Eurosurveillance Europe's journal on infectious disease epidemiology, prevention and control since 1996

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Eurosurveillance, Volume 10, Issue 7, 01 July 2005

Surveillance report

MORTALITY IN PORTUGAL ASSOCIATED WITH THE HEAT WAVE OF AUGUST 2003: EARLY ESTIMATION OF EFFECT, USING A RAPID METHOD

Citation style for this article: Nogueira PJ, Falcão JM, Contreiras MT, Paixão E, Brandão J, Batista I. Mortality in Portugal associated with the heat wave of August 2003: Early estimation of effect, using a rapid method. Euro Surveill. 2005;10(7):pii=553. Available online: http://www.eurosurveillance.org/ViewArticle.aspx?ArticleId=553

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During the first two weeks of August 2003, Portugal was affected by a severe heat wave.

Following the identification in Portugal of the influence of heat waves on mortality in 1981 and 1991 (estimated excess of about 1900 and 1000 deaths respectively), the Observatório Nacional de Saúde (ONSA) - Instituto Nacional de Saúde Dr. Ricardo Jorge, together with the Vigilância Previsão e Informação - Instituto de Meteorologia, created a surveillance system called ÍCARO, which has been in operation since 1999. ÍCARO identifies heat waves with potential influence on mortality [1].

Before the end of the 2003 heat waves, ONSA had produced a preliminary estimate of its effect on mortality. The results based on daily number of deaths from 1 June to 12 August 2003 were presented within 4 working days. Data was gathered from 31 National Civil registrars, covering the district capitals of all 18 districts of mainland Portugal, and representing approximately 40% of the mainland's mortality.

The number of deaths registered in the period 30 July to 12 August was compared with the ones registered during 3 comparison periods (of 2003): 1-14 July, 1-28 July, and 15-28 July. 15-28 July, the period best resembling the heat waves in time and characteristics, produced an estimation of 37.7% higher mortality rate then the value expected under normal temperature conditions. From this value, an estimate of 1316 death excess was obtained for mainland Portugal.

The main purpose of this article is to present the method used to identify and assess the occurrence of an effect (excess mortality) during the heat waves of summer 2003.

Introduction

heat waves are known to affect mortality rates. Severe heat waves effects in the United States have been described for the cities of St Louis (1966) [2], St Louis and Kansas City (1980) [3], Philadelphia (1993) [4] and Chicago (1995) [5].
The effects of heat waves appear to be important in Portugal. Portuguese heat waves episodes and their consequences are currently well documented [6-8].
Severe heat waves effects on mortality in June 1981 were acknowledged, initially in the concelho (small administrative unit) of Cascais within the district of Lisbon, and an estimation of excess of deaths prepared for the entire district of Lisbon was presented later (1988) [6]. In 1998, a study based on national mortality data, carried out by the Observatório Nacional de Saúde (National Observatory of Health, ONSA), estimated the number of heat waves related deaths nationwide at about 1900 [7].
In July 1991, Portugal was struck by another heat waves. Again, its effects on mortality were studied and a nationwide estimate of 1000 excess deaths was made [8].

Given the impact of the two previous heat waves, in 1999 ONSA created ÍCARO (standing for 'Importância do CAlor: Repercussão sobre os Óbitos', which means 'the importance of heat and its repercussions on mortality'), a system, which sought to conceive and operate an alert system for heat waves that influence mortality; and to study the characteristics and effects of heat waves [1]. The result of a joint action between ONSA and of the Centro de Vigilância, Previsão e Informação (the Insitute of Meteorology's Surveillance, Forecast and Information Service), this system generates the ÍCARO index, calculated and reported to other institutions, daily between 15 May and 30 September each year. This index indicates the possibility of occurrence of heat waves, with probable influence on mortality for the region of Lisbon, with an anticipation of 3 days (further details are available in "Fontes de informação", "ÍCARO" at www.onsa.pt).
In the summer of 2003, between 29 July and 13 August. all districts in Portugal experienced unusually high temperatures. At least 8 of the 18 mainland Portuguese districts had daily maximum temperatures above 32ºC during all this period. Four districts, corresponding to the non-coastal interior of Portugal, had daily maximum temperatures above 35ºC during the entire period.
When records going back to 1980 were consulted, it was seen that, for the first time during this period, 15 out of the 16 days between 29 July and 13 August had maximum temperatures above 32ºC in the district of Lisbon, including a noteworthy consecutive run of 10 days of such high temperatures. A 5 day run of temperatures above 35ºC was also recorded for the first time since 1980.
On 12 August 2003, while the heat waves was still happening, ONSA designed a preliminary study that aimed to assess the influence of the heat waves on mortality in the general population. Results were preliminary, because it was not yet possible to consider the full effect of the heat waves at this time.

