Health Impact of the 2003 Heat-Wave in France

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Abstract

An unprecedented heat-wave struck France in early August 2003, associated to high levels of air pollution. The meteorological event was accompanied by an excess of mortality that started early and rose quickly. Between August 1st and 20th, the excess of deaths reached 14,802 cases in comparison to the average daily mortality in the 2000 – 2002 period. It represents +60 % of mortality for all causes. The observed excess of mortality first affected the elderly (+70 % for 75 years-old and more), but was also severe for the 45 – 74 year olds (+30 %). In all age groups, females mortality was 15 to 20 % higher than male. Almost the whole country was affected by the excess-mortality, however its intensity varied significantly from one region to another and was at a maximum in Paris and suburbs (+142 %). The excess mortality clearly increased with the duration of extreme temperatures. With regard to the location, the highest mortality rate affected nursing homes where the number of deaths observed was twice the expected number. Following the descriptive studies carried out immediately after the heat-wave, two case-control surveys were carried out. The first study was conducted to identify individual risk factors (way of life, medical history, self sufficiency) and environmental factors (housing) in elderly people living at home. The second one was conducted to identify individual risk factors (autonomy/handicap, medical condition, drug consumption) and environmental risk factors (number and quality of personnel available; facility size and characteristics; prevention plans and therapeutic protocols) for elderly residing in a nursing home. This survey was made in two parts: a "facility case-control study" and an "individual case-control study". High levels of photochemical air pollution were associated to the heat-wave. A study was conducted to estimate the fraction attributable to ozone in the excess risks of mortality jointly related to temperature and ozone, and also to identify a decrease of expected mortality in the weeks following the heat-wave. In cities having experienced the highest excess risk of mortality (Paris, Lyon) the contribution of ozone was minor relative to temperature; the relative part of this air pollutant was higher but variable in cities where the excess risk of mortality was low. The study did not show a harvesting effect within the three weeks following the heat-wave. The French Heat-Wave National Plan, developed immediately after the 2003 event, includes a Heat Health Watch Warning System operating from 2004 and covering the whole country.

1 An exceptional heat-wave

An heat-wave struck France in early August 2003 after a warm month of June with temperatures 4 to 5 °C above seasonal averages, and a month of July closer to normality except high heat during the last two weeks. Unusual periods of high temperatures were observed in France between August 4th and August 12th, 2003. Throughout the country, 2/3 of the meteorological stations recorded temperatures above

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35 °C, sometimes above 40 °C in 15 % of the main French cities. In Paris, the temperature exceeded 35 °C for as long as 10 days, including 4 days in a row between August 8th and 11th, 2003, a situation never observed since 1873.

On August 11th and 12th, 2003, a minimal temperature of 25.5 °C was recorded in Paris during the night. This is the absolute record for minimal temperatures ever measured in Paris (source: French Weather Bureau – Meteo France). The French heat-wave was exceptional and the warmest year over the last 53 years in terms of minimal, maximal and average temperatures, and in terms of duration. In addition, the high temperatures and the sunshine causing the emission of pollutants significantly increased the atmospheric ozone level.

2 First descriptive studies

2.1 Mortality assessment during the heat-wave

The heat-wave of August 2003 had a severe impact on public health in France, with a mortality largely affecting the elderly people (1). On August 13th, 2003, data allowed the conclusion that a large-scale outbreak was to happen. An excess mortality of 3000 cases was estimated by the InVS based on the data provided by the Pompes Funèbres Générales (France's largest Funeral Parlour). A more complete analysis of the excess mortality for August 2003 was then conducted by The French Institute of Health and Medical Research (INSERM: Institut national de la santé et de la recherche médicale) (2), based on the death certificates passed on by the town councils to the county health offices (DDASS: Directions départementales des affaires sanitaires et sociales).

By comparing the number of deaths registered between August 1st and 20th, 2003 in France (41,621 reported deaths) and the expected number of deaths (i.e. estimated on the basis of the mortality in 2000, 2001 and 2002) for the same period (26,819 expected deaths), the excess mortality was estimated at 14,802 additional deaths. This is equivalent to a total mortality increase of 55 % between August 1st and 20th, 2003. The mortality increase was particularly high for the elderly (+70 % in people above 75 years old). It was different by sex (+40 % in men and +60 % in women). With regard to the location, the mortality rate was maximal in nursing homes where the number of deaths observed was twice the expected number.

