Has the impact of heat waves on mortality changed in France since the European heat wave of summer 2003? A study of the 2006 heat wave.

Anne Fouillet, Grégoire Rey, Vérène Wagner, Karine Laaidi, Pascal Empereur-Bissonnet, Alain Le Tertre, Philippe Frayssinet, Pierre Bessemoulin, Françoise Laurent, Perrine de Crouy-Chanel, et al.

Has the impact of heat waves on mortality changed in France since the European heat wave of summer 2003? *A study of the 2006 heat wave.*

Corresponding author:

Denis HEMON

INSERM-U754

16, avenue Paul Vaillant-Couturier

94800 VILLEJUIF Cedex, FRANCE

e-mail: denis.hemon@vjf.inserm.fr

Tel.: (+33) 01.45.59.50.37

Fax: (+33) 01.45.59.51.51

Co-Authors:

A. Fouillet[1], G. Rey[1], V. Wagner[2], K. Laaidi[2], P. Empereur-Bissonnet[2], A. Le Tertre[2], P. Frayssinet[3], P. Bessemoulin[3], F. Laurent[4], P. De Crouy-Chanel[2], E. Jougla[4], D. Hémon[1]

[1] INSERM, U754, IFR69, Université Paris Sud 11, Epidémiologie Environnementale des Cancers, Villejuif, France

[2] Institut de Veille Sanitaire (InVS) / French Institute for Health Surveillance

[3] Météo-France, Toulouse, France.

[4] INSERM, CépiDc, IFR69, Université Paris Sud 11, Centre d'Epidémiologie sur les Causes Médicales de Décès, Le Vésinet, France

1

Abstract

Context: In July 2006, a lasting and severe heat wave occurred in Western Europe. Since the 2003 heat wave, several preventive measures and an alert system aiming at reducing the risks related to high temperatures have been set up in France by the health authorities and institutions. In order to evaluate the effectiveness of those measures, the observed excess mortality during the 2006 heat wave was compared to the expected excess mortality.

Methods: A Poisson regression model relating the daily fluctuations in summer temperature and mortality in France from 1975 to 2003 was used to estimate the daily expected number of deaths over the period 2004-2006 as a function of the observed temperatures.

Results: During the 2006 heat wave (from 11th to 28th July), about 2065 excess deaths occurred in France. Considering the observed temperatures and with the hypothesis that heat-related mortality had not changed since 2003, 6452 excess deaths were predicted for the period. The observed mortality during the 2006 heat wave was thus markedly less than the expected mortality (approximately 4400 less deaths).

Conclusions: The excess mortality during the 2006 heat wave, which was markedly lower than that predicted by the model, may be interpreted as a decrease in the population's vulnerability to heat, together with, since 2003, increased awareness of the risk related to extreme temperatures, preventive measures and the set-up of the warning system.

Introduction

In August 2003, Western Europe experienced a heat wave that was exceptional in terms of duration, intensity, geographic extent and health impact [1-5]. In France, this event revealed an overall lack of reactivity by people (insufficient protective reflexes and help for the elderly), health professionals (poorly known diseases related to heat), the health system (difficulty perceiving the signals, lack of prevention recommendations) and the media (alarmist messages but no information on prevention).

In order to prevent the consequences of a new heat wave, a National Heat Wave Plan was set up by the Directorate General for Health to prevent the risks related to extreme temperatures [6]. The plan includes several measures: set-up of a system for real-time surveillance of health data, compilation of scientific recommendations on the prevention and treatment of heat-related diseases, air-conditioning equipment for hospitals and retirement homes, drawing up of emergency plans for retirement homes, city-scale censuses of the isolated and vulnerable, visits to those people during the alert periods, and set-up of a warning system. All the Directorates General of the Ministry of Health were involved together with the Directorate General for Civil Defence and Security.

During alert periods, other specific measures are to be implemented: intensification of care offer, visits to isolated and vulnerable people, and repeated preventive message broadcasting by the media.

Since summer 2004, the French Institute for Health Surveillance (Institut de Veille Sanitaire: InVS), in close collaboration with the national weather service (Météo-France), defined and implemented a heat health watch warning system on the basis of biometeorological indicators [7] and other criteria [8]. The warning system operates from 1st June to 31st August (seasonal surveillance period). When the alert criteria are fulfilled, an awareness and action

level is declared by the Prefect who manages the _département_ (French administrative unit with an average population of 600,000). A third level (maximum mobilisation) is implemented if the impacts of the heat wave overwhelm the health field: power cuts, drought, management problems in the funeral centers and heavy air pollution.

During an alert period and after it, the health impacts of the heat wave are estimated by comparing the observed and expected numbers of deaths. This comparison does not take into account the temporal pattern of temperatures. The national heat plan and the warning system are evaluated and improved each year (feedback from the various players, outside evaluation, exercises).

The alert system aims to give the public authorities three days' prior warning that a heat wave may occur, in order for the National Heat Wave Plan measures to be put into operation. The preventive measures and the new alert system are aimed at modifying the behaviour of people, health institutions and health authorities with regard to high summer temperatures.

