It is also worth emphasising that elevated odds ratios have been observed in towns where the climatic phenomenon was similar in length and intensity. For example the relative excesses of deaths in Paris, Barcelona and Torino were important [2]. Results from a number of different studies all favour an important role for this exceptional heat stress in the toll registered. The INSERM study showed a strong correlation between the number (n=0-1; n=2-5; n=5-10) of consecutive very hot days (Tmax > 35°C and Tmin > 20°C) and the relative risk of excess deaths among administrative departments (RR=1.3 ; RR=1.5 ; RR=1.8) [1]. There is also a trend between the relative excess mortality among the thirteen cities and the delta between the usual temperatures and the observed ones for August 2003 as shown in table 1.

Other factors can explain the heterogeneity between towns and regions regarding the impact of extreme temperatures. A chronological study of deaths, temperature, and ozone in 9 cities showed that the proportion of observed deaths explained by these last two variables was very low for Lille, Strasbourg, Marseille, Toulouse, moderate for Bordeaux, Rouen and very important for Paris and Lyon [5]. This result is in favour of a geographical heterogeneity of vulnerability to heat wave. Sociodemographic factors can partly explain this difference. For example, the percentage of ages over 74 years is more elevated in Nice (12.7% in 1999) than in Marseille (9.2% in 1999). Other factors certainly intervene, such as the size of the cities, the urban heat island, cultural habits, or adaptation to very hot temperatures. For example, Marseille suffered a heat wave in 1983, and in 2003, an 'emergency plan' to help the public and the hospitals prevent extreme heat effects already existed. This meant that the population of Marseilles was more likely to cope better with a heat wave. The influences of those factors have been analysed by the InVS in specific studies focusing on pollution [5], and heat related risk factors [2].

Based on those results, the French government decided to develop a National Heat Health Watch Warning System (Système d'Alerte Canicule Santé (SACS)) adapted for each département. The objectives are to anticipate the health effects of heat waves and to alert the authorities in time to allow the setting up of preventive actions [6]. It has been developed on the basis of a retrospective analysis of mortality and minimal and maximal temperatures data in fourteen pilot cities. The cut-offs have been set in order to anticipate large scale events three days in advance, resulting in an excess mortality above 50% in Paris, Lyon, Marseille and Lille and above 100% in the smallest cities. The system was extended département-wide using the 98th centiles of minimal and maximal temperatures. The national action plan that integrates this watch warning system has four levels. They correspond to various degrees of activations of actors concerning public health surveillance, social supports, and medical preventive actions. It runs from 1 June to 31 September and results in a close cooperation between the meteorological services and the public health agencies. During 2004 no heat wave was observed but the climatologic predictions estimate that summers as hot as 2003 could be more frequent in the future [7].

The efficiency of the heat health watch warning systems has never been put to the test completely. However, some published results support the hypothesis of their effectiveness in the short term, as well as the possibility of adaptation of the population to hot temperatures in the long term [8-10].

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ORIGINAL ARTICLES

Surveillance report

MORTALITY IN SPAIN DURING THE HEAT WAVES OF SUMMER 2003

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The effect of the elevated temperatures on mortality experienced in Europe during the summer of 2003 was observed in several countries. This study, carried out in Spain, describes mortality between 1 June and 31 August and evaluates the effect of the heat wave on mortality.

Observed deaths were obtained from official death registers from 50 provincial capitals. Observed deaths were compared with the expected number, estimated by applying a Poisson regression model to historical mortality series and adjusting for the upward trend and seasonality observed. Meteorological information was provided by the Instituto Nacional de Meteorología (National Institute of Meteorology).

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Spain experienced three heat waves in 2003. The total associated excess deaths were 8% (43 212 observed deaths compared with 40 046 expected deaths). Excess deaths were only observed in those aged 75 years and over (15% more deaths than expected for the age group 75 to 84 and 29% for those aged 85 or over). This phenomenon (heat-associated excess mortality) is an emerging public health problem because of its increasing attributable risk, the aging of the Spanish population and its forecasted increasing frequency due to global warming. The implementation of alert and response systems based on monitoring of climate-related risks, emergency room activity and mortality, and strengthening the response capacity of the social and health services should be considered.

