Risk Analysis, Vol. 25, No. 6, 2005

DOI: 10.1111/j.1539-6924.2005.00694.x

The 2003 Heat Wave in France: Dangerous Climate Change Here and Now

Marc Poumadère,[1,2]* Claire Mays,[1] Sophie Le Mer,[2] and Russell Blong[3]

In an analysis of the French episode of heat wave in 2003, this article highlights how heat wave dangers result from the intricate association of natural and social factors. Unusually high temperatures, as well as socioeconomic vulnerability, along with social attenuation of hazards, in a general context where the anthropogenic contribution to climate change is becoming more plausible, led to an excess of 14,947 deaths in France, between August 4 and 18, 2003. The greatest increase in mortality was due to causes directly attributable to heat: dehydration, hyperthermia, heat stroke. In addition to age and gender, combinatorial factors included preexisting disease, medication, urban residence, isolation, poverty, and, probably, air pollution. Although diversely impacted or reported, many parts of Europe suffered human and other losses, such as farming and forestry through drought and fires. Summer 2003 was the hottest in Europe since 1500, very likely due in part to anthropogenic climate change. The French experience confirms research establishing that heat waves are a major mortal risk, number one among so-called natural hazards in postindustrial societies. Yet France had no policy in place, as if dangerous climate were restricted to a distant or uncertain future of climate change, or to preindustrial countries. We analyze the heat wave's profile as a strongly attenuated risk in the French context, as well as the causes and the effects of its sudden shift into amplification. Research and preparedness needs are highlighted.

KEY WORDS: Climate change; France; hazards; heat wave; social amplification of risk

1. GENERAL INTRODUCTION

The dangers of climate change could be conceived as using a purely mechanistic and linear model. In the case of a heat wave, unusually warmer weather would be the direct and simple cause of excess deaths among the elderly population. In the hot summer of 2003, 14,947 excess deaths were recorded in France for the period of August 4–18 (Assemblée Nationale, 2004). In this article, we suggest that societal and contextual variables are tightly linked and mediate the perception and impact of such a potentially hazardous climate event. The 2003 heat wave episode in France, with its high toll of victims, as well as other impacts, is analyzed from this perspective.

The physical nature of a heat wave itself is not unambiguous: several definitions of the term heat wave exist within the international meteorological community. Nor did the emergence of the catastrophe in France impose itself initially upon perceptions. The media limited their first reports of heat wave impacts to anecdotal accounts of everyday inconvenience to holidaymakers, while hospital emergency services gave the alert of high mortality with little effect. Alarming estimates were made by undertakers early in the unfolding of the heat wave, but were rejected by the government as inappropriate. Measurement and reporting of impacts, too, are subject to contextual

1 Institut Symlog, 262 rue Saint Jacques, 75005 France.
2 Ecole Normale Supérieure, Cachan, France.
3 Risk Frontiers, Macquarie University, Sydney, NSW 2109, Australia.
* Address correspondence to Marc Poumadère, Institut Symlog, 262 rue Saint Jacques, 75005 France; poumadere@wanadoo.fr.

0272-4332/05/0100-1483$22.00/1

influences. The comprehensive epidemiological study that was eventually conducted relies upon statistical comparisons with previous years' death rates, and upon analysis of the death certificates that specify the cause of death. It appears though that medical judgment has changed over time, evolving toward more frequent declaration of heat wave effects as the initial cause of death.

Socioeconomic factors such as poverty and isolation combined with age and illness augmented the death toll in specific sectors of French society. While some parts of the population (e.g., elderly women) appear particularly vulnerable, a large variety of impacts can be noted. Worldwide, heat wave is reported as the predominant cause of death resulting from so-called natural hazards in postindustrial societies.[4] Despite such data, however, the risk was not cogently addressed in French public policy until the aftermath of the 2003 episode.

The conditions producing such a strong social attenuation of heat wave risk in the French context have thus to be better understood. Heat wave changed status in 2003 from an underperceived risk to a here-and-now example of dangerous climate. We analyze this shift and highlight research needs for better understanding and, perhaps, better preparation to cope with other climatic risks should they too move from the "virtual" into the here and now. While it seems difficult to attribute any single event such as a heat wave to climate change (and therefore to human influence, rather than viewing it solely as a natural hazard), it has to be noted that the Intergovernmental Panel on Climate Change (IPCC) and others suggest that more frequent and severe heat waves are likely to occur. Average temperature in France has increased by 1°C since the beginning of the 20th century against 0.6°C for the planet overall. In that perspective, the 2003 heat wave provides an opportunity to explore how one nation addresses a severe heat wave, notably through the prism of social attenuation of risk and its consequences.

2. THE 2003 HEAT WAVE IN FRANCE

2.1. Unusual Weather Conditions

While intuitively we can relate to the term heat wave, there seems to be no international consensus on its scientific definition. According to the American Meteorological Society glossary, heat wave corresponds to a period of three consecutive days during which the maximum temperature is above the threshold of 32.2°C, but it is also defined more generally as "a period of abnormally and uncomfortably hot and usually humid weather" (AMS, 2000, p. 366). The U.S. National Service of Meteorology has proposed another definition: persistence for a period of at least 48 hours of daytime temperature above or equal to 40.6°C, associated with nighttime temperature above or equal to 26.7°C. As for French meteorologists, a heat wave is simply a period during which the maximum temperature goes beyond 30°C, while acknowledging that maximum temperature may vary by several degrees within a radius around the official recording station, and that humidity, air motion, and radiant energy also influence the heat stress upon human health that is observed during a heat wave.