In July 2006, a severe heat wave occurred over a large part of France and lasted 18 days (11th to 28th July). It also affected other European countries [9]. According to Météo-France, this event was the second most severe heat wave recorded since 1950; the 2003 heat wave was the most severe. The intensity and duration of the 2006 heat wave were similar to those of the 1976 heat wave in France, during which 5000 excess deaths occurred [10].

The objective of the study was to predict the national daily mortality for the summers of 2004 to 2006 and to compare it to the observed mortality, using a model based on a combination of temperature indicators for the same day and the 10 preceding days. The model was built using the data from a 29-year period, from 1975 to 2003 [11]. The number of excess deaths observed during the 2006 heat wave was thus estimated and compared to the expected number of

excess deaths, assuming that the relationship between temperature and mortality during summer 2006 was similar to that observed during the summers of 1975 to 2003. This comparison was intended to contribute to assessing the health impact of the prevention and alert measures, and the population's general awareness due to the 2003 heat wave.

Material and methods

The study analysed the mortality in association with temperature over the 122 "summer" days, from 1st June to 30th September of each year, from 1975 to 2006 (3904 summer days in all), for the whole of France.

Mortality data

The daily counts of all-cause mortality (O_t) by age and gender were provided by the French National Institute for Medical Research (Inserm). The yearly population estimates were supplied by the French National Institute of Statistics and Economic Studies (INSEE).

Temperature data

The daily minimum and maximum temperatures (*Tmin* and *Tmax*) were obtained from 97 weather stations representative of the climate affecting the populations of the 96 French *départements* by the national weather service. The national daily values of minimum/maximum temperatures were the average of those 97 values, weighted by the populations of each *département*.

In order to obtain information on the usual temperatures in summer, the reference minimum/maximum temperatures were obtained by dividing each summer period into 12 10-day periods and averaging the temperatures for each 10-day period over the 28 years (1975-2002).

5

A 10-day moving average of the mean temperature (average of the daily minimum and maximum temperatures) was also calculated.

For each day, a cumulative maximum temperature variable (*CTmax*) was defined as the sum of the number of degrees above a cut-off point (27°C) from the current day *t* to either day *t-10* or the last day with a temperature higher than the cut-off point. The variable was equal to zero if the temperature was below the cut-off point on the day considered:

$$CTmax_t = \sum_{d=0}^{k} (Tmax_{t-d} - 27°C) \times I_{Tmax_{t-d} > 27°C}$$

in which: k is the lower of the value 10 and the value of the first previous day on which *Tmax_t* fell below 27°C; $I_{Tmax_{t-d} > 27°C}$ is equal to 1 if $Tmax_{t-d}$ is higher than 27°C and 0 otherwise.

Modelling the daily fluctuations in mortality as a function of observed temperatures

As detailed in a previous paper [11], the daily mortality rates were modelled using a generalized estimating equations (GEE) approach, with a Poisson distribution. This model enables both specification of an over-dispersion and a first-order autoregressive structure. Seasonal variations in mortality during summer were controlled using a quadratic function of the day (*Season*). In order to allow for the overall trend of death rates declining regularly, although not log-linearly, from year to year, the mortality in summer was adjusted by the mortality rate observed over a reference period (*MR_ref*). This approach takes into account the long-term mortality trend and turned out to be more robust than a linear term. Four months, October and November for year N-1, April and May for year N, were chosen to constitute the reference period because they immediately preceded the summer for year N and were not subject to high yearly variations in mortality.

The model was thus:

$$Log[E(O_t)] = Log(PopJ) + \mu + \beta \, Log(MR_{ref}) + Season + \sum_{k} \theta_k Temperature\ factor_{k,t}$$

6

In which *PopJ* is the population estimate for the year considered. The temperature factors (*Temperature factor$_{k,t}$*) are a combination of minimum/maximum temperatures, the moving average and the cumulative variable of the maximum temperatures, recorded on the day considered and the preceding two days. Interactions between minimum/maximum temperatures and the cumulative indicator were also added. This combination was considered to be the most predictive of daily mortality in summer, both for the days with usual temperatures and for the days during intense and lasting heat episodes. The model explained 79% of the extra-Poisson variability in the daily number of deaths observed during a series of 25 summers (1975-1999) used to fit the model and yielded an excellent temperature based prediction of the daily death counts observed for a series of 4 consecutive summers (2000-2003), totally disconnected from the period used to fit the model.

Evaluating the predictive performance of the model (1975-1999) for the period 2000-2003

In order to evaluate the predictive performance of the model, the parameters of the model were first estimated for the 25-year period 1975-1999. The daily numbers of deaths for the four summers 2000 to 2003 were then predicted from the observed daily temperatures and compared to the observed numbers of deaths.

Prediction for the period 2004-2006

The parameters of the model were then estimated on the full 29-year period, 1975-2003.

The resulting model was used to predict the daily expected number of deaths ($\hat{O}_t$) for the summers 2004 to 2006 from the observed daily temperatures. The daily baseline number of deaths $\hat{E}_t$ was the number of deaths predicted by the model for the summer days, 2004, 2005 and 2006, using the reference temperatures.