Methods

Mortality data

Mortality data were obtained from the 31 national civil registrars covering all

the district capitals of mainland (continental Portugal), and representing approximately 41.5% of overall mortality. The daily number of deaths registered from 1 June to 12 August was requested on 12 August, and obtained by 19 August.

Period of time studied

The reference period used for the death toll was 14 days, comprising data from 30 July (the first day of the heat waves +1 day for the death registration delay) and 12 August.

Expected number of deaths

The expected number of deaths (E) if the heat waves had not occurred was calculated using three periods within July 2003 (for comparison purposes): 15-28 July; 1-14 July; and 1-28 July, all excluding heat waves-influenced days. The product of 14 days multiplied by the average daily number of deaths registered for each of the three reference periods was used for the calculation of E, generating three expected death estimates.

Comparison of the expected and observed number of deaths

The number of deaths registered in each one of the national civil registrars was summed, constituting the total number of deaths observed (O).

The excess of deaths caused by the heat waves was calculated by the difference O–E, for each of the 3 different E values. These differences represent the number of heat waves-related deaths, for each of the comparison periods. $p = (O–E) / E = 1 – O/E = 1 – r$ represents the proportion of the excess of deaths in relation to the expected deaths.

Estimation of the total excess of deaths related to the heat waves in mainland Portugal

The total number of deaths related to the heat waves was estimated by $p \times ECont$ in which

ECont = 3486, the number of expected deaths, in the reference period, in the mainland and was calculated by the product of 14 days and 249 deaths. This last number is the daily average number of deaths in the same period as the heat waves in mainland Portugal in 2001 (the most recent mortality data available from ONSA).

Confidence interval estimates

Excess mortality 95% confidence limits (E_{Low} ; E_{Upp}) for each comparison period were obtained from the 95% confidence for the O/E ratio (r_{Low} ; r_{Upp}) calculated by the 'exact method' described by Silcocks that uses the relation between the Beta and Binomial distributions [11].

$E_{Low} = (r_{Low} – 1) \times 3486$ and $EUpp = (r_{Upp} – 1) \times 3486$.

Results

The total number of deaths registered between 30 July and 12 August was 1966. The daily average number was calculated as 140.4 [TABLE 1].

TABLE 1

Total and daily average number of deaths registered in participant civil Registrars' offices during the period of the heat wave for all 3 comparison periods, Portugal, 2003

	Heat wave period 30 July - 18 August	Period 15-28 July	Period 1-14 July	Period 1-28 July
Total no. of deaths	1966	1427	1454	2881
Daily average no.	140.4	101.9	103.9	102.9

The excess deaths estimates varied slightly for the three comparison periods used [TABLE 2].

TABLE 2

Number of expected deaths, excess of deaths and proportion of the expected deaths, in the period of the heat wave, in the counties of participant civil Registration Offices, according to the used reference periods, Portugal, 2003

	Deaths expected in the heat wave period (30 July-12 August)		
	Period 15-28 July	Period 1-14 July	Period 1-28 July
No. of expected deaths (E)	1427	1454	1440.5
Excess of deaths (Observed-Expected) (O-E)	539	512	525.5
p = (O-E) / E	0.377715	0.352132	0.364804
(95% CI)	(0.286-0.476)	(0.262-0.448)	(0.275-0.462)

The estimation of excess of deaths within the selected concelhos and during the period of the heat waves studied, amounted in 539 deaths, when the last 14 days prior to the heat waves are used as a comparison period. When compared with number of deaths registered during the first two weeks of July, the same estimate results in an excess death toll of 512.
The estimated excess of deaths, using the period 15-28 July for comparison, represents a heat-related death toll raise of about 37.8%.

Estimates of the total number of heat waves related deaths within the mainland
Using for comparison the period of two weeks that preceded the heat waves (15-28 July), an excess of about 1316 deaths was estimated [TABLE 3].Although the 3 reference periods provide similar estimates, as presented in table 3, the estimate using the period 15-28 July should be the most accurate, given its proximity to the first day of the heat waves.