So, certainly according to the French criterion, as well as those of several other countries,[5] what happened in France in the summer of 2003 fits the definition of a heat wave.[6] Meteorological reports cast that summer as France's hottest in 50 years. This record applies not only to the daily maximum (highest daily temperature, usually in the afternoon) but also the minimum (lowest recorded daily temperature, usually at the end of the night)[7] as recorded for the annual period of June 1–August 11. Maximum temperatures were noticeably hotter (>2°C) than those of the three prior recordholders (1976 with a maximum of 27.1°C, 1983 with 26.1°C, and 1994 with 26.3°C). Even more remarkable, during the 2003 heat wave, the lowest observed temperature (16.5°C) was 3.5°C hotter than the average lowest daily temperatures recorded (for the June 1–August 11 period) in France

[4] Postindustrial societies are those that, after a period dominated by industrialization, have undergone structural changes characterized by a dominant service sector and an increased use of information technology as an economic tool.

[5] In the United Kingdom, a heat wave corresponds to an increase of temperature by 4°C above the 30-year average for the place and month. The Royal Meteorological Institute in the Netherlands defines it as a period of at least five consecutive days during which the maximum temperature reaches 30°C. In South Australia, the state office of the Bureau of Meteorology, in an unpublished memo, defined a heat wave as a minimum of five consecutive days at or above 35°C, or three consecutive days over 40°C.

[6] Note, however, that the notion of "extreme temperatures" does vary considerably across the globe. Marble Bar, in northwest Australia, averages 154 days above 37.8°C (100°F) per year. Marble Bar holds the world record for extreme heat: a sequence of some 250 consecutive days measuring a maximum temperature of over 37.8°C under standard exposure conditions in 1923–1924 (Bureau of Meteorology, 2004). In this article, the terms "intense, extreme, or exceptional" are thus to be understood in reference to the French context.

[7] The elevated minimum temperature is significant in regard to health impact: persons vulnerable to heat need a recovery period (a relatively cool night) to limit harm.

during 1950–1980, and 1.4°C hotter than in 1994 (the second-ranking recordholder).

More than 70 French weather stations recorded record-breaking highs in the first 12 days of August 2003, of the 180 stations that together provide representative French coverage. From August 4, temperatures higher than 35°C were recorded at more than two-thirds of these weather stations. Temperatures over 40°C were found at 15% of the stations, unprecedented since 1873 (the beginning of weather record keeping in Paris). The only record unbeaten is that of the absolute (one-day) maximum temperature recorded on August 8, 1923, in Toulouse (44°C).

The gradual rise of maxima between August 1 and 5, 2003 (from a normal average of 24.8°C to a high of 37°C) was followed by a stationary period until August 13 of excessively high temperatures between 36°C and 37°C. August 11 and 12 stand out in this already unusual situation. On those two days the wind became very weak, increasing air pollution (a peak of NO_2 was observed in addition to the prior peaks of ozone, themselves particularly strong and durable during that period) and decreasing ventilation, thus augmenting the probability that this pollution would harm human health.

The 2003 heat wave continues to stand out when placed in a longer historical perspective. In his study of European climate variation during the "Little Ice Age" (between approximately 1370 and 1850), Le Roy Ladurie (2004) shows that a wealth of historical indicators can fill in for systematic measures and archives. Chuine *et al.* (2004) use a regional indicator, tracing harvest dates of *pinot noir* grapes over the centuries to estimate temperatures and demonstrate that 2003 was by far the hottest year seen in Burgundy. The temperature anomaly was +5.86°C, i.e., 43% greater than the anomaly hypothesized for the second hottest year: 1543 (+4.10°C). Luterbacher *et al.* (2004) estimate moreover that the summer of 2003 was the warmest in the whole of Europe since 1500. Throughout Europe in August 2003, only Andalusia (in Southern Spain) experienced a heat wave more severe than that of France.

2.2. Impact on Mortality

The intense heat wave was accompanied in France by a wave of short-term excess mortality of equally exceptional magnitude. A countrywide comprehensive epidemiological study was performed by the French National Institute for Health and Medical Research (Inserm; Hémon & Jougla, 2003, 2004). The excess mortality was assessed by comparing the numbers of deaths that occurred in August 2003 to a reference value (expected deaths; based on the average daily number of deaths observed during the months of July, August, and September of the three previous years, 2000–2002). Compared to other possible calculations of reference values and attribution of causes of death (cf. Hubert, 2003), this methodology has the advantage of being simple and robust. For the sole day of August 4, nearly 300 excess deaths were observed in comparison to the preceding years. The excess mounted in a regular and steep line to reach more than 2,000 deaths on August 12. From August 19 and for the subsequent week, mortality turned to normal daily levels. The cumulative number of excess deaths in regard to previous years was about 400 by August 4, 3,900 by August 8, 10,600 by August 12, and 14,800 by August 20, i.e., an overall excess of 60% in comparison to expected mortality (see Fig. 1).