7

The _observed excess mortality_ (O_t - $\hat{E}_t$) was defined as the difference between the observed number of deaths and the baseline number of deaths. The _expected excess mortality_ ($\hat{O}_t$ - $\hat{E}_t$) was defined as the difference between the expected number of deaths and the baseline number of deaths.

The heat wave period in summer 2006 was defined as the period with consecutive days of alert in at least one _département_. The first day of this period was that on which the biometeorological indicators were greater than or equal to the cut-off in at least one _département_ (11th July) and the last day was that on which the minimum and maximum biometeorological indicators were still greater than or equal to the threshold in at least one _département_ plus two days (28th July). In each _département_, a dual cut-off was defined for minimum and maximum temperatures, using a mortality-temperature study of 14 pilot cities, extended to cover the whole of mainland France **7**. Other criteria such as forecast reliability, wind, humidity, air pollution and holiday departures were also taken into consideration in the alert proposal **8**.

The observed excess mortality and the expected excess mortality during the 2006 heat wave were studied by gender for the whole population and for the two age groups (55-74 years, $\geq$ 75 years).

The confidence intervals of the difference between the predicted and observed deaths included the variance of the model estimates, the over-dispersed Poisson component and the residual autocorrelation for successive days.

Results

The daily fluctuations in the mortality rate and the minimum/maximum temperatures were closely correlated during the summers 2004 to 2006 (Figure 1). Several moderate heat episodes were observed in summer 2005. In 2006, the temperatures began increasing as of the first days of July, with daytime temperatures reaching 35°C, and night-time temperatures above 20°C. The decrease in temperature began on July 28th in the west. Temperatures were still very high at the end of the month in the south, where 6 _départements_ were still on alert during the first days of August. Seventy departments (76% of the French population) experienced at least two days of alert from June 29th to August 3rd, 2006. In July, only one day (6th) was free from alert, and the Paris area and the south-east of France were the most impacted regions (Figure 2). During the period of continuous alert, from 11th to 28th of July, 69 _départements_ experienced at least 2 days of alert.

Goodness-of-fit (1975-1999) and predictive performance (2000-2003)

In order to evaluate the predictive performance of the model, the daily numbers of deaths were predicted with the model for the four summers, 2000-2003, after adjusting on the calibration period 1975-1999. The observed mortality rates were very close to the expected mortality rates for the days with usual temperatures and for the 2003 heat wave (figure 3).

When the four summers, 2000 to 2003, were included in the calibration period, the estimate of the daily mortality rates during the periods with extreme temperatures was further improved. As a result, for the 29 summers from 1975 to 2003, the model explained 76% of the total extra-Poisson variability of the daily death count.

Temperature based prediction of mortality for summers 2004, 2005 and 2006

During summers 2004 and 2005, the observed numbers of deaths were 2% to 8% lower than the temperature based predicted deaths, independently of the daily temperatures (table 1).

During the three months, June, August and September 2006, the difference between the observed and the expected numbers of deaths was very small for people aged $\geq$ 55 years, with $\pm$15 deaths per day (1.3% of the daily mortality in summer) (table 1). The daily fluctuations in the expected mortality rates were closely correlated with the fluctuations in the observed mortality rates during those three months. A marked increase in mortality was observed for July 2006, when the heat wave occurred.

Table 1 here

Heat Wave 2006

During the 2006 heat wave, from 11th to 28th July, 2065 excess deaths were observed ($CI_{95\%}$ = [1630; 2499]), equivalent to an excess mortality of +9%. The expected number of excess deaths predicted from the observed temperatures was 6452 deaths ($CI_{95\%}$ = [6178; 6726]), and the expected mortality ratio was +27% (Table 2). Consequently, the estimated mortality deficit was very substantial: -4388 deaths ($CI_{95\%}$ = [-4920; -3855]).

For subjects aged 75 years and more, 1254 excess deaths ($CI_{95\%}$ = [907; 1 601]) occurred during the heat wave, i.e. an 8% increase in mortality. The expected number of excess deaths was 5080 deaths ($CI_{95\%}$ = [4824; 5334]), equivalent to an excess mortality of 34%. Thus, the excess mortality deficit was -3825 deaths ($CI_{95\%}$ = [-4263; -3386]).

For subjects aged 55 to 74 years, the observed and expected numbers of excess deaths were moderate, with 399 observed excess deaths ($CI_{95\%}$ = [226; 572]) and 1141 expected excess

deaths ($CI_{95\%}$ = [1061; 1221]) (Table 2). The excess mortality deficit was -742 deaths ($CI_{95\%}$ = [- 941; - 543])

Excess mortality occurred in both men and women during the 2006 heat wave (Table 2). The excess mortality and excess mortality deficit were greater for women, even for the elderly.

