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Temperature related mortality and ambulance service interventions during the heat waves of 2003 in Ticino (Switzerland)

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Summary

Objectives: This study investigates a potential increase in mortality and in the demand for ambulance emergency services among the elderly in particular, in Ticino in the summer of 2003.
Methods: Mortality rates and emergency ambulance interventions rates were compared with records from the previous years. We considered the whole population, aged 65 and over, as well as 75 and over.
Results: The 2003 mortality in the population was not significantly different from the previous years. The number of deaths among the elderly showed a small but significant deviation from the expected values during the first heat wave in June 2003, with no significant impact on the seasonal results. The number of ambulance service interventions was larger than during the previous years.
Conclusion: These results are consistent with findings in other studies. The heat waves (especially in June), were correlated with a higher number of ambulance callouts. In addition to some geographic, climatic, and social factors that had a protective impact, the response of the emergency services is likely to have contributed to a certain reduction in mortality.

Keywords: Heat – Mortality – Ambulance services – Elderly people – Switzerland – Ticino

The year 2003 was characterized by heat waves that were described as "hardly believable" by MeteoSwiss, the national weather service. All around Switzerland and at any given altitude, temperatures were over averages from May till September, with temperatures that had not been recorded since 1864, when systematic meteorological data recording started. As in many other places, most of the records were broken in the southern part of the Alps: the hottest summer, the hottest day, the hottest August, the hottest semester, as for about any other combination of different months, the number of summer and tropical days, and the hottest night.

If the weather conditions in Switzerland and in Ticino were exceptional, one should keep in mind that the values recorded remained far below other European countries such as Spain, Italy, or France, the zone of maximal anticyclonic influence.

During the summer of 2003, informal contacts established with the local public health authorities and the hospital network, as well as the homes for elderly people and the ambulance service network did not reveal any unusual trend, apart from the latter who reported an increase in emergency runs. A controversy about a potential increase in mortality among the elderly followed in the local media for the ensuing12 months. It was often based on a rough comparison with the data of 2002. When the definitive mortality data became available in mid 2004, the department of public health decided to investigate a potential increase in mortality during the summer of 2003, with a particular focus on the elderly (mortality and emergency medical service runs).

The link between environmental temperature and mortality has been documented for some time, as has the phenomenon of seasonal variation of mortality (Conn et al. 1946). A number of studies have shown that the relation between environmental temperature (where more often than not the mean is taken, but the use of minima or maxima does not induce major changes) and mortality shows, roughly speaking, a U, V, or a J-shape (Curriero et al. 2002), with a range of mean temperatures corresponding to a minimal mortality centred around 20 °C to 25 °C in southern Europe, 16.5 °C in the Netherlands, around 15.8 °C in North Finland, and from 26 °C to 29 °C in Taiwan (Alderson 1985; Kunst et al. 1993; Mackenbach et al. 1993; Pan et al. 1995; Keatinge et al. 2000).