The Inserm study finds that observed excess mortality is statistically significant starting with the age group 35–44 years for men (+27%) and 45–54 years for women (+23%). Excess mortality thus does not affect only the oldest population groups, although death ratios increase with age beyond 65 years to reach extreme values beyond 75 years: +85% for women aged 75 years and more, and +130% for women aged 95 years and more; +51% for men aged 75 years and more, and +85% for men aged 95 years and more. Persons over 75 years of age constitute 82.49% of the fatalities. The overall gender distribution is 64.25% for women and 35.75% for men (see Fig. 2).

Excess mortality was particularly heavy in the urban area of Paris and the four surrounding departments,[8] averaging some +150% (with a range of +127% in the city itself to +171% in the Val de Marne Department). A significant toll of excess deaths was observed for August 1–20 even in departments experiencing only a small number of days of heat wave. This excess was 52% in departments exposed to two to five days of extreme heat (i.e., >35°C maximum temperature) and higher in those exposed six or more days (+83%). The highest rates were observed in departments with a greater number of consecutive days of heat greater than 35°C. For example, overall excess mortality for persons over 75 years amounted to 1,200 deaths for nine consecutive days of heat over 35°C, with a progressive return to normal mortality as the maximum temperature sank to below 30°C. The number of deaths at home and in retirement homes doubled. Some two-thirds of the excess deaths took

[8] A department is an administrative territorial subdivision; there are about 100 in France.

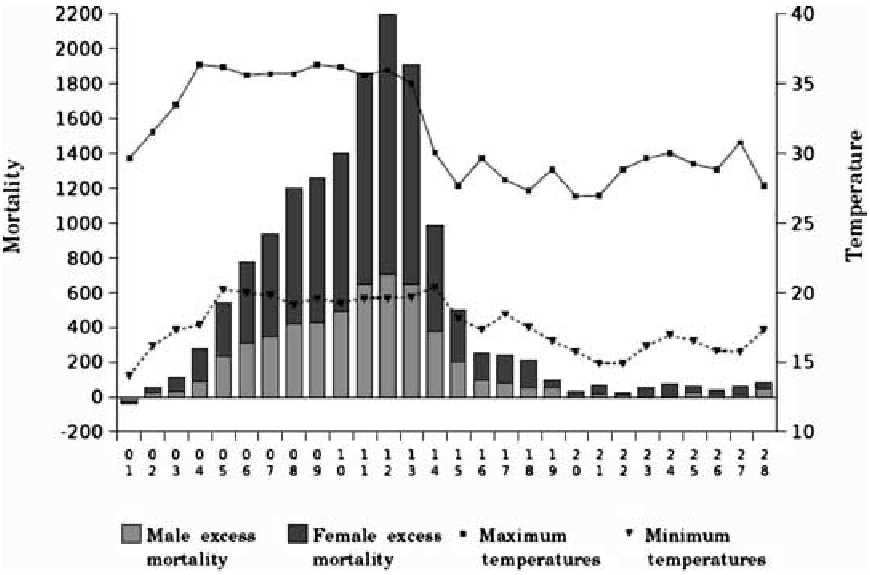

Fig. 1. Daily excess mortality and outside temperatures in France in August 2003.

place in institutions while one-third took place at home (see Fig. 2). Note that the original state of health of persons present in or transferred to institutions was variable and so the excess mortality cannot be linked directly to the place of death.

The causes of death are mentioned on the individual death certificates systematically established by physicians.[9] The greatest increases in mortality appear due to causes directly attributable to heat: dehydration and hyperthermia or heat stroke. The next causes of death that increased during that period were genital-urinary and respiratory illnesses. Unrelated causes of excess death included in the count (tumors, suicide, traffic accidents) show much more modest increases. A number of factors associated with the excess death rate act in a combined manner (age, preexisting illness such as heart disease, gender, medication, urban residence, duration of heat wave). Increased air pollution played a role as well. An epidemiological study conducted by the Health Monitoring Institute (InVS, 2004) over nine large French cities (Bordeaux, Lille, Lyon, Marseille, Paris, Rouen, Strasbourg, Toulouse, and Le Havre) estimates 379 excess deaths attributable to high concentrations of ozone during the period of August 3–17. Those concentrations in some places were 40% higher than the average of the previous years.

Mortality in France returned to its normal level starting August 19 and was maintained over the following months, both for the national population and for specific subgroups in which differential excess mortality rates had been observed (age groups, men and women, places of death, French regions), thereby ruling out a "harvest" effect.[10]

2.3. Socioeconomic Factors

The excess deaths mainly occurred in urban centers, such as the Paris area. The circumstances of death in isolation at home are portrayed by finely detailed data from the Institut Médico-légal[11] (IML; Lecomte & de Penanster, 2004). Four hundred and fifty-two persons who died at home in Paris from the heat wave, of a total of Paris home deaths of 919 (against 135 in 2002 during the same period) were transported to, and

[9] Hémon and Jougla (2004) report that the attribution of the cause of death by physicians establishing the death certificate during heat wave periods seems to vary over time. This observation, suggesting that "cause of death" judgments are sensitive to contextual factors, is significant in regard to our hypothesis of social attenuation of heat wave risk (see Section 3.2).

[10] A "harvest" effect would signify that the excess mortality observed during the heat wave in fact was due to the early death of persons who would have died in any case within several days, weeks, or months in the absence of a heat wave, thereby producing a subsequent drop below normal mortality rates.

