The impact of the 2003 heat wave on daily mortality in England and Wales and the use of rapid weekly mortality estimates

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Surveillance report

The impact of the summer 2003 heat waves on mortality in four Italian cities

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This study evaluates the impact of the 2003 heat wave on cause-specific mortality and the role of demographic characteristics and socioeconomic conditions that may have increased the risk of mortality in four Italian cities: Bologna, Milan, Rome and Turin.
Daily mortality counts, for the resident population by age, sex and cause of death were considered. Daily excess mortality was calculated as the difference between the number of deaths observed and the smoothed average. The impact of heat on health is measured in terms of maximum apparent temperature.
The greatest excess in mortality was observed in the north west of Italy (Turin, +23% and Milan, +23%). The old (75-84 years) and the very old (85+ years) were the age groups most affected, and when stratifying by sex, the increase in mortality seemed to be greater among females. The greatest excess in mortality was registered in those with low socioeconomic status in Rome (+17.8%) and in those with lower education levels in Turin (+43%).
The analysis of cause-specific mortality not only confirms results from previous studies of an increase in heat-related mortality by respiratory and cardiovascular diseases, but also shows a significant excess in mortality for diseases of the central nervous system and for metabolic/endocrine disorders.
Results from 2003 highlight the necessity of targeting future prevention programmes at the susceptible sub-groups identified. The introduction of warning systems alongside efficient preventive plans and the monitoring of mortality during heat waves may represent a valid tool for the reduction of heat-related deaths.

Introduction

Record high temperatures were observed across Europe during the summer of 2003. In Italy, the highest monthly mean was registered in many cities in August, with record maximum temperatures above 35°C for several consecutive days. There is debate among experts as to whether extreme temperatures, as observed in summer 2003, are a normal fluctuation in the climate or a sign of global warming attributable to human influences on the climate system [1].
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, has still to be defined [2,3]. The effect of extreme temperatures (often referred to as heat waves) on health is well documented throughout the literature and is known to enhance mortality from cardiovascular, cerebrovascular, and respiratory conditions [4-6].

One of the first documented episodes of Italian urban populations affected by heat was the heat wave of summer 1983 in Rome, which was associated with a 35% increase in mortality [4]. An evaluation of heat-related mortality in 21 Italian provinces was carried out by the Istituto Superiore di Sanità (Italian National Institute of Health) and over 4000 excess deaths (14% increase) were estimated among the elderly [7]. The study also reported a large heterogeneity of the effect among the Italian cities, with the highest increase in mortality observed in the provinces of the north west, followed by the cities of the south, and with the lowest effect observed in the central provinces and the north east [7]. These differences are mainly due to the different exposure levels during summer 2003, but may also be attributable to a different vulnerability of the populations related to individual, social and environmental factors.
This article presents a more detailed evaluation of the impact of heat waves on mortality during the summer of 2003 (1 June – 31 August) in four major Italian cities: Bologna, Milan, Rome and Turin. The aim is to analyse the impact of heat waves on cause-specific mortality and to analyse the role of demographic characteristics and socioeconomic conditions that may increase the risk of mortality.

Data and methods

Daily mortality counts, for the resident population by age, sex and cause of death were obtained from the local mortality information systems in each city. The impact of heat on health is measured in terms of maximum apparent temperature (Tappmax) which is an index of human discomfort based on air temperature and dew point temperature [8]. The latter combines two meteorological variables (temperature and humidity) that have been shown to have an impact on human health.
Expected daily mortality was computed as the mean daily value from a selected reference period (1995-2002 for Rome, Milan and Bologna and 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 socioeconomic level was evaluated for the census tract of residence using a deprivation index based on a series of components, namely education, occupation, unemployment, number of household members, overcrowding and household ownership data [9]. The indicator includes four classes: high, medium-high, medium-low and low. In Turin, a socioeconomic indicator for the over-65 years age group was developed based on the level of education subdivided into three classes (high, medium, low).

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 (+4.4°C), followed by Rome (+4.1°C), Turin (+3.4°C) and Bologna (1.6°C) [TABLE 1].