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Key Words: Europe, Spain, epidemiology, heat, adverse effects, human, meteorological factors, mortality, seasons

Introduction

The association between elevated temperatures and mortality has been reported since the early 20th century [1,2]. The actual magnitude of heat-related mortality may be greater than reported, since heat-related deaths are not well defined and heat is usually not listed on death certificates as causing or contributing to death [3,4,5]. Heat waves, because of their magnitude and duration, offer unique opportunities to study this association.

Much of the excess mortality from heat waves is related to cardiovascular and other chronic diseases [6,7] and is concentrated in the elderly [1,2,8]. The impact of heat waves on mortality seems also to be higher in urban areas, due to the 'urban heat island effect' [9,10,11]. Some studies suggest that this effect could be due to interaction between temperatures and air pollution [12].

In 1991 and 1995 Spain experienced two heat waves, both associated with excess mortality [13-17]. However, heat-related mortality was not considered to be a public health priority in Spain, and specific warning and/or surveillance systems were not implemented [18].

During the summer of 2003 Europe experienced a heat wave that was remarkable both in the magnitude and the duration of the high temperatures recorded. Thousands of deaths were associated with this meteorological phenomenon, highlighting the current inabiligy to deal with this kind of health threat.

This paper presents a summary of the results of the study to describe mortality and detect any excess mortality experienced in summer 2003 in Spain that was carried out by the Instituto de Salud Carlos III.

The heat wave of 2003 in Spain

Summer temperatures in Spain are usually high. The mean daily temperature during the period 1971-2000 for June, July and August for 48 out of the 50 provincial capitals was 21.8°C. Mean maximum and minimum temperatures for the same period were 28°C and 15.7°C respectively (Instituto Nacional de Meteorología).

However, Spain experienced an increase in temperatures during the summer 2003. Mean daily temperatures for the period June-August, in the same group of cities, were 12.9% (2.7°C) higher than the observed mean of the period 1971-2000. Mean maximum and minimum temperatures for the same period were 11.2% (3°C) and 16.2% (2.3°C) higher respectively compared with the series 1971-2000.

Increased mean and mean minimum temperatures during this period were registered in all 48 provincial capitals (range: 3.7% to 33.1% for mean temperatures and range: 2.7% to 24.8% for minimum temperatures) and all but one registered increased mean maximum temperatures (range: -0.6% to 23.7%) during the period June-August 2003.

Mean daily temperatures of 33°C and over were recorded for at least half of the days (46/92 days) of the period in 15 out of 48 cities. In 8 of these 15 cities temperatures over 33°C were registered for more than 60 of the 92 days in the period.

Methods

In order to estimate any possible excess in mortality in Spain in summer 2003, we compared observed mortality during the period July-August 2003 with expected mortality in the provincial capitals of the 50 provinces of Spain.

Through a query made to the database at the Ministerio de Justicia (Ministry of Justice), observed mortality was obtained for 27 computerised death registers . The remaining 23 death registers were not computerised, and teams of two people travelled to the provincial offices to obtain the desired data, which was then inserted into the study database. We collected information on date of birth and death, place of death, and place of residence at death for every death certificate entered in the death register between 1 June and 20 August 2003.

To estimate the expected mortality, the Instituto Nacional de Estadística (National Statistics Institute, INE) provided time series of deaths from 1980 to 2002 (2002 data were provisional) for the 50 cities included in the study. For the prediction of deaths in 2003 we have fitted Poisson regression models for different time periods including the year of death as a continuous variable. Age in five year groups (with the oldest group being '85 years and over') and month of death were also included in the model to adjust predictions for variations in age structure of the population and seasonality. Models better fitting observed mortality in the first 5 months of 2003 were based on the 1996-2002 and 1990-2002 time periods. We used models using both time series for each one of the 50 cities included in the study and for each one of the following age groups: 64 years and under, 65 to 74 years, 75 to 84 years, 85 years and over.