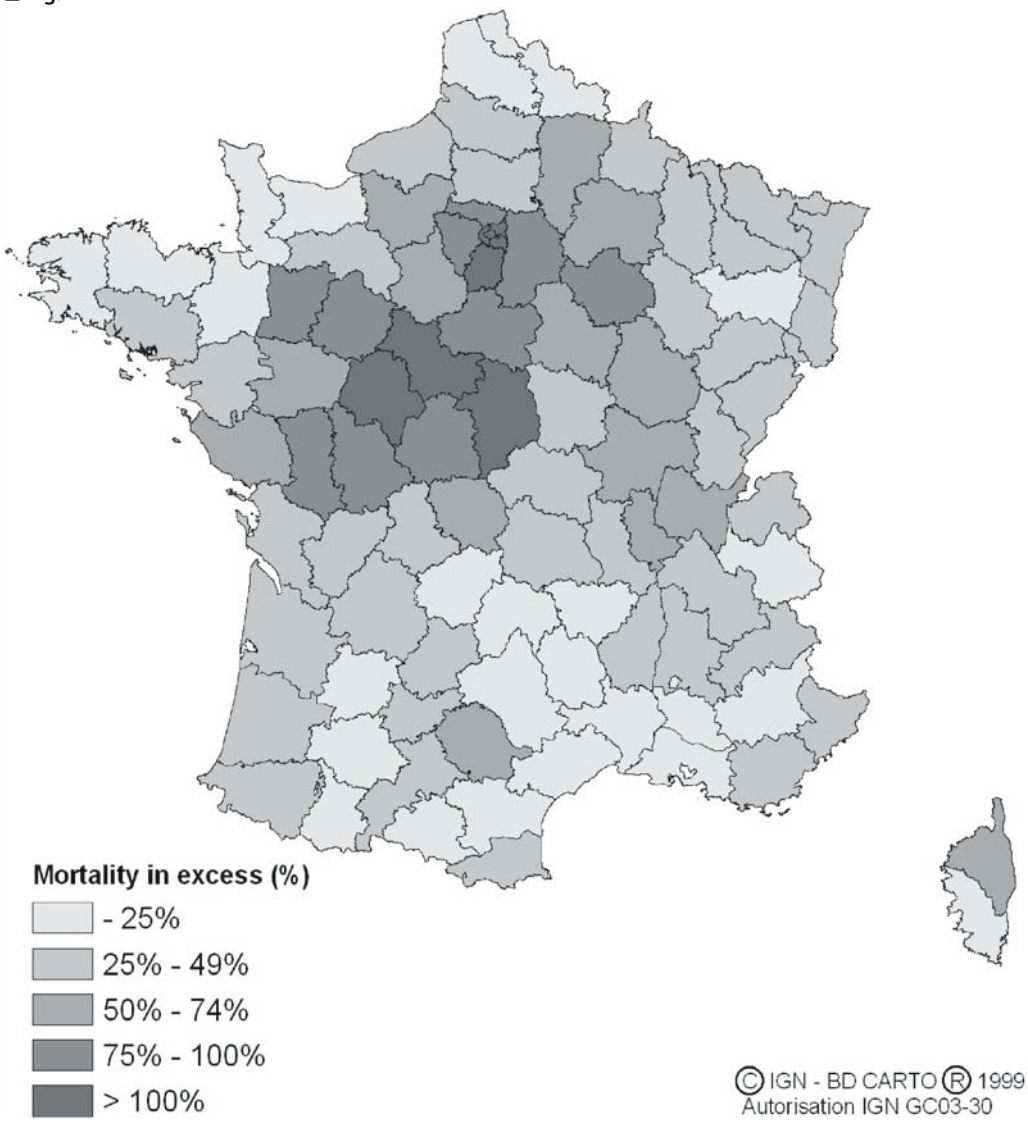
Almost the whole country was affected by the excess mortality, however its intensity varied significantly from one region to another *(› Fig. 1):* +20 % in Languedoc-Roussillon (South), +130 % in Ile-de-France (Paris and suburbs). The excess mortality clearly increased with the duration of extreme temperatures.