TABLE 1

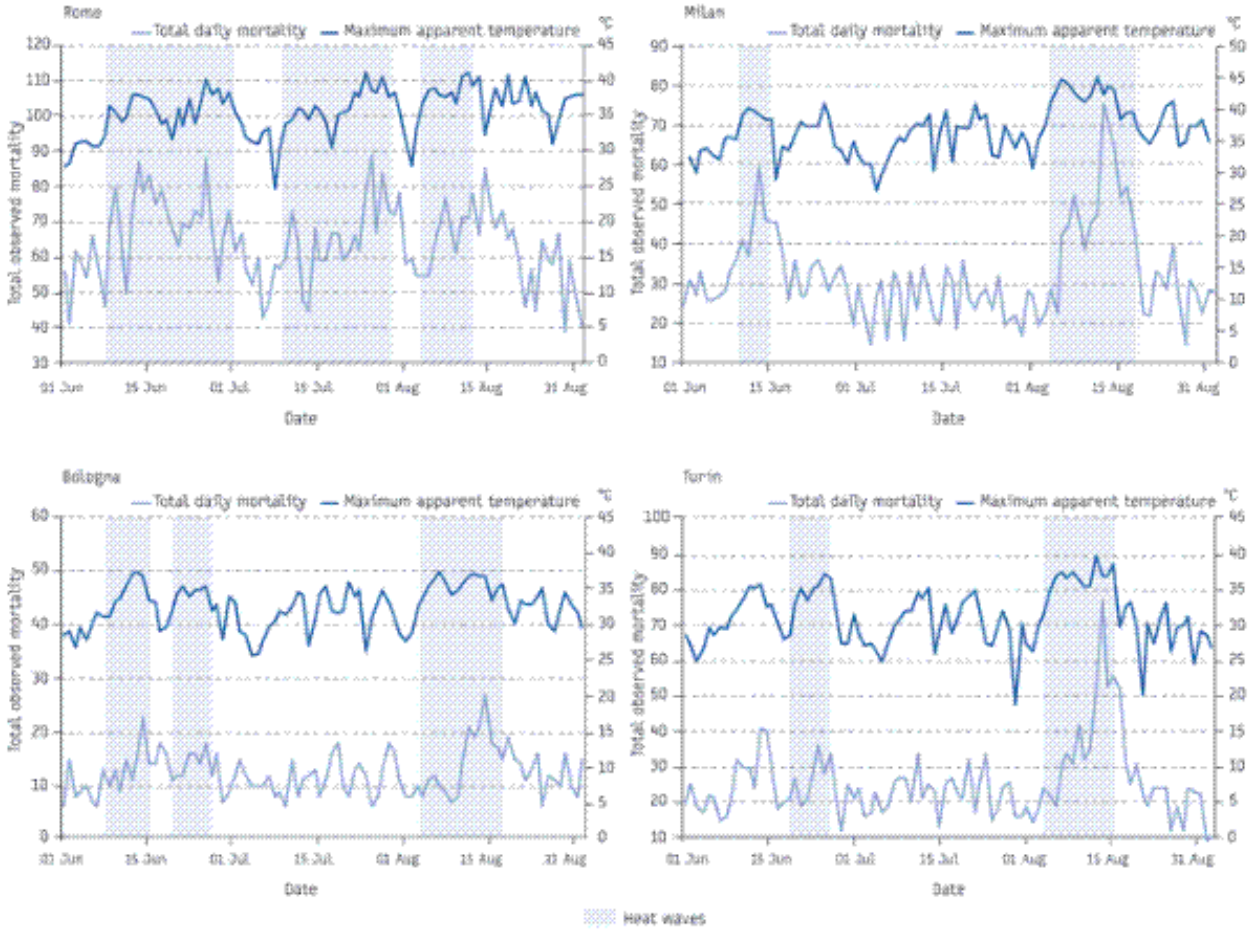
Maximum apparent temperature and percentage of variation in mortality for Rome, Milan, Turin, and Bologna during summer 2003 (June-August), Italy

	City (Reference period)			
Mortality	Rome (1995-2002)	Milan (1995-2002)	Turin (1998-2002)	Bologna (1996-2002)
2003	6089	2968	2332	1432
Reference period	5085	2409	1755	1257
% variation	19	23	33	14
Maximum apparent temperature (°C)	**Rome (1995-2002)**	**Milan (1995-2002)**	**Turin (1998-2002)**	**Bologna (1996-2002)**
2003	35.2	32.7	31.7	32.8
Reference period	31.1	28.3	28.6	30.4
Temperature increase (°C)	4.1	4.4	3.4	1.8

A city-specific definition of heat wave was developed in order to better reflect local conditions. heat waves have been identified as days with Tappmax above the 90th annual centile and for the first day, an increase of 2ºC compared with the previous day. This definition was made on the basis of the literature reviewed and on the relationship observed between temperature and mortality. Three major heat wave periods occurred in Rome, and two major heat waves occurred in the north of Italy: a minor one at the beginning of the summer (mid-June) and a major one in August [FIGURE].

FIGURE

Total daily mortality and maximum apparent temperature, Italy, 1 June-31 August 2003



The results of the analyses indicate a strong association between daily mortality and temperature; with peaks in mortality corresponding to peaks in temperature or with a lag of 1-2 days [FIGURE].

