important risk factor since the greatest excess was observed in the lower levels in both Turin (+43 % low education level) and Rome (+17.8 % low socio-economic level).

Tab. 1

Maximum apparent temperature and % variation in mortality for Rome, Milan and Turin during summer 2003

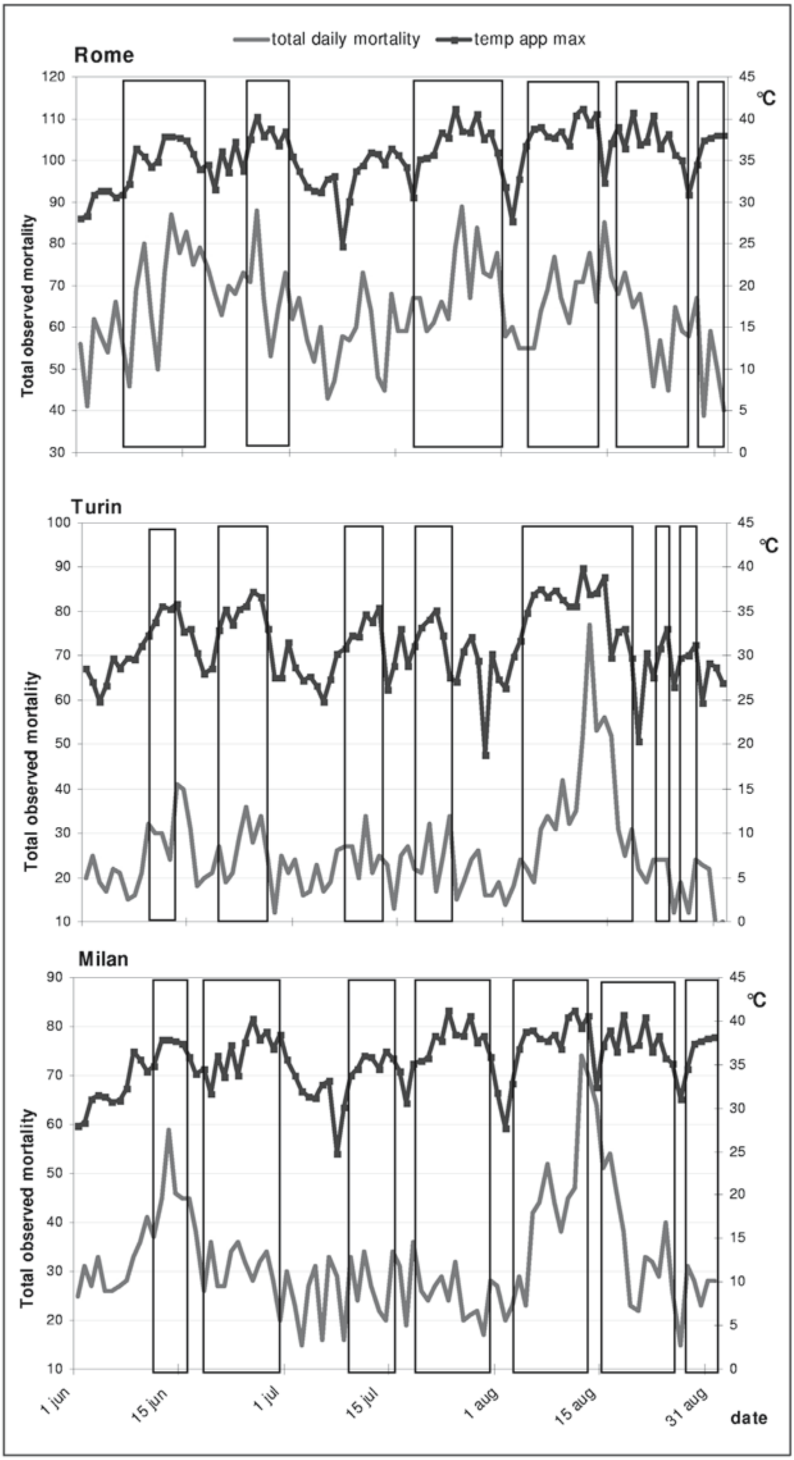
	Rome	Milan	Turin
mortality			
2003	6009	2968	2332
reference period	5065 (1995–2002)	2409 (1995–2002)	1755 (1998–2002)
variation	19 %	23 %	33 %
max. apparent temp (°C)			
2003	35.2	32.7	31.7
reference period	31.1 (1995–2002)	28.3 (1995–2002)	28.6 (1990–1999)
variation	13 %	16 %	11 %