[11] It is because the 450-body capacity of IML (Paris' forensic morgue) was overwhelmed by heat wave victims that the Ministry of Interior and the Paris police prefecture started to show concern. The IML faced a critical situation from August 10 to August 17, with massive arrivals and limited numbers of departures due to congestion of funeral homes. Note that the detailed IML data, discussed here to portray urban home deaths, are not statistically representative.

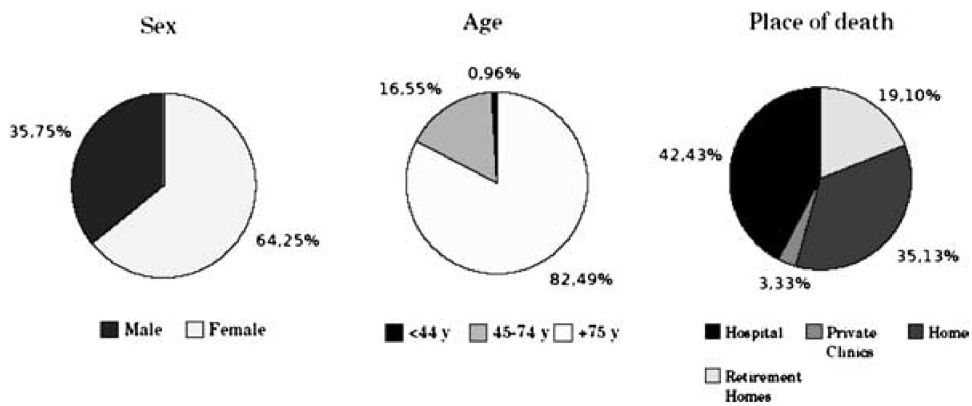

Fig. 2. Excess mortality distribution in terms of sex, age, or place of death in France, August 2003.

autopsied at, the IML. Friends or neighbors raised the first alarm in almost half of these cases. Otherwise, 24% of alerts came from family members, often those on holidays or not living in the city, who were alarmed by unanswered phone calls. Social workers and medical personnel alerted emergency services in 19% of the cases, with most remaining alerts being by concierges (building custodians). Of the victims, 92% lived alone and 41% resided in a one-room apartment, with a surface area of less than 10 m^2 in 12% of the cases. Just over half the victims lived on the two highest floors of Parisian buildings and, among them, more than one of three lived "under the roof in a room lit and ventilated by a skylight"—in other words, in traditional Parisian "service rooms"—commonly occupied by the elderly and by some of the heat wave victims younger than 60 years. In many reports, the primary response personnel (police, firemen) registered the "suffocating temperature where the bodies were found, between 36°C and 40°C."[12]

The IML accessed a social services file for 383 of the Parisian victims, of whom 337 lived alone. It was found that one of four had no family, friendly, or social link. Among the other three-quarters, links remained with the family (40% of cases), with neighbors or friends (33%), or with medical or social services (25%). It was also noted that 70% of the home victims had medical antecedents, particularly cardiovascular illness and/or psychological troubles.

[12] Compare to the Chicago 1995 heat wave (Klinenberg, 2002), characterized by the "urban heat island" effect (in which dark colored asphalt and concrete surfaces absorb and trap heat emitted from the sun, and the absence of vegetation and wind prevents cooling) and by the fact that living on the top floor multiplied mortal risk by 4.

This sample analysis of Paris deaths at home sheds light on specific socioeconomic factors that may be among the major determinants of lethal risk in the case of any heat wave in postindustrial urban contexts. Economic poverty is reflected in living conditions: victims at home are elders (or some younger than 60 years), in small to minuscule urban dwellings exposed to the sun and badly insulated. Social isolation is documented in many victims' limited human interaction. Ill health, both physical and psychological, completes the picture.

3. THE DANGERS OF HEAT WAVE BEYOND FRENCH BORDERS

3.1. A European Disaster

Several European countries experienced historic temperature peaks in August 2003, from 38.5°C (in England and Wales) to 47°C (in Portugal). UNEP (2004) and WHO (2004) report diversified heat wave death tolls across Europe. This diversity may be due to actual effects, or different national methods of reporting. Still, France stands out without a doubt as the country hardest hit, both in absolute numbers of deaths, and with a 60% excess above the expected mortality for the heat wave period. Only in France, so far, have full epidemiological investigations been conducted. There is controversy in at least one country (Italy) over a divergence between official and suspected figures. England and Wales report 16% excess mortality for August 4–13. Portugal experienced much higher temperatures but a surprisingly low increase in mortality (verified 26% augmentation in mortality) for the entire month of August (compared to the same period in the years 1997–2001). This nation set up a public health prevention service, in provision for future heat waves, for the City of Lisbon in 1999; excess mortality due to the 2003 heat wave here might be interpreted as the outcome of an interaction between the baseline climate of this country (relatively hot within Europe), the extremely high peak temperatures in 2003, and the preventive measures already in place in the densely populated capital. While figures have not been confirmed or updated for every European country, still the overall profile seen is one of a catastrophic death toll.[13]

3.2. Natural Hazards and Climate Change

A standard model in natural hazards research implies that preindustrial societies suffer large death tolls but other types of damage are more limited. As societies such as those in the EU, North America, and Australia move toward postindustrial economies, death tolls as a result of natural hazards impacts fall dramatically, but economic damage increases, equally dramatically (Burton *et al.*, 1978). Certainly, on a global scale, natural hazards deaths are concentrated in less developed countries. Since 1900 windstorms (including storm surges) have killed about 12 million, drought about 10 million, and flood nearly 7 million people, according to the CRED (Center for Research on the Epidemiology of Disasters) database. While we may question some of these death estimates, the CRED database records only 65,000 deaths globally from extreme temperatures (presumably high and low temperature extremes) in the same period, roughly two orders of magnitude less than the deaths recorded for tropical cyclones and related windstorms, droughts, and floods.