2.2 Heatstroke deaths in health care facilities

A survey conducted by the InVS referred to the deaths caused by heatstroke in public and private health-care facilities (3). This study pertained to all persons deceased from a heat stroke in a health care facility, over the whole country, between the 8th and 19th of August 2003. The case definition was: a body temperature equal to or greater than 40.6 °C before time of death, or before all cooling attempts, with reasonable exclusion of other causes of hyperthermia. A questionnaire was sent to the French medical facilities likely to care for heat stroke victims. A recall of the non-respondent facilities was undertaken on August 21st and August 25th. Overall, a response rate of 78 % was observed for state facilities and 53 % for private ones.

A total of 2851 heat stroke related deaths were reported. A body temperature ≥40.6 °C before time of death was recorded in 48 % of the cases [median: 41 °C, 25th percentile – 75th percentile: 40 – 42 °C]. More than half the deaths occurred between August 11th and 13th. The majority of deaths occurred in women (65 %), and 81 % in elderly people aged 75 and over. In this study, 16 % of the deceased lived alone,

Fig. 1



Analysis of over mortality in France August from 1st to 15th 2003, related to mean of deaths from 2000 – 2002 (source: InVS)

20 % in individual housing but not alone, and 63 % lived in health care facilities, mostly in retirement homes (47 %). For those aged 60 years and over (95 %), various diseases associated with heat stroke were notified, of which essentially, 30 % were mental illnesses, 23 % cardio-vascular diseases, and 12 % diabetes. For those aged under 60 (n = 146), a mental illness was notified for 41 %, excessive alcohol consumption for 20 % and a severe physical disability for 14 %. Three deaths were recorded for those less than 20 years of age. The date of onset of the symptoms, reported for 2417 deaths, corresponded to the day of or the day before death for 47 %. This time lapse was significantly shorter when the recorded body temperature was

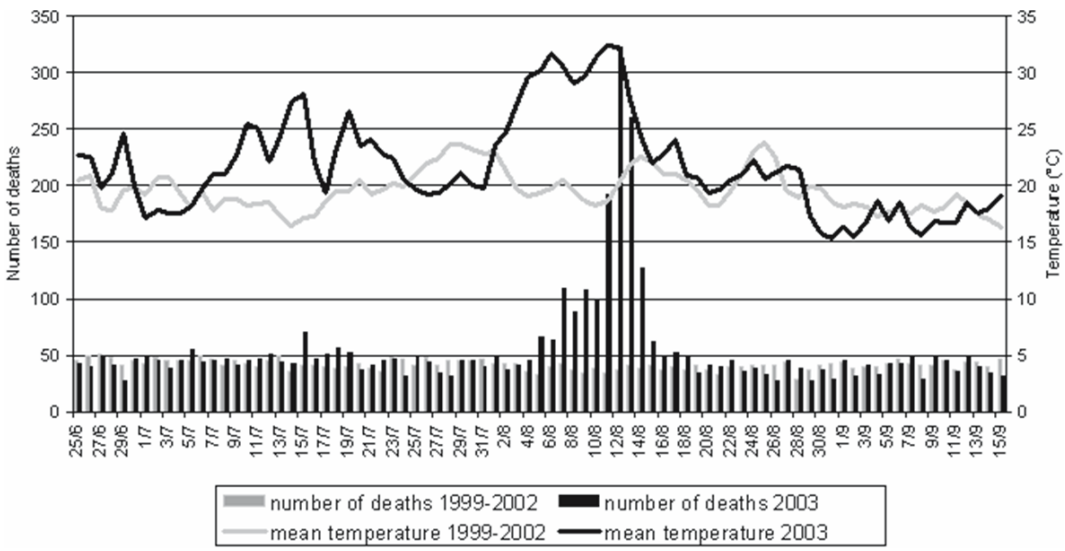
40.6 °C or higher (stringent case definition). When restricted to this latter sub-group, the analysis shows similar results, except for the time laps between symptoms onset and death.