Tab. 2

Total and excess mortality by age group and sex in Rome, Milan and Turin during summer 2003

Mortality reference period	Rome 1995–2002				Milan 1995–2002				Turin 1998–2002			
	observed	expected	excess	%	observed	expected	excess	%	observed	expected	excess	%
0–64	915	973	–58	**–6**	372	407	–35	**–9**	307	286	21	**7**
65–74	1163	1112	51	**5**	480	503	–23	**–5**	416	358	58	**16**
75–84	1938	1541	397	**26**	1020	715	305	**43**	752	539	213	**40**
85	1993	1439	554	**38**	1096	784	312	**40**	857	572	285	**50**
Total												
All ages	6009	5065	944	**19**	2968	2409	559	**23**	2332	1755	577	**33**
Gender												
Male	2768	2522	246	**10**	1299	1158	141	**12**	1074	859	215	**25**
Female	3241	2543	698	**27**	1669	1251	418	**33**	1258	896	362	**40**

Fig. 1



Total daily mortality and maximum apparent temperature, June 1st – 31st August 2003

Tab. 3

Total and excess mortality by cause of death in Rome, Milan and Turin during summer 2003

Causes of death	Rome				Milan				Turin			
	observed	expected	excess	%	observed	expected	excess	%	observed	expected	excess	%
Tumours	1921	1779	142	**8**	926	935	–9	**–1**	656	639	17	**3**
Circulatory	2328	1876	452	**24**	1044	832	212	**25**	892	631	261	**41**
Respiratory	327	236	91	**38**	282	155	127	**82**	201	128	73	**57**
Digestive system	227	253	–26	**–10**	121	103	18	**17**	97	85	12	**14**
Genito-urinary	81	63	18	**29**	57	41	16	**39**	40	27	13	**48**
Metabolic/ endocrine gland disorders	307	247	60	**24**	111	66	45	**68**	103	42	61	**145**
Psycho-logical illnesses	96	57	39	**70**	38	34	4	**12**	70	42	28	**67**
Central nervous system	254	137	117	**86**	133	61	72	**118**	85	38	47	**124**
Total												
All causes	6009	5065	944	**19**	2968	2409	559	**23**	2332	1755	577	**33**

Discussion

The exceptional heat waves of summer 2003 had a strong impact on the population in terms of mortality, especially in the northwest where peak temperatures reached record values. The high temperatures and the persistence of these conditions were a strong determinant of the increase in observed mortality.

The study considers a limited time window of three months as a more complete time series was not available. However, throughout the literature, the time series approach is considered the most valid tool for analysing heath impact of climate change as it accounts for short-term variation and allows for an accurate estimate of long-term effects. The reference period for the quantification of excess mortality is a matter of discussion as by using different reference periods, different estimates of excess mortality are produced. The reference period has to be sufficiently long to be representative of the variability of exposure and of the observed effect but, on the other hand, not too long in order to account for long-term variation of mortality due to variations in the denominator and of mortality rates.

Daily mortality trends and peaks in mortality show a temporal variation associated to temperature trends (7,8). However, prolonged periods of high temperature may have a diverse effect on health compared to periods with extreme peak values but a lower mean. In summer 2003, persistent high temperatures maintained above-average levels of mortality. The limited time window analysis did not permit an evaluation of the harvesting effect (displacement of mortality), but lower excess mortality during the third heat wave period in Rome for example, could be attributed to a reduction in the susceptible population, as observed in other cities (7).

It is equally important when comparing results for different cities and regions to consider whether heat waves are a recent phenomenon or have been occurring on a regular basis, as the estimate of expected deaths and the associated excess might vary considerably.

During the summer months many Italian cities are typified by seasonal migration, hence populations in urban areas are reduced (eg. Milan, Rome). Although this aspect may be accounted for in the time series, it is important to note that the migratory pattern is not equally distributed among the population (9). Susceptible groups, such as the elderly and ill of lower socio-economic status, often remain in the city, creating a bias in predicted excess death. The high number of excess deaths in these subgroups might reflect the higher proportion of elderly people of low socio-economic status who remain in the city during summer. Other socio-economic factors that might have an impact on health include poor housing quality, lack of air conditioning, lack of access to social and health services, and individual behaviours (e.g., alcohol consumption and taking medication).