However, nearly 95% of the human deaths resulting from natural hazards in postindustrial societies (as opposed to globally) recorded by CRED are attributed to extreme temperatures. Similarly, Posey (1980) reported that heat waves kill more U.S. residents than hurricanes, tornadoes, lightning, and floods combined. In Australia, a fairly intense effort at counting human deaths in natural hazards reveals that heat waves have killed more than any other single hazard type (Blong, 2005).

Heat wave deaths thus dominate the records of postindustrial countries; these data suggest that heat waves provide an exception to the general model of low natural-hazards-related death tolls in such societies.

Extreme events, too, dominate the record. An example is provided by European-settled Australia, where nearly half of all heat-related deaths have occurred in just 11 years. More than 50% of all natural-hazards-related building damage in Australia in the 20th century was produced by 1.8% of the events in the Risk Frontiers (2004) database of Macquarie University, Sydney.[14] Without high-quality records it is difficult to make similar assertions for other countries, but all the anecdotal evidence emphasizes that natural hazard deaths and damage are dominated by the tolls exacted in just a few events.

Global climate change research focuses on future events representing serious threats for humanity, characterized by several levels of uncertainty (e.g., nature of the events, trends and nonlinearity, timing). The role of anthropogenic activity since industrialization, notably through the concentration of greenhouse gases, is a source of controversy around the nature and the extent of its impact on the complex climatic system (Bard, 2003). While accounting for all factors that contribute to climate change remains a challenge, Stott *et al.* (2004) estimate with a confidence level > 90% that human activities since 1851 have more than doubled the risk of a heat wave such as the 2003 European occurrence. The dangers of climate change are themselves undergoing a process of definition (Dessai *et al.*, 2004; Lorenzoni & Pidgeon, 2004).

Some researchers establish links between moderate climate change (e.g., observed temperature variation) and the frequency of more extreme meteorological events (e.g., for Europe, wind storms, heat waves). The IPCC report (IPCC, 2001) considers it likely that global climate change will be accompanied by an increase in the frequency and intensity of heat waves. The World Meteorological Organization considers that the trend has already started (WMO, 2000). An increase by 88% of heat waves in the United

13 Beyond the other UNEP or WHO reports mentioned here, UNEP (2004) reports 7,000 deaths in Germany, 4,200 in Spain, 1,400 in the Netherlands, 150 in Belgium. Varying figures are now claimed for Italy: 7,659 excess deaths by the Italian National Institute of Health (ISS, August 2004); some 12,000 estimated by Sant'Egidio Community Hospital, San Gallicano, Rome, on the basis of numbers published by the Italian National Institute of Statistics (ISTAT).

14 Events recorded (by Risk Frontiers, the industry-funded natural hazards research center at Macquarie University) include human deaths and damage to the built environment resulting from nine natural perils: tropical cyclones, bushfires, floods, wind gusts, tornadoes, hailstorms, earthquakes, landslides, and tsunami. Data on over 5,000 hazard occurrences are integrated.

States in the period 1949–1995 is reported by Gaffen and Ross (1998). Stott *et al.* (2004, pp. 612–613) affirm that "under unmitigated emissions scenarios, [. . .] by the end of this century [. . .] 2003 would be classed as an anomalously cold summer." Dessai (2002, 2003, p. 37) in his study of heat stress and mortality in Lisbon over the period 1980–1998 states that: "Global environmental change, in particular climate change, will have adverse effect on public health. The increased frequency/intensity of heat waves is expected to increase heat-related mortality and illness." The August 2003 heat wave over Europe gives meaning to that prediction with a tragic here-and-now reality.

4. HEAT WAVE RESPONSE IN FRANCE: A SHIFT FROM ATTENUATION TO AMPLIFICATION

4.1. Social Attenuation and Amplification of Heat Wave Risks in France

Heat wave health impacts in urban areas of the Western world are well documented. Extensive analysis is provided by Whitman *et al.* (1997) and Klinenberg (2002) for the 1995 Chicago heat wave. Several cases of heat wave occurrences have been analyzed in Europe: 1987 in Athens (Katsouyanni *et al.*, 1988), 1994 in Belgium (Sartor *et al.*, 1995), and 1995 in Great Britain (Rooney *et al.*, 1998). These stress the unequal social impacts of these events. Two recent international literature reviews of heat wave health impacts are available, one of them in French (Besancenot, 2002; Basut-Samet, 2002). Besancenot (2002) identified over 1,000 publications on heat wave health impacts (most in English; eight in French). He stressed the need for risk-based prevention of premature deaths, taking into account differential vulnerability (most threatened are older women of low socioeconomic status), and insisted on the "absolute urgency" of such risk prevention in the perspective of global warming. This advice was not heeded before the 2003 heat wave, but France's 2004 "Plan Canicule" (see Section 4.2) is largely built upon Besancenot's risk prevention approach.