2.3 Mortality assessment in urban areas

A survey on the daily trend mortality was conducted by the InVS in thirteen of the largest urban areas in France (Bordeaux, Dijon, Grenoble, Le Mans, Lille, Lyon, Marseille, Nice, Paris, Poitiers, Rennes, Strasbourg and Toulouse) during the 2003 heat wave (between August 1st and 19th). An excess of mortality was found between the 2003 heat-wave and the corresponding period in 1999/2002, at the lowest in Lille (+4 %) and the highest in Paris (+142 %, *Fig. 2*). A disparity of the heat-wave's impact appeared among the thirteen cities (4).

Dijon, Paris, Le Mans and Lyon, where the excess in mortality was particularly marked, are located in the central and eastern regions, where the 2003 mean temperatures were especially high compared to the preceding years. Marseilles, Nice and Toulouse, located in the South of France, suffered less from the heat-wave compared to towns with similar temperatures in August 2003 but not used to very hot summers (5).

Fig. 2



Comparison of daily mortality and mean temperature in Paris for years 2003 and 1999 – 2002 (source: InVS)

3 Etiologic factors studies

Following the descriptive studies carried out immediately after the heat-wave, two case-control surveys were conducted by the InVS to identify the risk factors of death for the elderly living at home and those residing in a nursing home (6).

The aim of the study for the elderly living at home was to identify individual risk factors (way of life, medical history, self sufficiency) and environmental factors (housing) in elderly people living at home (7).

A case control study was conducted in Paris, Val de Marne, Tours and Orleans. These sites were selected because they are urban areas which were affected by the heat wave and because they present different social and architectural patterns. Cases were defined as: people aged 65 and over, deceased between August 8th to 13th, living at home and with death certificate not mentioning accident, suicide or surgical complications. Controls were matched with cases on age (+/–5 years), gender and place of residence (area of 100,000 residents). A questionnaire was administered face to face or by phone to the next to kin for cases and to controls themselves or next of kin if necessary. Size of sampling was evaluated at 300 cases and 300 controls.

Data were collected using satellite pictures to assess the heat island profile of the home places. Data analysis is currently in progress, using SAS. We use matched pairs analysis to estimate odds ratios and confidence intervals for each potential risk factor. All potential risk factors derived from the questionnaire are assessed in univariate analysis. The final multivariate model will entered into a conditional, step-wise logistic regression model.

The aim of the study for the elderly residing in a nursing home was to identify individual risk factors (autonomy/handicap, medical condition, drug consumption) and environmental risk factors (number and quality of personnel available; facility size and characteristics; prevention plans and therapeutic protocols). This survey is made of two parts: a "facility case-control study" and an "individual case-control study". The target facilities are retirement homes and hospital units for the long term care of the elderly in the areas characterized by a high level of heat wave-related mortality. The selection of facilities was done on the basis of a rapid postal survey conducted in August 2003. The facilities with the higher level of mortality are the "cases" in the "facility case-control study". They are paired to controls on criteria of geographical proximity and mean level of autonomy of the residents. 200 cases and 200 controls are investigated. Within each of the "cases facilities", two "individual cases" are randomly selected among the persons deceased between 5th and 15th of August 2003 (excluding non heat-related causes). Each individual case is paired with the person who was still alive on the first of September, and whose age is the closest to the case. The data on cases and controls are gathered through a questionnaire administered during face-to-face interviews with the administrative and health care personnel. Matched pairs analysis is used to estimate odds ratios and confidence intervals for each potential risk factor. All potential risk factors derived from questionnaire are tested in univariate analysis. The final multivariate model will use a conditional, stepwise logistic regression model.

The results of theses case-control surveys have been used to define profiles of sensitive people for the 2004 Heat-Wave National Plan.

4 Contribution of air pollution by ozone and interaction with temperature

The meteorological conditions during the heat-wave contributed to a photochemical air pollution that was very unusual according to its duration and its geographical spread. Consequently, the question of the specific contribution of high levels of ozone to the mortality in excess was asked early by the Public Health Authorities. A study (8), carried out by the Heath and Surveillance Programme in 9 cities (PSAS-9), had three objectives: 1) to estimate the short-term risks of death due to ozone pollution during the heat-wave and compare them to the risk estimates observed in normal weather conditions; 2) to evaluate the excess risks of mortality jointly related to air temperature and ozone, and the relative part of each risk factor; 3) to quantify if a decrease of expected mortality in the weeks following the heat-wave (short-term harvesting effect) exists.