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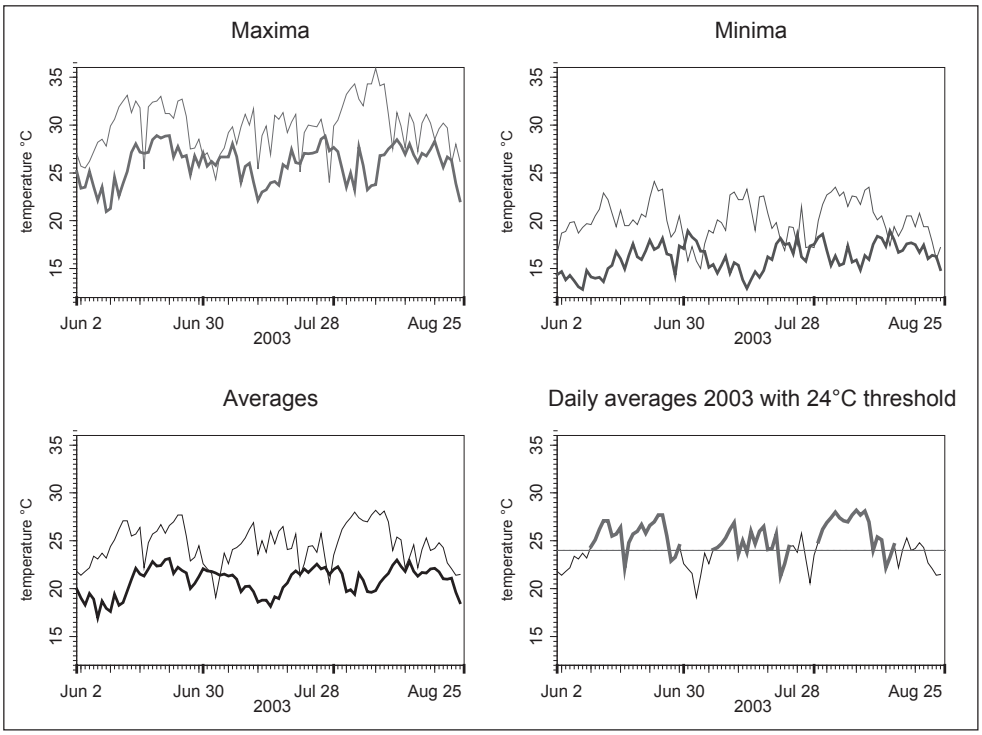

Figure 1 Distribution of the temperatures in Lugano (Ticino, Switzerland), the larger urban area, during the summer 2003 (thin lines) and averages of the three previous years (thick lines).

One of the first difficulties that arises when one tries to study the impact of heat waves on mortality is the capacity to define the heat wave itself and its duration. When they can be found, definitions of heat waves vary from a country to another.

A heat wave can be followed by a significant increase in mortality when compared with the seasonal averages. In 2003, this phenomenon was observed in several European countries (Hémon and Jougla 2003; Centers for Disease Control and Prevention 2004; Conti et al. 2004; Vandentorren et al. 2004). As a general trend, the mortality rate rises rapidly as soon as the heat wave starts and reaches a maximum 24 to 48 h after the first peak of temperature. Then the rate seems to decline more or less slowly, regardless of the temperatures observed. Spring or early summer heat waves probably have a more severe impact than the ones that happen later in the summer (Wolfe et al. 1999)

Most deaths attributable to heat waves could be avoided if an adequate alert system were properly defined, but prevention efforts are in fact difficult to put into practice because the time lag between exposure and potential death is very short. However, weather forecasts can provide a lead time of a few days and most current weather-warning systems are based on such forecasts.

Contrary to what could be expected, there is little literature about the impact of heat waves on ambulance service runs, and more generally on morbidity. Weisskopf et al. (2002) reported a link between heat related emergency medical service runs and heat related mortality, and showed that public health preparedness and response may significantly contribute to reducing both phenomena. Kovats et al. (2004) pointed out that there is no clear evidence of a relation between total emergency hospital admissions and high ambient temperature, though there is evidence of a heat related increase in admissions in the 75+ age group for respiratory disease.

Our aim in this study was to investigate whether the heat waves of 2003 had a significant impact on mortality, on the seasonal mortality results and on the demand for ambulance emergency services, especially among the elderly (65+ and 75+ age groups).

Materials and methods

The canton of Ticino (2004 pop. 317 300, 2 813 km^2) is located in the south of Switzerland, on the southern slope of the central Alps, bordering on Italy. Though largely a mountainous region, Ticino embraces the Ticino River valley and part of Lago Maggiore and of the Lake of Lugano, so that a large majority of the population lives slightly above sea level (altitude of 200 m to 300 m).