Scientific knowledge regarding the dangers of heat waves is thus largely available, both at the international level and in the French context. Similar knowledge is being translated into local action and used as a basis for risk prevention decisions and communication. For instance, a co-author of an epidemiological study of the July 1983 heat wave over the City of Marseilles (Thirion *et al.*, 1992), currently director of the public health unit at Marseilles University Hospital, gave a press conference at the Town Hall on July 8, 2003 providing preventive medical advice for different age groups. The impact of the 2003 heat wave in Marseilles was limited to 25% excess deaths (in contrast to some 150% excess deaths in the Paris area).

On the level of organizational preparedness, the case of a retirement home with 135 permanent residents in Cachan, Val de Marne (south of Paris) is noteworthy. The director formulated a set of risk prevention measures for activities, ranging from medical procedures to catering and maintenance tasks, and including behavioral advice to patients and staff (Association Monsieur Vincent, 2004). Whereas the Val de Marne Department overall experienced the highest level of excess deaths in France (+171%), this retirement home lost only one severely handicapped patient to the heat wave.

More local examples probably could be found of a successful risk-based preventive approach to the 2003 heat wave in France. However, the elevated death toll shows that such knowledge integration and effective action remained rare. This suggests that among public health issues heat wave has been a socially attenuated risk (Kasperson *et al.*, 1988; Renn *et al.*, 1992; Pidgeon *et al.*, 2003) for much of French society, including risk management professionals in the public and private sectors. A further indication is given by the fact that reanalysis of 50 years of historical data, prompted by the 2003 calamity, allowed Inserm (Hémon & Jougla, 2003) to identify 6,000 excess deaths in France for two weeks in the summer of 1976 (+30% over the prior three-year average). These excess deaths had never before been identified, although the data had been available for 27 years.[15]

Diverse explanations might be advanced for the reasons behind this social attenuation. Risk perception surveys show generally that technological risks are preeminent over natural hazards (Slovic, 2000). Heat waves can be perceived as a normal part of the summer, a holiday period associated with warmer weather. Given the social characteristics of the most vulnerable groups (elderly, isolated, sick, poor), a stigma effect (Goffman, 1963) and tendency toward rejection likely exist in France where, as in most parts of the Western world, the polar opposites of youth and well-being are idealized. Cross-cultural research

[15] The 1976 heat wave did not go unnoticed, but attention focused upon French farmers' agricultural losses, to the point that the Parliament voted an exceptional "drought tax" to help them out.

has identified particularly high levels of trust and fatalism in French public attitudes toward health risks (representative national survey of 1,500 French and 1,500 U.S. residents; Slovic *et al.*, 2000). The French (at 68%) were about three times more likely than U.S. residents to agree that "decisions about health risks should be left to the experts." More than twice as many (79%) agreed that "I feel I have very little control over risks to my health." Similarly, the French agreed more than the Americans that "[w]hen there is a really serious health problem, the public health officials will take care of it. Until they alert me about a specific problem, I don't really have to worry." Health professionals themselves may have been caught up before 2003 in an attenuation process: according to Hémon and Jougla (2004), physicians establishing death certificates in 2003 declared heat wave effects (dehydration and hyperthermia or heat stroke) as the initial cause of death more often than for previous heat waves (e.g., 1976), thus significantly changing the normative structure of medical causes of death. On the larger level of French political and administrative traditions, Porter (1995) insists on the elitist attitude of secrecy and a reluctance to share quantified information.

All these factors may have contributed to the social attenuation of heat wave risks that prevailed in France until the shift that occurred during the 2003 episode. They also help to explain observations suggesting that eminent public figures such as the Prime Minister and Minister of Health thought it appropriate to attempt to maintain the 2003 event in a state of attenuation. As the public health catastrophe began to emerge in August, instructions were given to limit dissemination of death numbers. Alerts given by overwhelmed hospital emergency personnel were caricatured as corporatist claims. The grave nature of the situation was denied by government. The official count of fatalities[16] soon lagged behind reports from undertakers, who provided an early and accurate estimation of the alarming number of deaths by simple comparison with their previous year's numbers. In official press statements, blame was placed upon various others: general practitioners absent on holidays, families, and French society at large lacking in solidarity with elders,[17] the previous government who reduced the working week from 39 to 35 hours (thereby rendering hospital personnel unavailable). The concept of a "harvest" effect was also introduced (not confirmed by subsequent records; see Section 2.2). Last, but not least, government attempted to divert attention with a media decoy, proposing to eliminate a bank holiday as a "social solidarity" decision.[18]

It must be noticed that this governmental effort took place during a short span of time throughout which the outcome in terms of attenuation or amplification was initially uncertain. Perceptions could swing either way, and the government was apparently optimistic as to its chances of overcoming the political and social crisis. But the disaster was too large, and some amplification stations too powerful. Media attention was first attracted by events such as forest fires or inconveniences to vacationers, but then focused on human casualties as the major consequence of the heat wave.

When the perception of the heat wave disaster in French society resolutely shifted away from attenuation, government rapidly adapted to respond to the amplification.[19] Administrative reports were ordered from health, internal affairs, social, and elder services and commissions were named in the National Assembly to shed full light on the event. The General Director of Health was dismissed, and the Minister of Health eventually resigned. A risk prevention and response plan was ordered by the government to be ready before summer 2004.