Table 2 here

Discussion

The comparison of the observed and expected mortalities during the 2006 heat wave has shown that 2065 excess deaths occurred in the total French population. In the absence of preventive measures, given the temperature levels, 6452 excess deaths were expected during that period. Consequently, the excess mortality was much lower than expected on the basis of the temperature based model (-4400 deaths, approximately). These findings may be related to the establishment of preventive measures in the context of the National Heat Plan.

For summers 2004 and 2005, the model generated a moderate overestimate of the daily number of deaths of 2 to 8%, independently of the temperature level. Excluding the month of July, the daily expected and observed numbers of deaths were close in 2006. During the 2006 heat wave, the excess mortality was marked for the oldest people and for women.

Although the results were derived from a statistical model, the good predictive performance of the model for the 2000-2003 period strengthens confidence in the results.

A long-term downward general mortality trend in France from 1975 to 2003 was observed. This trend would probably have been occurring, with or without interventions, from 2004 to 2006. This long-term time course of mortality from 1975 to 2006 is taken into account by the

adjustment on the mortality observed in the reference period. The time course of the daily mortality in summer is thus relative to the evolution of mortality on the reference period.

The difference between mortality during the summer and mortality during the reference period seemed to have changed in 2004 and 2005 compared to the difference observed from 1975 to 2003. The mortality observed during the months used as the reference period (October, November, April and May) have a regular time course from year to year and is probably not responsible for the differences with respect to the estimates for the summers of 2004 and 2005.

It does not seem easy to choose between the different hypotheses that may be advanced to explain that result. After the 2003 heat wave, several preventive measures were taken by the population and by health institutions and authorities to limit the risks associated with high temperatures. Those measures may have modified the relationship between the reference period and summer mortalities during summers 2004 and 2005. The results may thus reflect a marked awareness of vulnerable people (mainly aged people) during these two summers following the 2003 experience, even though the weather was not extremely hot. This behaviour would have been specific to the summer period, compared to the reference period

A long-term harvesting effect of the excess deaths observed in 2003 has also been proposed as an explanation for the mortality deficit in 2004 [12]. However, the excess mortality in 2003 (+15000 deaths) was smaller than the mortality deficit observed in 2004 (-25000 deaths) [13]. The hypothesis therefore seems to be an improbable explanation for the overestimates for the summers of 2004 and 2005. The mortality during those two summers may also have been influenced by other factors that were not identified.

The pattern of the observed mortality deficit for summer 2006, compared to the expected deaths, was quite different since the deficit was only observed during the 18 days of the heat wave in July 2006.

The marked excess mortality deficit during the 2006 heat wave in France suggested a decrease in the population's vulnerability to high temperatures, probably associated with:

- the French population's increased awareness of the risks related to extreme summer temperatures after the 2003 heat wave;

- the set-up of preventive measures with regard to the effects of high temperatures by the health authorities and institutions after the 2003 heat wave;

- the set-up and implementation of the heat health watch warning system (HHWWS) by the InVS and Méteo-France as of summer 2004.

Other countries have established systems for preventing the effects of heat waves. Most were developed and implemented at a local level; rarely on a national scale [17-20]. In some cases, the system simply consists in prevention messages included in weather forecasts. Some countries have assessed their warning systems and found evidence that higher levels of heat awareness and implementation of a warning system were responsible for lower levels of mortality when another heat wave occurred [14; 16; 21].

The present study compared the daily mortality of the whole French population. Although temperatures are heterogeneous in different places in France, the daily population-weighted average of temperatures on the national scale turned out to be highly correlated with the daily number of deaths in summer. Considering the whole population markedly reduced the variability related to small frequencies in studies of specific urban areas. However, from an

operational point of view, the alert criteria which determine warning system level should be determined for each *département*. A finer geographic analysis of the mortality-temperature relationship might thus be used to investigate whether a decrease in population vulnerability occurred in various regions of France.

In conclusion, while about 2100 excess deaths occurred during the 18-day period of the 2006 heat wave, the observed excess mortality was much lower than that expected on the basis of the model (approximately 4400 deaths less). The deficit may be related to a change in summer mortality response, which may be due to public awareness of the dangers of high temperatures, the preventive measures set up by the health institutions and authorities, and the set up of a heat warning system after the 2003 heat wave, even though the respective contributions of those factors cannot be distinguished. However, given the magnitude of the persisting excess mortality – 2100 deaths – ongoing prevention remains necessary.

Key messages Box

During the July 2006 heat wave, about 2065 excess deaths occurred in France. Considering the observed temperatures and under the hypothesis that the quantitative association between temperature and mortality observed during the 32-year period (1975-2003) had not changed, 6452 excess deaths were predicted for the 2006 heat wave.

The excess mortality was thus much lower than expected (-4400 deaths, approximately), which may be related to the establishment of preventive measures in the context of the National Heat Plan since 2004.

Acknowledgments

Competing interests

The authors certify that this study was conducted without any financial or personal competing interest.