We considered mortality (source: Swiss Federal Statistical Office) and emergency ambulances service interventions in Ticino for the summer months of 2000 to 2003. Ambulances

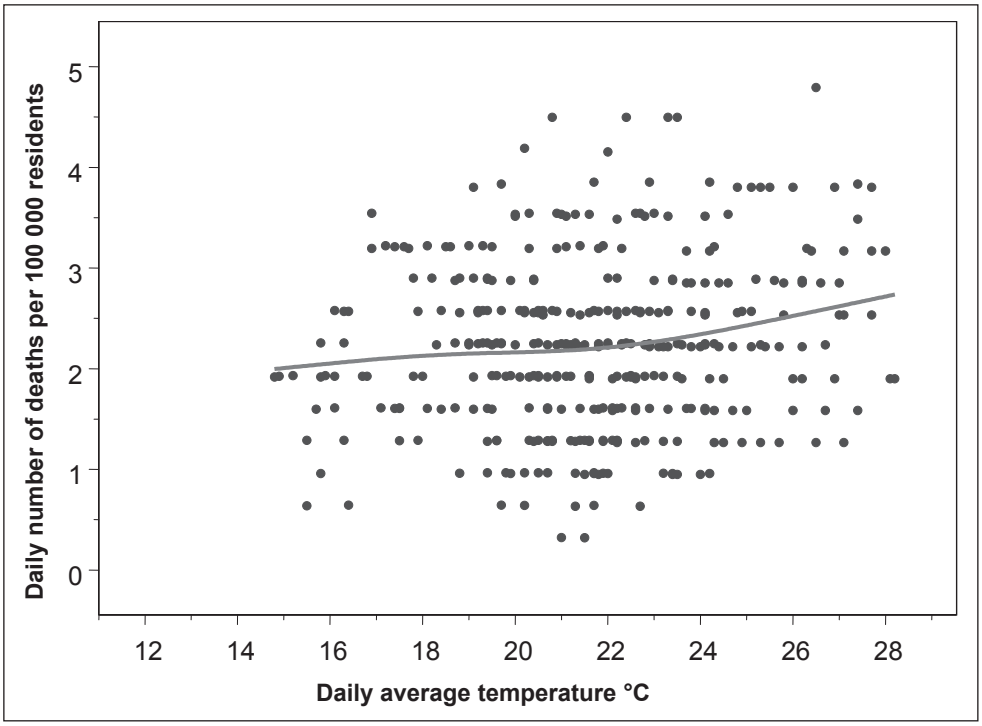

Figure 2 Scatter plot* of the overall daily mortality rate in Ticino (Switzerland) per 100 000 residents and average daily temperature in Lugano for June, July, and August 2000 to 2003.

* The continuous curve was obtained using cubic spline fitting (Hamming 1973).

service data (source: Cantonal Federation of Ambulance Services) was available for 2001 to 2003 only.

Three groups were considered for the analysis: the whole population, the elderly aged 65 and over and the elderly aged 75 and over. The analysis was initially focused on the elderly, thus ambulance services data was made available only for the 65+ and 75+ age groups.

In order to define a threshold temperature value for the heat waves, we plotted the daily average temperatures and daily mortality for the summer periods of 2000 to 2003, and estimated a risk curve with cubic splines. The temperatures reported in Lugano (source: MeteoSwiss) were used as it is the largest urban area of Ticino with about 118 000 residents.

A slight bend around 23 °C to 24 °C of the risk curve can be visually seen on Figure 2, and seems to indicate an upward mortality trend for temperatures higher than this point. We thus chose the value 24 °C so as to be conservative in identifying risk periods. From a geographical point of view, this value is also consistent with the upper bound of some minimum mortality ranges estimated in Europe with 22.0 °C in the Baden Württemberg, and 25.7 °C in Athens (Keatinge et al. 2000).

We defined as heat waves any period corresponding to the following criteria: average daily temperature over 24 °C during three days or more, without falling below this threshold for more than one day, including the three days following the end of the wave. The latter criterion was motivated by the literature: mortality usually decreases slowly after the period of high temperature. Indeed, the documented cases of Chicago (1995) or Athens (1987) both showed a return to usual mortality values three days after the decrease in temperature (Besancenot 2002).

The software S-PLUS® 6.2 was used for the descriptive and analytic evaluation of the data presented in this paper. Historical daily data from 2000 to 2002 (summer months) was used to estimate the mean of a Poisson distribution. An estimated 95 % prediction intervals for the results of 2003 was derived from this model. Assuming an α-level of 5 %, any observed value lying outside the 95 % prediction interval was said to differ significantly from the corresponding expected value. The number of deaths and the number of ambulance interventions were standardised before analysis using the target population on December 31st of the previous year, so as to take into account both the population increase and the population ageing phenomena. In other words we used the daily rates per 100 000 as input for the analysis rather than the raw numbers of deaths or interventions.