TABLE 3

Estimates for the total number and 95% confidence intervals of heat wave related deaths in the mainland, according to the reference periods used, Portugal, 2003

	Period of the heat wave (30 July – 12 August 2003)		
	Period 15-28 July	Period 1-14 July	Period 1-28 July
Total no. of heat wave related deaths	1316.7	1227.5	1271.7
(95% CI)	(998.0-1659.1)	(916.3-1561.6)	(958.3-1611.7)

Discussion

The best estimate of the effect of the heat waves of August 2003 on the mortality of the Portuguese mainland population was 1316 deaths. For comparison periods further away from the start date of the heat waves, the estimates produced values of 1271 and 1227 deaths. These results were consistent among themselves, conveying additional confidence to the estimates, although for the reasons mentioned above, the value 1316 deaths, calculated based on the period 15-28 July, should be the most reliable.

Rural versus non-rural population

The exclusive use of civil registrars in district capitals only was chosen because of time and organisational restraints. This option may have introduce some systematic bias, forexample, there may be under
-representation of rural areas where
1. the ability of the population to resist heat might be different from other areas – contributing to some inaccuracy in estimates;
2. age distribution might be different – having more elderly citizens might translate in a greater effect on mortality.
In line with past experience which has found higher mortality in older age groups, this could represent an underestimation of mortality.
This rapid method is not meant to estimate rural and non-rural effects of heat waves. As long as the interest lies in identifying and assessing a heat waves effect, the use of mainly non-rural areas can be an additional factor of difficulty. The use of a balanced or proportional sample of civil registrar's offices in future estimates is advised to prevent this potential bias.

Preliminary nature and limitations of estimates

The urgency to find out the dimension of the heat waves's effects on mortality imposed the following limitations:
1. the period studied ended on 12 August. It is expected that the heat waves's influence continued beyond this date;
2. the use of a sample of national civil registrars of mainland Portugal made up of all district capitals instead of all concelhos.
The first limitation necessarily induces an underestimation of heat waves excess related deaths

The second limitation may produce either an under- or an overestimation, since the populations of the concelhos not represented in the sample may have experienced different effects of the heat waves.
The average number of deaths registered annually in the participating 31

national civil registrars corresponds to about 41.5% of the total deaths registered in mainland Portugal (data from 2001). Therefore, the likelihood that including deaths registered in the remaining national civil registrars would change the estimates profoundly is low.

Alternative explanations for the excess of deaths

The excess number of deaths could have originated, totally or partly, from simultaneous phenomena besides the heat waves:

1. The presence of a high number of tourists increases the population of the Portuguese mainland during the month of August. However, their presence is equally high during the month of July, especially in the last two weeks, which was the time period used as the main comparison period. Also, most tourists visiting Portugal during summer do not belong to the oldest age groups, and so are unlikely to have made much contribution to the heat waves related excess of deaths;
2. Visits by Portuguese who have emigrated abroad, and their descendents are more frequent in August than in July, and this could contribute to the increase of mortality, independently of the influence of the heat waves. However, such visitors tend to bein good health and belonging to younger age groups, and therefore more resistant to the harmful effects of heat waves than the elderly.
3. Road accidents are more frequent during the month of August, which could influence excess deaths. However, this should not influence the current estimates, since the number of fatal victims of road accidents in August is very similar to that of July (157 deaths were reported during July 2002 and 130 during August 2002 - data from Direcção Geral de Viação (Directorate-General for Transport) [9]).
4. A series of forest fires happened during the same time period as the heat waves. According to the general media, there were 18 fatalities. These deaths may only indirectly be attributed to the heat waves. While they influence the total number of deaths to 12 August 2003, only some of these deaths (and presumably a small proportion) will have been registered in the national civil registrars participating in this study.

The 2003 heat waves influenced the excess of mortality less than the 1981 heat waves

There may be several reasons for this:

1. Access to and quality of healthcare is better in 2003 than in 1981;
2. Contrary to the events of 1981 and 1991, there was an alert for the 2003 heat waves and intervention deployed by the Serviço Nacional de Bombeiros e Protecção Civil (National Service of Firemen and Civil Protection), in order to diminish the effect of the heat waves;
3. Athough there is no scientifically sustained confirmation yet, it seems natural that heat waves striking early in the year should have more influence on mortality than those which occur later. The adaptation of the individual to progressively rising temperatures should explain a higher resistance to heat.
4. The nature of the July/August 2003 heat waves was unusual, having three different temperature peaks. The daily maximum air temperatures dropped considerably for one day between the first and second peak (3-4 August) in the coastal districts of Portugal, where most of the Portuguese population lives. Therefore it can be argued that the majority of the Portuguese population was not exposed to a consecutive period of heat stress longer that that of 1981, and this could be a major explanation for the observed reduced heat waves impact.