Funding

Authors' Contributions

AF was in charge of the statistical modelling and analysis of data, participated in the interpretation of data and drafted the manuscript. GR participated in the statistical analysis and interpretation of the data. DH and EJ were the principal investigators of the study and participated in the interpretation of data. DH provided statistical and epidemiological expertise. EJ, in collaboration with FL, contributed to the acquisition of the data on all-cause mortality and mortality by medical cause of death. PF and PB made substantial contributions to the acquisition of the climatic data. Contributors from French Institute for Health Surveillance (VW, KL, PEB, ALT and PDCC) provided expertise on the Heat/Health Watch Warning system and 2006 heat wave. All the authors revised the manuscript and have approved the final version.

References

1. Fouillet A, Rey G, Laurent F, Pavillon G, Bellec S, Guihenneuc-Jouyaux C et al. Excess mortality related to the August 2003 heat wave in France. *Int Arch Occup Environ Health* 2006; **80:** 16-24.

2. Kosatsky T . The 2003 European heat waves. *Euro Surveill* 2005; **10:** 148-9.

3. InVS. Impact sanitaire de la vague de chaleur d'août 2003 : premiers résultats et travaux à mener. *Bull Epidemiol Hebdo* 2003; **45-46:** 1-12.

4. Grynszpan D . Lessons from the French heatwave. *Lancet* 2003; **362:** 1169-70.

5. Vandentorren S, Bretin P, Zeghnoun A, Mandereau-Bruno L, Croisier A, Cochet C et al. . August 2003 heat wave in France: risk factors for death of elderly people living at home. *Eur J Public Health* 2006; **16:** 583-91.

6. Direction Générale de la Santé. Plan national canicule. 2006. http://www.sante.gouv.fr/canicule/doc/plan_canicule_2006.pdf

7. Pascal M, Laaidi K, Ledrans M, Baffert E, Caserio-Schonemann C, Le Tertre A et al. . France's heat health watch warning system. *Int J Biometeorol* 2006; **50:** 144-53.

8. Laaidi K, Pascal M, Berat B, Strauss B, Ledrans M, Empereur-Bissonnet P . Système d'alerte canicule et santé 2006 (sacs 2006). Rapport opérationnel. Institut de Veille Sanitaire (InVS). Saint-Maurice. 46p. Juin 2006.

9. Estimated daily mortality during July 2006 in England and Wales. *Health Stat Q* 2006; **32:** 107-11.

10. Rey G, Jougla E, Fouillet A, Pavillon G, Bessemoulin P, Frayssinet P et al. . The impact of major heat waves on all-cause and cause-specific mortality in France from 1971 to 2003. *Int Arch Occup Environ Health* 2007; **80:** 615-26.

11. Fouillet A, Rey G, Jougla E, Frayssinet P, Bessemoulin P, Hémon D . A predictive model relating daily fluctuations in summer temperatures and mortality rates. *BMC Public Health*. 2007, 7:114.

12. Valleron A, Boumendil A . [Epidemiology and heat waves: analysis of the 2003 episode in France]. *C R Biol* 2004; **327:** 1125-41.

13.   Toulemon L, Barbieri M . The Mortality Impact of the August 2003 Heat Wave in France. *25th International Population Conference IUSSP, Tours* 18-23 July, 2005.

14.   Weisskopf MG, Anderson HA, Foldy S, Hanrahan LP, Blair K, Torok TJ et al. Heat wave morbidity and mortality, Milwaukee, Wis, 1999 vs 1995: an improved response? *Am J Public Health* 2002; **92:** 830-3.

15.   Smoyer KE . A comparative analysis of heat waves and associated mortality in St. Louis, Missouri--1980 and 1995. *Int J Biometeorol* 1998; **42:** 44-50.

16.   Tan J, Zheng Y, Song G, Kalkstein L, Kalkstein A, Tang X . Heat wave impacts on mortality in Shanghai, 1998 and 2003. *Int J Biometeorol* 2007; **51:** 193-200.

17.   Tan J, Kalkstein LS, Huang J, Lin S, Yin H, Shao D . An operational heat/health warning system in Shanghai. *Int J Biometeorol* 2004; **48:** 157-62.

18.   WHO Regional Committee for Europe. Heatwaves: impacts and responses. *WHO 1-11.* 2003.

19.   Michelozzi P, de' Donato F, Accetta G, Forastiere F, D'Ovidio M, Perucci C et al. . Impact of heat waves on mortality - Rome, Italy, June-August 2003. *MMWR Morb Mortal Wkly Rep* 2004 May 7; **53(17):** 369-71.

20.   Kalkstein L, Jamason P, Greene J, Libby J, Robinson L . The Philadelphia hot weather-health watch/warning system: development and application, summer 1995. *Bull Am Meteorol Society* 1996; **77:** 1519-1528.

21.   Naughton MP, Henderson A, Mirabelli MC, Kaiser R, Wilhelm JL, Kieszak SM et al. Heat-related mortality during a 1999 heat wave in Chicago. *Am J Prev Med* 2002; **22:** 221-7.