Results

For the summer of 2003, the analysis did not show any observed mortality above the 95 % predictive intervals for the overall population, the 65+ and the 75+ age groups.

Three heat waves were identified when we applied the cri-

Period	Mean Temp	Observed Mortality O	Expected Mortality E	95 % Prediction interval	Ratio O/E
June 2003	24.8 °C	239	212	161–264	1.13
July 2003	23.9 °C	216	219	167–272	0.99
August 2003	25.1°C	210	219	167–272	0.96
Heat waves:					
9 to 30 June	25.6 °C	187	156	111–200	1.20
8 to 26 July	24.7 °C	135	134	93–175	1.01
2 to 20 August	26.2 °C	140	134	93–175	1.04
Total heat waves	25.5°C	462	424	352–497	1.09
Total Summer 2003	**24.6 °C**	**665**	**651**	**561–740**	**1.02**
Summer 2001	**21.2 °C**	**672**			
Ratio 2003/2001		0.99			
Adjusted ratio[a]		0.98			
Summer 2002	**21.3 °C**	**646**			
Ratio 2003/2002		1.03			
Adjusted ratio[a]		1.02			

[a] with a correcting factor to control the population increase effect

Table 1 Mortality observed in the overall population of Ticino, Switzerland, (n = 315 616), expected values and comparison with years 2001 (n = 311 397) and 2002 (n = 312 963)

teria defined in the previous section: from June 9th to June 30th, from July 8th to July 26th, and from August 2nd to August 20th.

Within the overall population, an increase that is not significant was observed during the first heat wave, in June (187 deaths versus 156 expected, see Table 1).

Among the 65+ age groups, no specific abnormal trend or value was detectable on Figure 3. This observation is confirmed by the results displayed in Table 2: the monthly data or the whole summer period (558 versus 550 expected) did not show a mortality rate with a significant deviation from the natural variations usually observed. However, we observed a significant excess of deaths (16 %, 152 versus 131 expected) for the first heat wave.

The conclusions are almost identical for the 75+ age group, for which results are displayed in Table 2 (443 versus 437

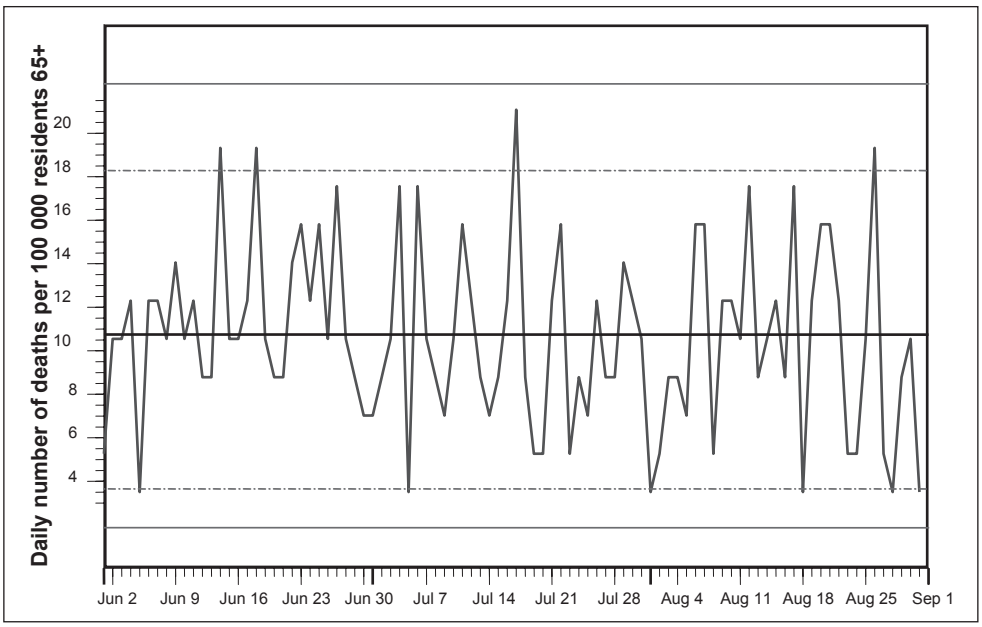

Figure 3 Daily mortality rate* per 100 000 residents of the 65+ age group in Ticino (Switzerland) from 1st June to 31st August 2003.