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%), 577 (+33%) in Turin, 559 (+23%) in Milan and 175 (+14%) in Bologna [TABLE 2].

TABLE 2

Total and excess mortality by age group and sex in Bologna, Milan, Rome, and Turin during the summer period (June-August) 2003 compared to the reference period, Italy

Mortality	Rome				Milan			
	Observed	Excess	%	95% CI	Observed	Excess	%	95% CI
All ages	6089	944	19	15.6-21.5	2988	559	23	18.8-27.6
0-64	915	-58	-6	-12.1-0.1	372	-35	-9	-17.9-0.7
65-74	1163	51	5	-1.4-10.5	480	-23	-5	-13.1-4.0
75-84	1938	397	26	20.2-31.4	1020	305	43	33.9-51.4
85	1993	554	38	32.4-44.6	1096	312	40	31.5-48.1
Sex								
Male	2768	246	10	5.7-13.8	1299	141	12	6.1-18.3
Female	3241	698	27	23.1-31.8	1669	418	33	27.0-39.8

Mortality	Turin				Bologna			
	Observed	Excess	%	95% CI	Observed	Excess	%	95% CI
All ages	2332	577	33	27.5-38.3	1432	175	14	8.0-19.8
0-64	307	21	7	-4.7-19.4	154	-10	-6	-20.9-8.7
65-74	416	58	16	5.0-27.4	202	-41	-17	-28.3-5.4
75-84	752	213	40	29.5-49.5	534	92	22	11.3-32.3
85	857	285	50	39.8-59.9	562	139	33	21.9-43.6
Sex								
Male	1074	215	25	17.6-32.5	686	84	14	5.4-22.5
Female	1258	362	40	32.6-48.2	752	93	14	6.0-22.3

In Rome, excess mortality was observed throughout the summer, but predominantly during the three heat waves observed [8]. The first heat wave (9 June–2 July) was associated with an increase in mortality of 352 deaths; a total of 319 excess deaths occurred during the second heat wave period (10–30 July) and 180 excess deaths during the third (3–13 August) [FIGURE]. In the northern cities, although temperatures above the reference mean were observed throughout the summer, excess mortality was mainly concentrated in the first part of August, when weather conditions became more extreme [FIGURE]. In Milan, 380 excess deaths were recorded during the August heat wave (5-18 August), while in Turin, 257 excess deaths were recorded during the heat wave from 3-14 August [FIGURE]. In Bologna, temperatures were less extreme throughout the summer and heat wave periods were shorter, with less impact on mortality, and 62 excess deaths during the August heat wave (3-17 August).
When subdividing by age group, excess mortality increased dramatically with age; the greatest impact observed in the old (75-84 years) and the very old (85+ years) age groups. In the latter group, mortality increased by 50% in Turin, 40% in Milan, 38% in Rome, and 33% in Bologna [TABLE 2]. When stratifying by age group, there is probably some residual confounding related to sex, in that there is a larger proportion of females in the older age groups. In fact, when stratifying by sex, the increase in mortality seems to be greater among females, [TABLE 2] suggesting a possible higher susceptibility.

The analyses of cause-specific mortality illustrated how the greatest excess in mortality was observed for central nervous system, circulatory, and respiratory diseases and metabolic/endocrine and psychological illnesses [TABLE 3].

TABLE 3

Total and excess mortality by cause of death in Rome, Milan, and Turin during the summer period (June-August) 2003 compared to the reference period, Italy

Causes of death	Rome				Milan				Turin			
	Observed	Excess	%	95% CI	Observed	Excess	%	95% CI	Observed	Excess	%	95% CI
Tumours	1921	142	8	3.2-12.8	926	-9	-1	-7.3-5.4	656	17	3	-5.2-10.5
Circulatory	2328	452	24	19.1-29.2	1044	212	25	17.9-33.1	892	261	41	32.1-50.6
Respiratory	327	91	38	23.4-53.4	282	127	82	60.7-103.2	201	73	57	35.3-78.7
Digestive system	227	-26	-10	-22.0-1.4	121	18	17	-3.5-38.4	97	12	14	-8.6-36.6
Genitourinary	81	18	29	1.0-57.3	57	16	39	2.9-75.1	48	13	48	2.2-94.1
Metabolic/endocrine gland disorders	307	60	24	10.2-38.0	111	45	68	36.9-99.5	103	61	145	97.9-192.6
Psychological illnesses	96	39	70	35.8-103.8	38	4	12	-23.6-47.3	70	28	67	27.6-105.7
Central nervous system	254	117	86	63.2-108.9	133	72	118	81.0-155.1	85	47	124	76.1-171.2
All causes	6009	944	19	15.6-21.6	2968	559	23	18.8-27.6	2332	577	33	27.5-38.3