Figure 1: Daily observed mortality rate (black), and minimum (blue) and maximum (red) temperatures, 1st June to 30th September 2004 to 2006 – France

1st June to 30th September 2004

1st June to 30th September 2005

1st June to 30th September 2006
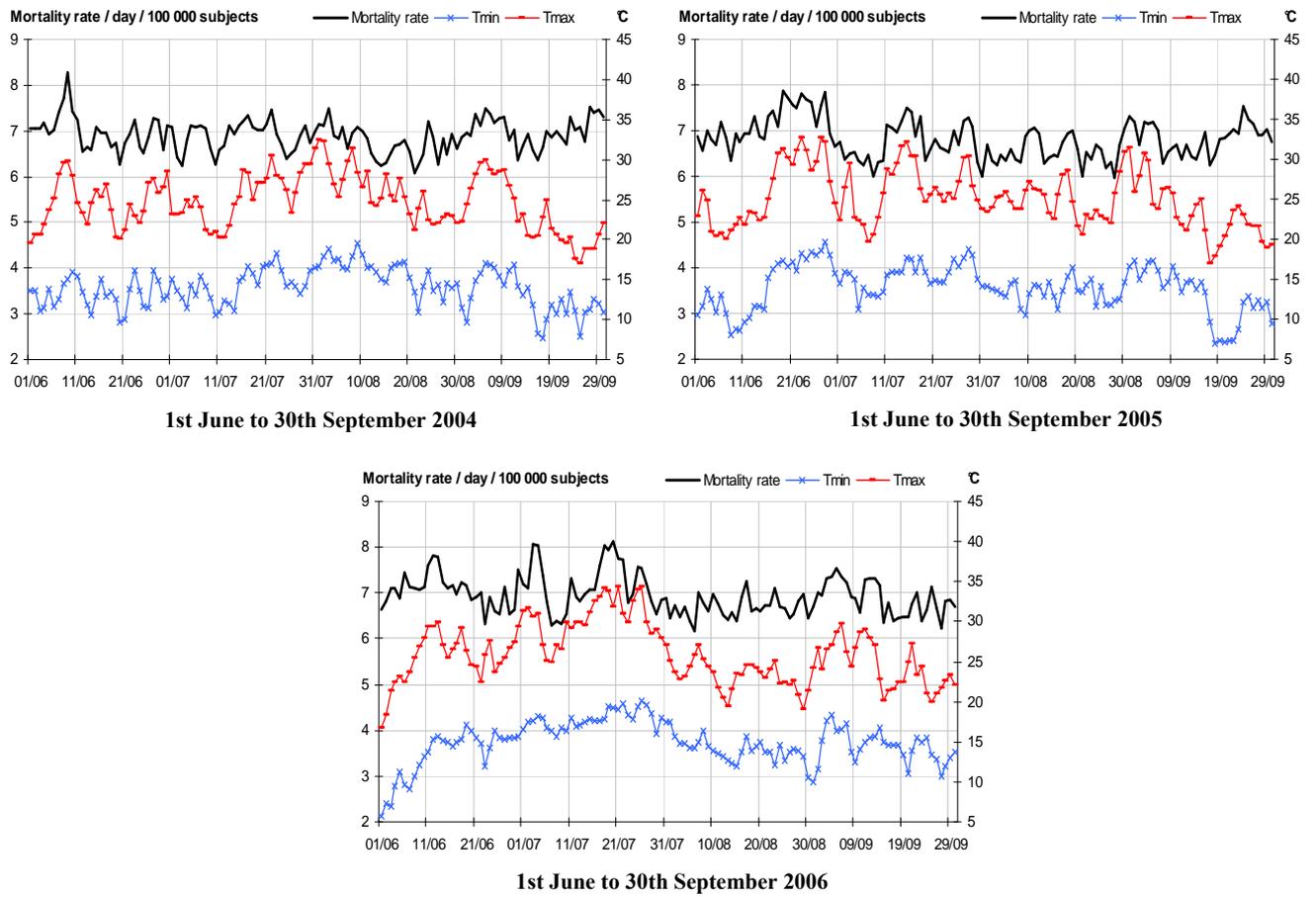
Figure 2: French _départements_ on alert in July 2006.

Total number of days on alert by _département_

Total number of days in alert per departement :