* The median, the 5 % and 95 % quantiles, and the 1 % and 99 % quantiles are represented with a central continuous line, dashed lines, and the two extreme continuous lines. They were calculated with the observed values during the same periods from 2000 to 2002.

Period	Observed Mortality O		Expected Mortality E		95 % Prediction interval		Ratio O/E	
	65+	75+	65+	75+	65+	75+	65+	75+
June 2003	196	**157**[b]	179	143	159–200	130–155	1.09	1.10
July 2003	184	145	185	147	165–206	134–160	0.99	0.99
August 2003	178	141	185	147	165–206	134–160	0.96	0.96
Heat waves:								
9 to 30 June	**152**[b]	**117**[b]	131	105	114–149	94–116	1.16	1.11
8 to 26 July	110	86	114	90	97–130	80–101	0.96	0.96
2 to 20 August	119	94	114	90	97–130	80–101	1.04	1.04
Total heat waves	381	297	359	285	330–387	267–303	1.06	1.04
Total Summer 2003	**558**	**443**	**550**	**437**	**514–585**	**415–459**	**1.01**	**1.01**
Summer 2001	**555**	**445**						
Ratio2003/2001	1.01	1.00						
Adjusted ratio[a]	0.99	0.93						
Summer 2002	**544**	**418**						
Ratio 2003/2002	1.03	1.06						
Adjusted ratio[a]	1.01	1.04						

Table 2 Mortality observed in the 65+ age group (n = 56920) and the 75+ age group (n = 27077) in Ticino, Switzerland, e xpected values and comparison with years 2001 (n = 54709 and 25832 respectively) and 2002 (55813 and 26471 respectively)

[a] with a correcting factor to control the population increase effect
[b] out of the 95 % prediction interval

expected for summer 2003). A significant excess of deaths (11 %, 117 versus 105) is observed for the first heat wave.

Regarding the ambulance service interventions among the 65+ age group, a rather long period in June was singled out in Figure 4. The shape of the graph for the 75+ age group was almost identical (not displayed in this paper). During this period, the number of interventions is above average, and even reaches peaks never recorded before.

Significantly higher than expected values of ambulance call-outs for the 65+ age group were observed for the first heat wave, (234 versus 155 expected, +51 %, see Table 3), for the third heat wave (156 versus 134 expected, +16 %), for the