Analysis of mortality by cause (*Tab. 3*) gave a valid insight on the effects of heat waves on health in medical terms, confirming previous results of increases in heat-related mortality by respiratory and cardiovascular diseases (4,10,11) and showing that extreme heat can worsen the conditions of people suffering from chronic disease. These results may be an important in the identification of susceptible populations and the development of effective warning systems and prevention programs. In Italy, as in other countries, the possible effects of global warming could make susceptible subgroups more vulnerable (1,2) and together with the increasing proportion of elderly people may enhance heat-related mortality. It is important to recall the heterogeneous nature of the health impact of heat waves in terms of its characteristics, such as the intensity and temporal variation in relation to the meteorological conditions between the different cities. Results from 2003 highlight the necessity of implementing further preventive actions targeting the groups of susceptible people involved (over 75+ especially females) as well as disadvantaged areas of the city and low income populations.

Demographic and social factors, as well as the level of urbanisation, air pollution and the efficiency of social services and health-care units represent important local modifiers of the impact of heat waves on health. Further analysis to observe the lag effect between heat exposure and health effects as well as the cumulative effect linked to time of exposure between extreme and normal conditions.

Concerning the latency between the peak in temperature and the increase in the mortality trends, the data showed that peaks in mortality was observed 1 – 2 days following the heat wave. These results are coherent with results of previous time series studies that reported temperature lags at 0 – 3 days as having the maximum effect on mortality and demonstrate that heat related-mortality is a very acute event requiring timely intervention.

The evaluation of the heat waves during 2003 stress the importance of introducing further preventive measures, for both the general population and susceptible groups, to reduce heat-related deaths during summer. Heat stress conditions may be predictable, and appropriate prevention measures may reduce heat-related mortality. This is achievable if efficient and effective warning systems are introduced to alert the residents of urban areas of the oppressive weather conditions.

In 2004, the Italian Department for Civil Protection implemented a national program for the evaluation and prevention of the health effects of heat waves during the summer period. Heat\Health Watch\Warning System (HHWWS) (12,13) and city-specific prevention programs are activated during the summer period in order to reduce the heat-related deaths.

The implementation of warning systems integrated with prevention and response programmes at the national level are a valid tool for the monitoring and surveillance of mortality and the reduction of heat-related deaths during heat waves. Furthermore, the national project includes the identification of susceptible subgroups, such as the elderly aged 75+ and people with specific illnesses who are at higher risk during heat waves. Health guidelines, developed by the Ministry of Health, have been put in place for the implementation of appropriate local prevention programs.

References

Yoganathan D, Rom WN (2001) Medical aspects of global warming. Am J Ind Med40:199 – 210

Patz JA, McGeehin MA, Bernard SM, et al. (2000) The potential health impacts of climate variability and change for the United States: executive summary of the report of the health sector of the US National Assessment. Environ Health Perspectives 108:367 – 76

Albertoni F, Arcà M, Borgia P, Perucci CA, Tasco C (1984) Heat-related mortality Latium Region summer 1983. MMWR 33(37):518 – 521

Semenza J et al. (1996) Heat-Related Deaths during the July 1995 Heat Wave in Chicago. The NE J of Med Jul 11;335(2):84 – 90

Kalkstein LS, Valimont KM (1986) An Evaluation of summer discomfort in the United States using a relative climatological index. Bulletin of the American Meteorological Society 67(7):842 – 48

Michelozzi P, Perucci CA, Forastiere F, Fusco D, Ancona C, Dell'Orco V (1999) Inequality in health: socio-economic differentials in mortality in Rome, 1990 – 95. Journal Epidemiology and Community Health 11:687 – 93

Braga AL, Zanobetti A, Schwartz J (2001) The time course of weather-related deaths. Epidemiology 1;12:662 – 7

Hajat S, Kovats R, Atkinson R, Haines A (2002) Impact of hot temperatures on death in London: a time series approach. J Epid Comm Health 56:367 – 372

Michelozzi P, Fano V, Forastiere F, Barca A, Kalkstein LS, Perucci CA (2000) Weather conditions and elderly mortality in Rome during summer. Bulletin of the World Meteorological Organization 49(4):348 – 355

Semenza JC et al. (1999) Excess hospital admissions during the July 1995 heat wave in Chicago. Am J of Prev Med 16:269 – 277

Weisskopf M et al. (2002) Heat wave morbidity and mortality, Milwaukee, Wisconsin, 1999 vs 1995: an improved response? Am J of Public Health 92(5):830 – 833

Kalkstein LS, Nichols MC, Barthel CD, Greene JS (1996) A new spatial synoptic classification: application to air mass analysis. International Journal of Climatology 16:983 – 1004

Sheridan SC (2002) The re-development of a weather type classification scheme for North America. International Journal of Climatology 22:51 – 68

Response to Temperature Extremes