None
1 - 7
8 - 14
15 - 21
22 - 31

Source : ©IGN-GéoFLA®, Paris, 1999 ; InVS-Sacs, 2006.
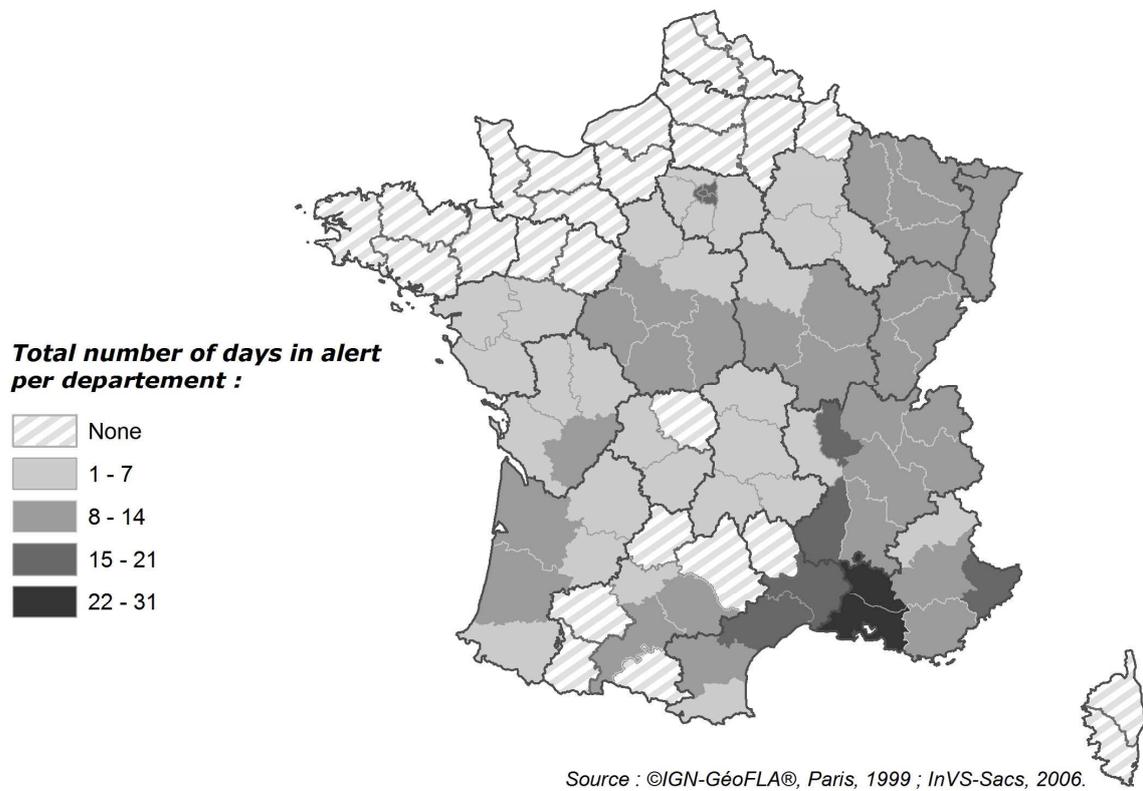
Figure 3: Daily fluctuations in observed mortality rates (black), baseline mortality rates (blue) and expected mortality rates (red) in the summers 2000, 2001, 2002 and 2003 with a 25-year calibration period (1975-1999) - Subjects aged ≥ 55 years - France

1st June to 30th September 2000

1st June to 30th September 2001

1st June to 30th September 2002

1st June to 30th September 2003
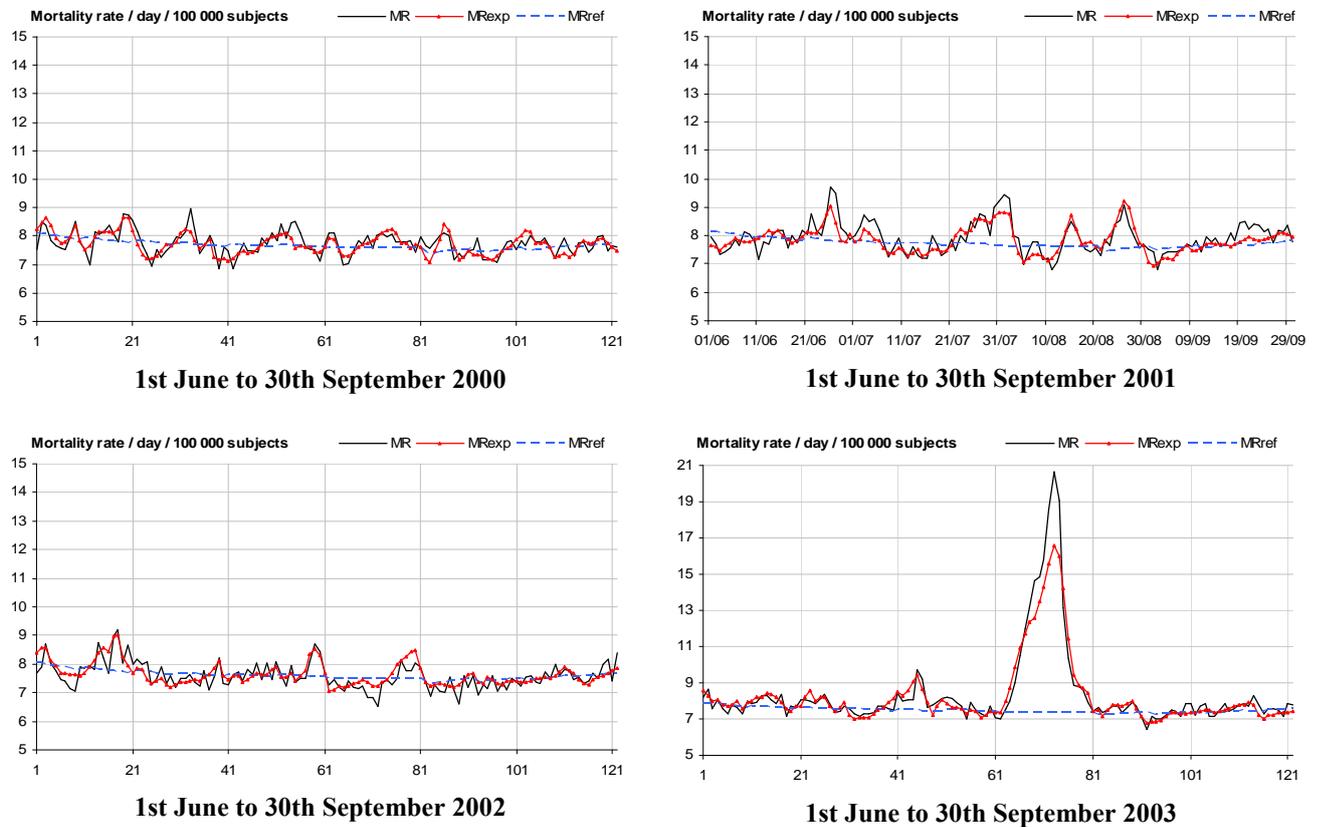
X-axis: days from 1st June to 30th September; Y-axis: mortality rate per 100000 subjects per day