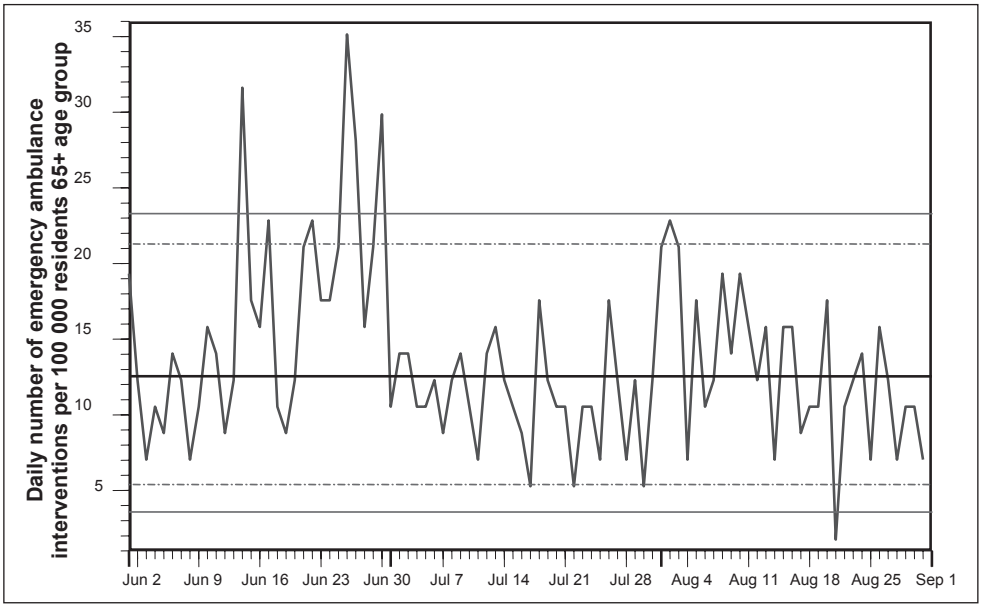

Figure 4 Ambulance service interventions* per 100000 residents of the 65+ age group observed in Ticino (Switzerland) from 1st June to 31st August 2003.

* The median, the 5 % and 95 % quantiles, and the 1 % and 99 % quantiles are represented with a central continuous line, dashed lines, and the two extreme continuous lines. They were calculated with the observed values during the same periods in 2001 and 2002.

Period	Observed Number of Interventions O		Expected Number of Interventions E		95 % Prediction interval		Ratio O/E	
	65+	75+	65+	75+	65+	75+	65+	75+
June 2003	**286**[b]	**186**[b]	211	140	189–233	127–153	1.36	1.33
July 2003	195	136	218	145	196–241	132–157	0.89	0.94
August 2003	230	154	218	145	196–241	132–157	1.06	1.06
Heat waves:								
9 to 30 June	**234**[b]	**149**[b]	155	103	136–174	92–114	1.51	1.45
8 to 26 July	121	84	134	89	116–152	78–99	0.90	0.94
2 to 20 August	**156**[b]	**105**[b]	134	89	116–152	78–99	1.16	1.18
Total heat waves	**511**[b]	**338**[b]	422	280	391–454	262–297	1.21	1.21
Total Summer 2003	**711**[b]	**476**[b]	**648**	**429**	**609–686**	**407–451**	**1.10**	**1.11**
Summer 2001	**614**	**395**						
Ratio2003/2001	1.16	1.21						
Adjusted ratio[a]	1.11	1.13						
Summer 2002	**644**	**434**						
Ratio 2003/2002	1.10	1.10						
Adjusted ratio[a]	1.08	1.07						

[a] with correcting factor to control the population increase effect
[b] out of the 95 % prediction interval

Table 3 Ambulance service interventions observed in the 65+ age group (n = 56920) and the 75+ age group (n = 27077) in Ticino, Switzerland, expected values and comparison with years 2001 (n = 54709 and 25832 respectively) and 2002 (55813 and 26471 respectively)

cumulated period of the three heat waves (511 versus 422 expected, +21%), for June (286 versus 211 expected, +36 %), and for the whole summer period (711 versus 648 expected, +10 %). As shown in Table 3, the conclusions remain almost unchanged for the 75+ age group.

A complementary analysis was carried out regarding the reasons why ambulances were required, when available (2001 to 2003, n = 1779, missing data 9.3 %). The first case histories recorded showed an increase in the distribution of sudden indispositions (58 % of the callouts during the three heatwaves of 2003 versus 51 % for the other days, p-value chi square test 0.0134). Unfortunately, no data was retrieved regarding the outcome for every patient.

Discussion

The mortality in Ticino during the summer of 2003 turned out not to be significantly higher than expected, though the observed values were slightly above the predicted values.

When reduced to a simple but less informative comparison with 2002, mortality shows variations of +2 % for the overall population, +1 % for the 65+ age group, and +4 % for the 75+ age group, namely +3 %, +3 %, and +6 % for the rough data, not standardized by the target population (see Tables 1 and 2). These increases all remain within a natural variation range, usually equal to a few percentiles, and are not comparable with the increase observed in large urban areas in France (Vandentorren et al. 2004) or Italy (Conti et al. 2004) during the same period.

These results are in line with the preliminary data published by the Swiss Federal Statistical Office in November 2003, reporting an increase in mortality exceeding the natural variations only in Geneva and Basel, and with the analysis made by Grize et al. (2005).