4.2. France's "Plan Canicule"

The decision to engage a thoroughgoing heat wave risk prevention policy for France was made by the Prime Minister when it became clear that the

16 The government chose to rely upon a thorough analysis of all death certificates, which combine medical and administrative legitimacy, rather than considering readily available statistical estimates.

17 Research conducted by Attia-Donfut and Segalen (1998) indicated that intergenerational solidarity is still a dominant characteristic of French society.

18 This tentative diversion attracted neither much attention nor opposition. As the measure came into effect in 2005, opposition is heard from many quarters, with unions questioning the effective link between the lost Monday holiday and supposed benefits to social programs. The paid holiday was officially eliminated, but the observed tendency was to conserve it: large enterprises granted it anyway, employees of some public administrations were granted leave of absence without question to spend their long weekend away from their desk, and in education, school-by-school decisions were made as to open or not. Although full-page newspaper advertisements placed subsequently by government vaunted the number of initiatives funded by the lost holiday, intergenerational solidarity was hardly the dominant theme in discussions over this measure perceived as hitting restaurant and hotel businesses particularly hard.

19 A high point of amplification was reached in the quality press when the national daily *Le Monde* stated on the front page of its September 10 issue that summer 2003 was the deadliest in France since the end of World War II.

amplification process could not be reversed. Based notably upon reports by Inserm and the National Assembly, a "Plan Canicule"[20] was prepared in a relatively short time and presented by the Ministry of Health in May 2004 (Ministry of Health, 2004). The objectives are structured around three principles (responsibility, prevention, and solidarity) and the roles of different individuals and institutions. Four levels of alert are defined (vigilance, alert, intervention, requisition), and three accompanying measures are described (count at-risk persons, create cooled rooms, support emergency medical services and personnel). As of 2004, the alert scheme is activated from June 1 to October 1 each year.

A total of 486 million Euro were budgeted for 2004–2008 to be distributed over the national hospital system, with a special Summer 2004 Emergency Commission to "assure that no administrative delay slows the distribution" of the plan (Ministry of Health, 2004, p. 5). What this windfall for the usually tightly funded hospital system is to be spent on, or how that is to be determined, is not mentioned. Nurses were to "benefit" from removal of a ceiling on their overtime so as to assure the "efficiency" of healthcare in case of crisis (p. 5). Clearly, this part of the plan relies explicitly on the goodwill and physical stamina of nursing professionals. By removing institutional safeguards that prevent these individuals from working unlimited amounts of overtime, however, it would appear rather to jeopardize their efficiency and overlook the more fundamental need—already a subject of professional concern, independently of the heat wave—to plan for sufficient staffing during the summer period.

However, Lagadec (2004, p. 169) emphasizes with regret that the national exercise planned to test the plan in July 2004 was cancelled. He highlights the "extraordinary number" of actors that would have had to be involved, and infers that future crises of similar character will require a "huge effort" of pluralistic coordination that France, lacking an integrative risk culture, may be hard pressed to achieve.

5. DISCUSSION AND CONCLUSIONS

A continuous period of elevated day and night temperatures during the first half of the month of August 2003, far more intense than what is usually observed in the French climatic context, led directly to almost 15,000 deaths, an excess of 60% over expected mortality for the period.

This event bears out what research has already identified, i.e., that heat waves are a major mortal risk, number one among so-called natural hazards in postindustrial societies. In France, the elderly, especially women, were most vulnerable, but excess mortality was observed even for men in the 35–44 years age group (23% excess). Strong correlations appear as well with urban living conditions, poverty, isolation, and ill health. Thus, heat wave is confirmed as the silent killer of mute victims, unveiling social inequalities in the face of risks (Klinenberg, 2002).

We have seen that several definitions of heat wave exist among the international community of meteorologists. Some rely upon absolute temperature thresholds for day and night temperatures, while others consider relative excess above past averages. Duration is another factor. However, based upon the French experience, heat waves may be seen as an event that brings the dangers of climate into the here and now (in contrast to future and uncertain concerns, and to other distant parts of the world, i.e., less developed countries). Among those dangers, direct fatalities are foremost, but a large span of impacts must be considered.

Further research could bear on heat wave as a systemic risk (e.g., OECD, 2003) as clearly it qualifies for this description: complex, characterized by open system boundaries, second-order uncertainty, and controversy. The administrative and political division of Europe into different countries is swept aside in the case of heat wave: high temperatures easily jump formal borders and victims are to be found in many countries. Grave impacts, direct and indirect, immediate and delayed, are to be found not only in the area of health, but in farming, forestry,[21] glacier

[20] *Canicule* is the French word for heat wave, from Latin; in English a related term is found in "dog days," a sultry part of the summer supposed to occur during the period that the Dog Star, Sirius (or Canicula) rises at the same time as the Sun, variously reckoned between early July and early September.