In Rome, the most significant excess was registered for diseases of the central nervous system (+86%) and respiratory diseases (+38%). When subdividing by age group, the excess, for both causes, was greatest in the old (+123%, +52%) and the very old (+100% and +45%) age groups. In Turin, a statistically significant increase in mortality was observed for metabolic/endocrine disorders (+145%), diseases of the central nervous system 124%) and respiratory diseases (+57%). Cardiovascular disease registered the greatest excess in Turin (+41%) [TABLE 3]. In Milan, the most significant excess in mortality was associated with metabolic/endocrine disorders (+68%), respiratory diseases (+82%) and disorders of the central nervous system (+118%).

Analysis by socioeconomic level illustrates the greatest excess among the lower levels in both Turin (+43% increase in deaths of those with a low level of education) and Rome (+17.8% increase in deaths of those with low socioeconomic level), suggesting that this could be an important risk factor.

Discussion

The unusual heat waves of summer 2003 had a strong impact on the population in terms of mortality, especially in the north west, where peak temperatures reached record values. Daily mortality trends and peaks in mortality showed a temporal variation associated with temperature trends [9,11]. Furthermore, prolonged periods of high temperatures may have a stronger effect on health compared with periods with extreme peak values but a lower mean. During summer 2003, the persistent high temperatures were a strong determinant of the increase in observed mortality.

This study gives a valid insight into the effects of heat waves on health in medical terms, confirming previous results of increases in heat-related mortality by respiratory and cardiovascular diseases [5,13,14] and showing that extreme heat can worsen the conditions of people suffering from chronic disease. The most interesting result that arises form this study is the increase in deaths caused by diseases of the central nervous system in all cities which include different illnesses associated with the elderly (e.g., Parkinson's disease, Alzheimer's disease) [13] and other illnesses which require constant medication which may enhance the susceptibility of these subjects [15].

These results may be an important tool for identifying susceptible populations, and developing effective warning systems and prevention programmes. In Italy, as in other countries, the possible effects of global warming could make susceptible subgroups more vulnerable [2,3] 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 characteristics, such as the intensity and temporal variation in relation to the meteorological conditions between the different cities. Demographic and social factors, as well as the level of urbanisation, air pollution and the efficiency of social services and healthcare units, represent important local modifiers of the impact of heat waves on health. 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 deprived urban areas and low income populations.

Concerning the latency between the peak in temperature and the increase in the mortality, the data showed that peaks in mortality were observed 1-2 days following the heat wave. These results are consistent 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.

Some methodological aspects need to be discussed. Firstly, a limited time window of three months was used as a more complete time series was not available. The choice of

reference period is a controversial topic throughout the literature, as by using different reference periods, different estimates of excess mortality are produced. Summer 2003 mortality was compared with that of a reference period which was selected to be long enough to account for the variability of the exposure variable and of the observed effect, and, 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. However, the limited time window analysis did not permit an evaluation of a possible 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 [10].

During the summer months, many Italian cities are affected by seasonal migration, and populations in urban areas are reduced (e.g., Milan, Rome) [12]. It is important to note that the migratory pattern differs from year to year, depending on when heat waves occur, and may be unequally distributed among the population. Susceptible groups, such as the elderly and ill people with lower socioeconomic 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 socioeconomic status who remain in the city during the summer. Several socioeconomic factors might have an impact on health, including poor housing quality, lack of air conditioning, lack of access to health and social services, and individual behaviours (e.g., alcohol consumption and taking medication).
The evaluation of the heat waves of 2003 emphasise the importance of introducing further preventive measures, both for the general population and for 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 residents in urban areas to the oppressive weather conditions. In 2004, the Italian Department for Civil Protection implemented a national programme for the evaluation and prevention of the health effects of heat waves during summer. A Heat/Health Watch/Warning System (HHWWS) [6,16,17] and city-specific prevention programmes were activated during summer 2004 in Bologna, Milan, Rome and Turin, while in four other cities (Brescia, Genoa, Palermo and Florence) warning systems were run experimentally for the first time. Warning systems and prevention programmes will be extended to other cities in summer 2005 as part of the national plan.

The implementation of warning systems and prevention programmes at both the national and local level and the monitoring and surveillance of mortality during heat waves may represent a valid tool for the reduction of heat-related deaths. Furthermore, the national plan 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 prevention programmes. On the basis of the data collected during summer 2004, it will be possible to assess and compare the performance of intervention programmes implemented in each city and to evaluate the reduction of heat-related deaths.

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