We observed however, excess deaths among the 65+ and 75+ age groups (+16 % and +11 %) during the first heat wave in June 2003, with no significant impact on the summer 2003 results. There is also weak evidence that there were excess deaths among the whole population during the same period (+20 %). This supports the idea of a more severe impact of early summer heat waves (Wolfe at al. 1999). Provided that we did not have to deal with another confounding event, we may assume that a slight harvesting phenomenon was observed, which could have anticipated the death of rather "young" people suffering from chronic or disabling diseases, and not sufficiently aware of being exposed to increasing risk. Some population adaptation also probably occurred throughout the summer.

The number of ambulance services interventions was larger than expected, especially in June: +36 % for the 65+ age group, and + 33 % for the 75+ age group. Since no other particular phenomenon that could have had a significant impact on pub-

lic health in Ticino was reported during this period, we may ascribe this rise in interventions to the heat wave. Kovats et al. (2004) have raised the hypothesis that many heat related deaths occur in people before they come to medical attention. The absence of evidence of linear correlation between emergency ambulance runs and mortality in June 2003 (0.23 for the 65+ age group, p-value 0.226; 0.22 for the 65+ age group, p-value 0.233) contrasts with the study of Weisskopf et al. (2002) for Milwaukee. This could suggest that Ticino faced an intermediate situation, which was close to being critical, during the first heat wave of June 2003. We might thus assume that the reaction of the emergency medical services was adequate in Ticino.

But one can rightfully raise the question of more efficient prevention measures that could have reduced the workload of the emergency ambulance services. Unfortunately the data recorded does not allow us to properly assess the question, but Weisskopf et al. (2002) showed that it is also possible to reduce emergency medical service runs with changes in public health preparedness and response.

A literature review (Basu and Samet 2002; Besancenot 2002; O'Neill et al. 2003) shows that some demographic groups are exposed to higher risk factors: children under 12 months, elderly people over 60, 65, or 70 depending on the studies, people living in urban central areas, people engaged in heavy labour, lower social classes. Behavioural risk factors include living alone, being confined to bed, using tranquillisers, suffering from mental disease or alcoholism, not leaving your home at least once a day, or living on the higher floors of multi-storey buildings.

Among the factors that have not allowed us to conclude on a significant excess of deaths during the summer of 2003, we may identify:

- the heat waves themselves that did not reach such extreme values as those observed in France or in Italy: the maximum temperatures were not as high as in France, humidity always remained low, and night temperatures were high but not excessive;
- the almost Mediterranean climate that characterizes Ticino when compared with the other Swiss cantons, and consequently a population more prepared for heat waves;
- the absence of large urban areas that would create an "urban heat island" with elevated temperatures, especially at night;
- the social and cultural environment, especially the social cohesion of Ticino, where family and neighbourhood links are still well developed, thus reducing isolation and risk among the less socially integrated population; and
- a home assistance service that can be called with a simple remote control (TeleAlarm) which is rather widespread over the territory, though a comparison with other regions regarding this factor would be necessary.

Finally, we know that the ozone related mortality may be enhanced when the temperature reaches a given level (Sartor et al. 1995) that is, both effects do not just simply add up. Because ozone levels remained lower than the levels of many European urban areas (in Lugano the alert threshold of 240 µg/m^3 was never reached and the information threshold of 180 µg/m^3 was reached 18 times), we may assume that part of the effects seen for morbidity and mortality can be attributable to high ozone levels, but that a serious interaction, which would have multiplied these effects, did not happen in Ticino.

In the event of a heat wave, an alarm procedure system should rely on scientific evidence. The current procedure used in Ticino, defined by the Health and Environment Operative Group [see www.ti.ch/ in Italian] might in the future, consider integrating a local specific association model between temperature and observed mortality, based on a longer period of observation than the one considered in this paper. Precision is indeed important in this field since full heat response plans increase costs and can generate an undesirable "crying wolf" effect (Weisskopf et al. 2002).