[21] Reports by UNEP (2003, 2004) sum 647,069 hectares burned in a total of more than 25,000 forest or brush fires in Portugal, Spain, Italy, France, Austria, Finland, Denmark, and Ireland. Portugal was the worst hit with 390,146 hectares burned, destroying 5.6% of its wooded area. Delayed impacts of drought and fire may include soil erosion and flooding. Drought also weakens trees and makes them more vulnerable to disease and insects. The 146-year-old oak in Guernica, Spain, symbol of Basque freedom, had survived the civil war bombings of April 1937. Weakened for years by a fungus, the tree finally succumbed the following spring to damage sustained in the 2003 drought (*Le Monde* and *El País*, April 23, 2004), adding this symbolic impact to the long list of losses.

volumes,[22] water supply, energy supply, and technological operations,[23] to mention but these. Heat wave as a systemic risk includes a tradeoff between vulnerabilities: for instance, while the population vulnerability in Europe can be lowered by increased use of air conditioning (Kovats, 2004), the energy production system itself can be vulnerable to heat wave (see note 20). The effects of heat wave are felt across the economy. In December 2003, UNEP considered the European heat wave to be the world's most costly weather-related disaster for the year, with agricultural losses alone estimated at over $10 billion.[24] While the large variety of impacts is evident, their full extent and their systemic interaction remain unknown, perhaps forever.

Most of the phenomena involved in the 2003 heat wave in Europe are well known and understandable: the immediate causality of the persistent Azores anticyclone (Black *et al.*, 2004) leading to heat unusual in duration and intensity (difficult to predict on a seasonal basis; André *et al.*, 2004); sociodemographic influences on excess mortality; extensive impacts on the environment and human activities. However, the causal chain between unpredictable physical events and their impact on, for instance, human health is constructed ex post and does not take into account the interaction of so-called natural hazards with other variables in a societal context. We suggest that the complex links between physical and social levels blur perceptions of risk, contributing to its social attenuation and rendering more difficult the evaluation of consequences. A notable indication of the blurring effect was the absence in France prior to 2003 of any systematic knowledge-based risk prevention approach to heat waves; the Plan Canicule set up after the 2003 heat wave reveals how little had been done before. Lagadec (2004, p. 1) bluntly states that people were "killed by an unprecedented heat wave phenomenon and the system's incapacity to meet this lethal event," and points to the cultural factors underlying the bureaucratic management fiasco. A second indication of blurring is that the public health impact of a heat wave can go totally unnoticed; this was the case with France's 1976 heat wave: 6,000 excess deaths were discovered 27 years after the fact. The 1976 heat wave was collectively defined not as a fatal event, but as economic damage suffered by farmers.

The 2003 heat wave in France also showed how a shift in the perception of a risk can occur: while previously socially attenuated, heat waves became an unambiguous danger. As the public health catastrophe became undeniable, the heat wave emerged as a here-and-now example of dangerous climate, hitherto denied in the French context. In the short term, policy making was affected in such a way that the thorough Plan Canicule was made ready in record time.

The consequences of interactions between hazards and societal factors are numerous and critical for research in the area of risk analysis and climate change. Research should assess how various groups, including risk assessors, downplay the dangers of so-called natural hazards, not as an individual or professional choice but as an unquestioned attenuation embedded in their roles or cultural experience. One should also verify if present risk policies are structurally influenced by these phenomena in such a way as to indirectly downplay the risks from such hazards. As a European disaster, the 2003 heat wave affected a large and densely populated area, but its impacts were not homogeneous. Contextual factors and local risk prevention policies should be investigated through comparative studies to identify different modes of anticipating and coping with such a climatic event (cf. Poumadère *et al.*, submitted; Tol *et al.*, in press).

The 2003 heat wave in France may have long-term consequences on climate policy making as well as on general attitudes, such as distrust toward politicians. Will the amplification of heat wave risk observed in 2003 (revealed, for instance, in concerns expressed and links made with climate change issues) prevail in France? Or will the underlying cultural factors that shaped the original attenuation predominate? This point is crucial both in terms of risk prevention and adaptation, for research today (see Section 3.2) further demonstrates the contribution of human activities to climate change. While it is difficult to attribute any single event to global warming, the research cited

22 Alpine glaciers lost 5–10% of their volume (Grazzani *et al.*, 2003).

23 Heightened energy demand and unfavorable environmental operating conditions (rivers too hot and water levels too low to assure coolant) led Electricity of France (EdF) in August 2003 to request temporary exemption of agreed operating parameters for one-third of the French nuclear park (16 reactors out of 58). Nuclear power stations, which generated some 85% of France's electricity in 2003, had to operate at a much reduced capacity, and EdF (Europe's main electricity exporter) cut its power exports more than half. The heat wave episode revealed a series of vulnerabilities in nuclear power production; so much so that the French safety authority ASN (2004) considers that the climatic situation could be repeated and recommended augmenting nuclear plant ventilation, installing air conditioning, and the creation of monitoring and alert systems.

24 For instance, with reference to 2002 figures, more than 23 million tons of cereal production were lost in the European Union

points to a notable increase in the risk of even hotter summers in the future. In this context, monitoring national evolutions regarding social amplification and attenuation of dangerous climate change and its consequences may contribute to identify opportunities for, and constraints to, adaptation.

ACKNOWLEDGMENTS

A first version of this article was presented by invitation at the International Workshop on "Dangerous" Climate Change (Norwich, June 28–29, 2004) organized by the Centre for Environmental Risk, University of East Anglia, and the Tyndall Centre for Climate Change Research. Thanks are offered to organizers Prof. Nick Pidgeon and Dr. Irene Lorenzoni, to the participants of the workshop, and to three anonymous reviewers who provided insightful comments.

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