Observed number of deaths were compared with expected and the percent variation was calculated for every city ([O-E/E]*100). An overall weighted mean percent variation, using expected number of deaths for each city as weighting variable, was also calculated.

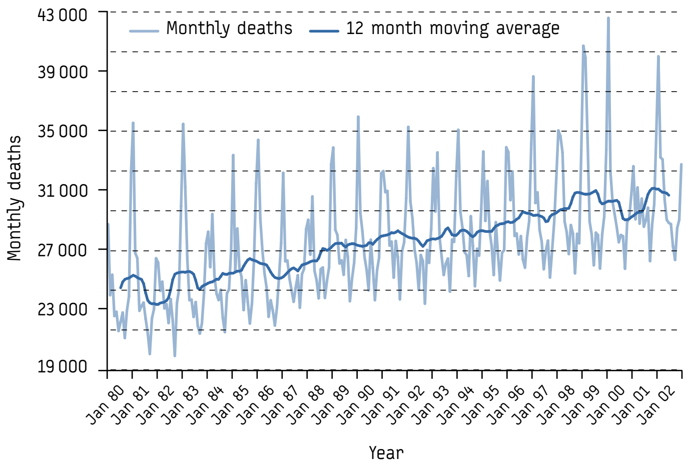
Results

The 50 cities included in the study represent 35% of the total population and all climate spectra in Spain. Median population per city is 152 690 inhabitants with a range between 31 506 and 3 016 788 inhabitants. Of all deaths registered in Spain in the period 1980-2002, 48.7% were registered in this group of cities. In the year 2002 this percentage was 48%.

There is great variability in the daily number of deaths registered in Spain. However, time series show a marked seasonality with peaks in winter months. Smaller peaks are observed in summer months. The increasing trend observed since 1980, probably due to the aging of the population, and to a lesser degree to population growth, seems to have stabilised in recent years [FIGURE 1]. The year of mortality trend stabilisation varies from one city to another.

FIGURE 1

Monthly deaths and 12 month moving average, Spain, 1980-2002

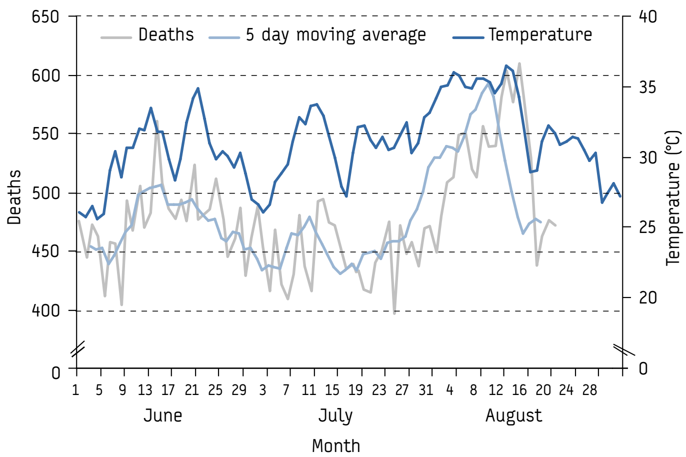


During June-August 2003 a total of 43 212 deaths were registered in the 50 provincial capitals under study. Of these, 14 236 (33%) occurred in June, 13 895 (32%) in July and 15 081 (35%) in August. For 141 deaths, the date of birth was not available. For the 43 071 deaths for which age could be calculated, 13 039 (30%) were of people aged 85 years or older, 13 831 (32%) were of people aged 75 to 84 years, 7888 (18%) were of people aged 65 to 74 years, and 8312 (19%) were of people aged 64 years and under.

Figure 2 shows daily deaths, a 5 day moving average of daily deaths, and mean daily temperatures in the 50 cities under study during summer 2003. In this figure we observe a peak in daily deaths during the second week of August. Two smaller peaks, in mid-June and during the second week of July are also observed. The three peaks observed in daily deaths coincide with the three waves of high temperatures suffered along the summer. Although there is an important variability in daily deaths and temperatures registered among the provincial capitals included in the study, the pattern observed in figure 2 is applicable to most of them.