Among the limitations of the present study, one should mention that the total mortality was considered for the analysis since the causes of death were not available, thus making the assessment of possible association with temperature less precise. In addition, the model used to estimate the expected mortality assumes that the mortality rate remains constant. If there were a negative long term trend in mortality, expected mortality for 2003 would be slightly overestimated.

The small number of years of historical data taken for the analysis did not allow us to fit a Poisson mortality evolution model to obtain an alternative estimate of the expected mortality defined according to the method presented above. Though not showing large discrepancies it seems however, that this method does lead to larger values of expected mortality (Hémon and Jougla 2003).

To conclude, there was a slight excess of mortality in the 65+ and 75+ age groups in Ticino during the first heat wave in June 2003, with no significant impact on the whole period of June–August 2003. This result is consistent with findings in other studies regarding Ticino (Swiss federal statistical office 2003; Grize et al. 2005). The reduced excess mortality in later heat waves indicates that some frail people probably died in earlier heat waves, and that some acclimatization in the population occurred.

The heat waves, especially in June, were correlated with the number of ambulance callouts, and could suggest that Ticino faced an intermediate situation, which was close to being critical.

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Zusammenfassung

Temperaturabhängige Sterblichkeit und Notfalleinsätze während der Hitzewellen im Jahr 2003 im Kanton Tessin (Schweiz)
Ziel: Die Studie untersucht, ob im Kanton Tessin während der Sommermonate 2003 ein Anstieg der Sterblichkeit und der Anzahl Notfalleinsätze, besonders unter der älteren Bevölkerung, zu verzeichnen war.
Methoden: Die Sterblichkeitsraten und Notfalleinsätze wurden mit den Angaben des Vorjahres verglichen. Dabei wurde die Gesamtbevölkerung in Betracht gezogen sowie die Altersgruppe der über 65-Jährigen und der über 75-Jährigen.
Ergebnisse: Die Sterblichkeit im Jahr 2003 variierte nicht signifikant gegenüber den Vorjahren. Bei der Gesamtbevölkerung wurde eine bedeutend höhere Sterblichkeit während der ersten Hitzewelle vom Juni 2003 beobachtet, ohne bedeutende Auswirkungen auf die Monats- und Saisonergebnisse. Die Anzahl der Notfalleinsätze war höher als in den Vorjahren.
Schlussfolgerung: Die vorliegenden Ergebnisse stimmen mit anderen Studien überein. Während der Hitzewellen (besonders derjenigen vom Juni) wurde ein Anstieg der Notfalleinsätze verzeichnet. Neben geographischen, meteorologischen und sozialen Aspekten, die eine schützende Wirkung hatten, war vermutlich auch der Einsatz der Notfalldienste für den Rückgang der Sterbefälle mit verantwortlich.

Résumé

Mortalité liée à la température et interventions des services d'ambulances durant les vagues de chaleur de 2003 dans le canton du Tessin (Suisse)
Objectifs: Enquêter sur une possible augmentation de la mortalité et de l'utilisation des services d'ambulances, en particulier pour les personnes âgées, durant l'été 2003 dans le canton du Tessin.
Méthodes: Les taux de mortalité et le nombre d'intervention des services d'ambulances ont été comparés avec les chiffres des années précédentes. L'étude a porté sur la population totale, sur les 65 ans et plus, ainsi que sur les 75 ans et plus.
Résultats: La mortalité de la population n'est pas significativement supérieure à celle des années précédentes. Les décès des personnes âgées mettent en évidence une déviation légère mais significative par rapport aux valeurs attendues durant la première vague de chaleur (juin 2003), mais sans impact sur les résultats saisonniers. Le nombre d'interventions des services d'ambulances a été supérieur à celui des années précédentes.
Conclusion: Ces résultats corroborent les conclusions d'autres travaux. Les vagues de chaleur (surtout celle de juin), sont en lien avec un nombre plus élevé d'interventions des services d'ambulances. Outre certains facteurs géographiques, météorologiques et sociaux qui ont sans doute eu un effet protecteur, la réponse des systèmes d'interventions d'urgence a probablement aussi contribué à une certaine réduction de la mortalité.

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