MR: observed mortality rate; MRexp: expected mortality rate; MRref: baseline mortality rate

Table 1: Comparison of the observed and expected numbers of deaths by month for summers 2004, 2005 and 2006, considering a similar relationship between the mortality during the summer and the mortality during the reference period – Subjects ≥ 55 years and more - France.

	June	July	August	September
2004				
Baseline number of deaths $\hat{E}_t$	35 998	36 254	35 653	34 758
Observed excess deaths $O_t - \hat{E}_t$	-1 742	-1 442	-1 614	-388
Expected excess deaths $\hat{O}_t - \hat{E}_t$	318	319	762	492
Observed - Expected numbers of deaths $O_t - \hat{O}_t$	**-2 060**	**-1 761**	**-2 376**	**-880**

1st June to 30th September 2004

	June	July	August	September
2005				
Baseline number of deaths $\hat{E}_t$	36 039	36 295	35 745	34 797
Observed excess deaths $O_t - \hat{E}_t$	-212	-1 474	-1 648	-586
Expected excess deaths $\hat{O}_t - \hat{E}_t$	2 468	496	52	362
Observed - Expected numbers of deaths $O_t - \hat{O}_t$	**-2 680**	**-1 971**	**-1 700**	**-949**

1st June to 30th September 2005

	June	July	August	September
2006				
Baseline number of deaths $\hat{E}_t$	35 693	35 947	34 897	34 463
Observed excess deaths $O_t - \hat{E}_t$	418	2 087	-5	773
Expected excess deaths $\hat{O}_t - \hat{E}_t$	872	7 181	-453	566
Observed - Expected numbers of deaths $O_t - \hat{O}_t$	**-454**	**-5 094**	**448**	**207**

1st June to 30th September 2006

O_t: observed number of deaths; $\hat{O}_t$: expected number of deaths; $\hat{E}_t$: baseline number of deaths.

MR: observed mortality rate; MRexp: expected mortality rate; MRref: baseline mortality rate

Table 2: Observed and expected excess deaths and mortality ratio by age group and gender – France – 11th to 28th July 2006

	Baseline deaths $\hat{E}$	Mortality ratio			Number of excess deaths		
		Observed $O/\hat{E}$	Expected $\hat{O}/\hat{E}$	$O/\hat{O}$	Observed $O-\hat{E}$	Expected $\hat{O}-\hat{E}$	$O-\hat{O}$
All ages							
Total	23515	**1.09**	**1.27**	**0.85**	**2065** [1630; 2499]	**6452** [6178; 6726]	**-4388** [-4920; -3855]
Men	12213	**1.08**	**1.21**	**0.89**	**979** [712; 1245]	**2552** [2408; 2695]	**-1 573** [-1886; -1260]
Women	11306	**1.10**	**1.35**	**0.81**	**1083** [812; 1354]	**3906** [3740; 4073]	**-2824** [-3164; -2484]
55-74 years							
Total	5974	**1.07**	**1.19**	**0.90**	**399** [226; 572]	**1141** [1061; 1221]	**-742** [-941; -543]
Men	3992	**1.06**	**1.17**	**0.91**	**230** [94; 367]	**669** [606; 733]	**-439** [-594; -284]
Women	1978	**1.09**	**1.24**	**0.88**	**173** [82; 265]	**467** [429; 506]	**-294** [-401; -188]
≥ 75 years							
Total	14954	**1.08**	**1.34**	**0.81**	**1254** [907; 1601]	**5080** [4824; 5334]	**-3825** [-4263; -3386]
Men	7974	**1.08**	**1.26**	**0.86**	**536** [353; 719]	**1628** [1519; 1 737]	**-1092** [-1311; -873]
Women	8586	**1.09**	**1.40**	**0.78**	**740** [496; 985]	**3 423** [3249; 3598]	**-2 683** [-2997; -2369]

O: observed number of deaths; $\hat{O}$: expected number of deaths; $\hat{E}$: baseline number of deaths.