FIGURE 2

Daily deaths, 5 day moving average and daily mean temperatures for 50 provincial capitals, Spain, June-August 2003



Tables 1 and 2 show the total expected and observed deaths and estimated excess mortality percent for the 50 provincial capitals and for the two time periods better predicting expected deaths (1996-2002 and 1990-2002). Excess deaths in summer 2003 compared with expected is 10.6% (4151 deaths) higher than expected using as predictor the model based on the1996-2002 time series and 7.9% (3166 deaths) using as a predictor the model based on the 1990-2002 time series.

TABLE 1

Expected (based on 1996-2002 time-series) and observed deaths; difference and percentage variation compared with expected deaths by provincial capital, Spain, June-August 2003

Capital city	Expected	Observed	Observed-Expected	Difference (%)
ALAVA	452	486	34	7.52
ALBACETE	407	485	78	19.16
ALICANTE	546	658	112	20.51
ALMERIA	418	494	76	18.18
AVILA	275	297	22	8
BADAJOZ	465	519	54	11.61
BALEARES	906	952	46	5.08
BARCELONA	3993	4674	681	17.05
BURGOS	486	576	90	18.52
CACERES	297	298	1	0.34
CADIZ	442	513	71	16.06
CASTELLON	433	496	63	14.55
CIUDAD REAL	279	267	-12	-4.3
CORDOBA	817	899	82	10.04
CORUNA (LA)	827	873	46	5.56
CUENCA	224	208	-16	-7.14
GERONA	404	469	65	16.09
GRANADA	873	873	0	0
GUADALAJARA	288	300	12	4.17
GUIPUZCOA	736	813	77	10.46
HUELVA	559	553	-6	-1.07
HUESCA	192	219	27	14.06
JAEN	449	466	17	3.79
LEON	454	479	25	5.51
LERIDA	450	526	76	16.89
LOGRONO	371	420	49	13.21
LUGO	413	410	-3	-0.73
MADRID	6209	6942	733	11.81
MALAGA	1266	1380	114	9
MURCIA	819	927	108	13.19
NAVARRA	666	725	59	8.86
ORENSE	440	446	6	1.36
OVIEDO	773	831	58	7.5
PALENCIA	316	361	45	14.24
PALMAS (LAS)	991	1060	69	6.96
PONTEVEDRA	362	360	-2	-0.55
SALAMANCA	529	568	39	7.37
SANTA CRUZ	607	623	16	2.64
SANTANDER	578	632	54	9.34
SEGOVIA	239	217	-22	-9.21
SEVILLA	2003	2314	311	15.53
SORIA	172	169	-3	-1.74
TARRAGONA	326	398	72	22.09
TERUEL	181	146	-35	-19.34
TOLEDO	411	420	9	2.19
VALENCIA	2172	2499	327	15.06
VALLADOLID	795	890	95	11.95
VIZCAYA	882	967	85	9.64
ZAMORA	263	304	41	15.59
ZARAGOZA	1605	1812	207	12.9
TOTAL	**39 061**	**43 212**	**4151**	**10.63**

Table 2

Expected (based on 1990-2002 time-series) and observed deaths; difference and percentage variation compared with expected deaths by provincial capital, Spain, June-August 2003