An interaction on mortality, between high temperatures and high ozone concentrations, was not observed. For the whole set of the studied cities (Paris, Lyon, Marseille, Lille, Bordeaux, Toulouse, Le Havre,

Rouen and Strasbourg), the pooled excess risk of mortality – for an increase of 10 μg/m³ of the ozone air concentration – was 1,01 %. This value is slightly higher than, but not statistically different from, the excess risk usually estimated in these cities. On the other hand, the town-specific excess risks were more heterogeneous among the 9 cities than in the previous works. The health impact attributable to ozone pollution, worked out from August 3rd to 17th, was 379 deaths in excess in the 9 cities (for a total population of 11 million inhabitants).

Comparing effects of temperature and ozone, it appeared that in the cities experiencing the highest excess risk of mortality, Paris and Lyon, the relative part of ozone was minor: it represented respectively 7 and 3 % of the excess risk of mortality related to the two risk factors. For cities where the excess risk of mortality was moderate, the contribution of ozone was higher (except in Bordeaux: 2 %) but very variable, from 32 % (Rouen) to 85 % (Toulouse).

Modelling of the "heat-wave effect" on mortality, independently of any particular factor, did not show a harvesting effect within the three weeks following the heat-wave. The deaths which occurred during the meteorological event were not anticipated on only a few days, and the loss of life was probably larger for over three weeks.

5 Heat Health Watch Warning System

To prevent another terrible epidemic related to extreme temperatures during summertime, the French Public Health Authorities have developed a Heat-Wave National Plan. It includes a Heat Health Watch Warning System (HHWWS) which operates since 2004, from June to August, and covers the whole metropolitan country.

The warning system is based on thresholds of biometeorological indices, defined from historical dataset of the previous 30 years daily mortality and meteorological indicators (9). Out of seven meteorological indicators tested (related to temperature and humidity), the minimal and maximal temperatures, coupled and averaged on three consecutive days, had the highest sensitivity and specificity and have been chosen as biometeorological indices. The HHWWS aims to alert the French Authorities to the possibility of a significant outbreak: so the warning thresholds correspond to an expected daily mortality in excess of 50 or 100 %, according to the size of the city. The level 2 of the Heat-Wave National Plan is activated when the 3-day forecasting of the coupled biometeorological indices reach the thresholds.

References

1. Basu R, Samet JM (2002) Relation between elevated ambient temperature and mortality: a review of the epidemiologic evidence. Epidemiol Rev 24(2):190 – 202
2. Hemon D, Jougla E (2003) Estimation of mortality and epidemiologic characteristics. INSERM U170-IFR69 report September 25th 2003. http://www.inserm.fr
3. InVS (Institut de Veille Sanitaire) (2003) Impact sanitaire de la vague de chaleur en France survenue en août 2003. Rapport d'étape. http://www.invs.sante.fr
4. Vandentorren S, Suzan F, Medina S, Pascal M, Maulpoix A, Cohen JF, Ledrans M (2004) Mortality in thirteen French cities during the August 2003 heat-wave. Am J Public Health 94(9):1518 – 1520
5. Keatinge WR, Donaldson GC, Cordioli E, Martinelli M, Kunst AE, Mackenbach JP, Nayha S (2000) Heat related mortality in warm and cold regions of Europe: observational study. BMJ 321:670 – 672
6. Semenza JC, Rubin CH, Falter KH, Selanikio JD, Flanders WD, Howe HL et al. (1996) Heat-related deaths during the July 1995 heat wave in Chicago. N Engl J Med 335(2):84 – 90
7. Clarke JF (1972) Some effects of the urban structure on heat mortality. Environment research 5:93 – 104

8. InVS (Institut de Veille Sanitaire) (2004) Vague de chaleur de l'été 2003 : relations entre températures, pollution atmosphérique et mortalité dans neuf villes françaises. Rapport d'étude. http://www.invs.sante.fr

9. InVS (Institut de Veille Sanitaire) (2004) Système d'alerte canicule et santé (SACS) 2004. Rapport opérationnel. http://www.invs.sante.fr