Although all these reasons may be behind the reduction of the effects of the 2003 heat waves, it does not appear possible to determine the relative influence of each.
In conclusion, at the date of issue of the report, the heat waves of 2003 was estimated as having caused about 1316 deaths up to 12 August, mainly in the elderly.

Definitive 2003 heat waves effect

The work and methodology presented here gave sound evidence of severe impacts on the health and mortality of the population, and this stimulated the responsible institutions to exert unusual efforts to gather complete information and knowledge abut what really happened. The Portuguese Direcção-Geral da Saúde (General Directorate of Health) was able to obtainthe death certificates for summer 2003 earlier than usual to create a database. A joint report on the complete and final effects of the heat waves effects , prepared by the Direcção-Geral da Saúde and ONSA, was finished in April 2004, and replaced all previous plans for future studies [10].
This report showed that the heat waves's impact on mortality occurred between 30 July and 15 August. For the estimation of the expected number of deaths without the heat waves effects, mortality data by district, sex and age group for the years of 2000 and 2001 were used. A total excess mortality of 1953 deaths (1866-2039:95%CI) was estimated. These deaths were observed in the older age groups, mainly 75 years old and above. The number of excess deaths estimated for women were more than twice the number estimated for men. Mortality effects were observed in all Portuguese districts, and the non-coastal districts had higher relative increases in mortality (Guarda, Castelo Branco, Portalegre and Évora). Causes of deaths most strongly associated with the heat waves were 'heatstroke' (O/E=70.0) and 'Other disorders of fluid, electrolyte, and acid-base balance' (O/E = 8.65). Other important associated causes of death accounting for higher mortality were 'diseases of the circulatory system' (758 estimated excess deaths, of which about 370 were 'cerebrovascular disease', about 145 were 'ischaemic heart disease' and 118 were 'heart failure'), 'diseases of the respiratory system' (about 255 excess deaths) and 'all malignant neoplasms' (about 131 excess deaths).
These full effect estimations clearly show that the 2003 heat waves was different from the 1981 heat waves in several ways: most importantly, the mortality impact differed in age groups, with children being spared, and it was more intense for women.

Direct comparisons between final full heat waves effect and preliminary estimate is not possible, for two main reasons: the time periods in the two methodologies are different; and the underlying starting data are different. While the final full effect estimate is based on the date of death, basic data of the preliminary estimation methodology is solely the number of deaths registered by the civil registrar's offices on each given working day, which does not account for locally displaced deaths, holidays and other similar phenomena.
This limitation could be overcome by having a wider period of civil registrar office notifications, allowing for all deaths during the intended period of study to be accounted for, but such a solution is against the intended nature of the methodology meant to give a timely estimate of possible effects of the heat waves. This is a valuable solution when definitive mortality data is not available quickly enough.
The sooner this rapid method is applied to estimate heat waves effects,

either during or after the heat waves occurrence, the more likely it is that mortality impact estimates will be biased towards the lower limits, but when significant impact is shown, the method's objectives are met.

Further developments
In the summer of 2004, a system of daily mortality surveillance was established that will henceforth operate annually in tandem with the ÍCARO surveillance system. This new daily mortality surveillance system was created based on the experience and methodology described in this paper. This system consists mainly of collecting very simple data (the total number of registered deaths) on a daily basis from a sample of 67 civil registrar's offices distributed throughout the districts of mainland Portugal. Of these 67 offices, 31 are from district capitals and participated in the work presented here.

Acknowledgements
We are most grateful to the General Director of the Direcção Geral dos Registos e do Notariado and the Conservatórias do Resgisto Civil who promptly collaborated with ONSA and without whom this work would not have been possible.

We are particularly grateful to Dr Teresa Abrantes and Dr Fátima Coelho of the Portuguese Meteorology Institute, for helping us reviewing air temperatures for recent years, particularly the 2003 summer data.

We are grateful to the Fundação de Ciência e Tecnologia (FCT) that partially funded this work (Projecto POCTI/ESP/39679/2001).

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