Capital city	Expected	Observed	Observed-Expected	Difference (%)
ALAVA	450	486	36	8
ALBACETE	427	485	58	13.58
ALICANTE	534	658	124	23.22
ALMERIA	475	494	19	4
AVILA	276	297	21	7.61
BADAJOZ	463	519	56	12.1
BALEARES	954	952	-2	-0.21
BARCELONA	4009	4674	665	16.59
BURGOS	513	576	63	12.28
CACERES	320	298	-22	-6.88
CADIZ	464	513	49	10.56
CASTELLON	491	496	5	1.02
CIUDAD REAL	301	267	-34	-11.3
CORDOBA	840	899	59	7.02
CORUNA (LA)	860	873	13	1.51
CUENCA	235	208	-27	-11.49
GERONA	402	469	67	16.67
GRANADA	909	873	-36	-3.96
GUADALAJARA	287	300	13	4.53
GUIPUZCOA	758	813	55	7.26
HUELVA	579	553	-26	-4.49
HUESCA	211	219	8	3.79
JAEN	466	466	0	0
LEON	489	479	-10	-2.04
LERIDA	487	526	39	8.01
LOGRONO	401	420	19	4.74
LUGO	413	410	-3	-0.73
MADRID	6186	6942	756	12.22
MALAGA	1295	1380	85	6.56
MURCIA	853	927	74	8.68
NAVARRA	681	725	44	6.46
ORENSE	456	446	-10	-2.19
OVIEDO	782	831	49	6.27
PALENCIA	332	361	29	8.73
PALMAS (LAS)	1004	1060	56	5.58
PONTEVEDRA	391	360	-31	-7.93
SALAMANCA	556	568	12	2.16
SANTA CRUZ	578	623	45	7.79
SANTANDER	613	632	19	3.1
SEGOVIA	240	217	-23	-9.58
SEVILLA	2058	2314	256	12.44
SORIA	183	169	-14	-7.65
TARRAGONA	335	398	63	18.81
TERUEL	184	146	-38	-20.65
TOLEDO	399	420	21	5.26
VALENCIA	2255	2499	244	10.82
VALLADOLID	818	890	72	8.8
VIZCAYA	908	967	59	6.5
ZAMORA	281	304	23	8.19
ZARAGOZA	1644	1812	168	10.22
TOTAL	**40 046**	**43 212**	**3166**	**7.91**

Assuming that 48% of deaths were registered in the provincial capitals (data for 2002) we can estimate between 6595 and 8648 excess deaths in Spain from 1 June to 20 August 2003, using the 1990-2002 or 1996-2002 time series respectively for our model.

Although results using both models, based on the 1990-2002 and 1996-2002 time series, do not differ very much, we consider that the later time series (1996-2002) better estimates expected deaths because of the stabilisation of the mortality trend in the last few years. The following results refer only to the comparison with the model based on the 996-2002 time series.

The excess deaths were higher in August (17% more than expected), but observed deaths were more than expected for the three months under study (9% in June and 5% in July) [TABLE 3]. Only the elderly were affected and important decreases in mortality were registered in people under 65 years throughout the entire period, while we observed 29% excess deaths among people 85 years and over [TABLE 3].

Table 3

Expected (based on 1996-2002 time-series) and observed deaths; difference and percentage variation compared with expected deaths by month and age group for 50 provincial capitals, Spain, June-August 2003

June	Observed	Expected	Observed-Expected	Difference (%)
0-64 years	2761	2858	-97	-3.39
65-74 years	2556	2765	-209	-7.56
75-84 years	4575	3999	576	14.40
> 84 years	4316	3374	942	27.92
TOTAL	**14 208**	**12 996**	**1212**	**9.33**
July	**Observed**	**Expected**	**Observed-Expected**	**Difference (%)**
0-64 years	2744	2914	-170	-5.83
65-74 years	2578	2812	-234	-8.32
75-84 years	4459	4063	396	9.75
> 84 years	4057	3423	634	18.52
TOTAL	**13 838**	**13 212**	**626**	**4.74**
August	**Observed**	**Expected**	**Observed-Expected**	**Difference (%)**
0-64 years	2807	2831	-24	-0.84
65-74 years	2754	2733	21	0.77
75-84 years	4797	3956	841	21.26
> 84 years	4666	3330	1336	40.13
TOTAL	**15 025**	**12 850**	**2175**	**16.92**
June - August	**Observed**	**Expected**	**Observed-Expected**	**Difference (%)**
0-64 years	8312	8603	-291	-3.38
65-74 years	7888	8310	-422	-5.08
75-84 years	13 831	12 018	1813	15.08
84 years	13 039	10 127	2912	28.76
TOTAL	**43 071**	**39 058**	**4013**	**10.27**

Table 4 shows expected and observed deaths and estimated mortality difference percent for the period January- August 2003. Deaths registered in January and February, and to a lesser extent in March, were fewer than expected. However, the excess detected in the summer period overcompensated for this difference and for the first 8 months of 2003 we detected 1964 (1.7%) more deaths than expected.

Table 4

Expected (based on 1996-2002 time-series) and observed deaths; difference and percentage variation compared with expected deaths by month for 50 provincial capitals, Spain, January-August 2003

	January	February	March	April	May	June	July	August	Total
Observed	16 777	14 418	15 208	14 042	14 051	14 236	13 895	15 081	117 708
Expected	17 851	15 671	15 455	13 906	13 800	12 994	13 213	12 854	115 744
Observed - Expected	-1074	-1253	-247	136	251	1242	682	2227	1964
Difference (%)	-6.02	-8	-1.6	0.98	1.82	9.56	5.16	17.33	1.7

Discussion

Observed deaths in June, July and August 2003 in Spain were between 7.9% and 10.6% higher than expected. Although excess mortality was more important in August, excess deaths were observed from June. Significant excess mortality was observed only in the elderly (75 years and older), while among those 64 years and younger, mortality decreased during this period. Access to air conditioning at work and use of swimming pools and other practices that lower body temperature among younger people could account for part of this reduction. Further studies of mortality in people aged 74 years and under are needed to explain these findings.

The objective of this study was to estimate any excess mortality experienced in Spain during summer 2003. An association between mortality and temperatures or other variables such as ozone and other pollutants has not been tested. However, the known association between high temperatures and mortality, the fact that the three heat waves experienced in Spain in the summer of 2003 occurred near in time to the three periods of high mortality registered and the distribution of this high mortality throughout the country reinforce the hypothesis of this association.

Based on these results, estimated excess deaths in Spain could be between 6595 and 8648. However, this study included data from provincial capitals and therefore, although they cover a wide range of city sizes, the urban heat island effect [9,10,11] described in the literature could account for part of this excess mortality, and results would not be representative of mortality in Spain, because it may differ in rural areas.

A second study of mortality carried out by the Instituto de Salud Carlos III in a random sample of 107 out of 7458 rural villages with fewer than 10 000 inhabitants, representing a total of 140 807 people, estimated a 40% increased mortality compared with the mean mortality observed in the three previous years (2000-2002) [18]. This study strengthens the magnitude of the results presented in this article.

Mortality experienced in Spain during the winter of 2002-2003 was marginally less than mortality observed during the previous winter. It could be argued that people who unexpectedly did not die during the preceding winter were the people who died during the summer. Data from a newly established mortality surveillance system (not presented in this article) show an excess mortality in the months following the summer, probably associated to an early appearance of the 2003-2004 influenza season. These results would not support the 'harvesting' theory.

Population groups at high risk, such as people 85 years and older, as identified in this study and possibly because of the mechanisms explained by Kenney et al [19] and Foster et al [20], can be identified and specific preventive measures aiming exposure reduction can be implemented if good coordination between surveillance and alert systems and social and health services is achieved.

Results of several studies showing the association between high temperatures and mortality during heat waves in several cities in Spain were published during the 1990s. However, the magnitude and media coverage, and therefore the social impact of the heat wave experience in summer 2003 transferred the debate from academia to the community and political arena.

This debate has altered decision makers' perception of heat-related health problems and the control of heat-related mortality has become a priority. For summer 2004 the Spanish government launched the *Plan de acciones preventivas contra los efectos del exceso de temperaturas sobre la salud* (Prevention plan against adverse effects on health of high temperatures) [21], improved for the summer 2005 and created an interministerial steering commission for this initiative. This plan included:

- A temperature-based alert system using as alert threshold the 95th centile of observed daily maximum temperatures during the last 25 years.
- Awareness campaigns addressed to high risk groups, the general population and healthcare and social services professionals.
- A voluntary register of people at high risk who could benefit from support activities delivered by the Red Cross and other social organisations.
- Development of conduct protocols during heat waves for healthcare and social services professionals.
- A daily mortality surveillance system.

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