ORIGINAL ARTICLES

Surveillance report

THE EFFECT OF THE SUMMER 2003 HEAT WAVE ON MORTALITY IN THE NETHERLANDS

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In the Netherlands, between 1400 and 2200 deaths in the summer of 2003 may have been heat-related. The fact that the maximum temperatures were lower than in some other European countries, and occurred in less heavily populated areas, may have led to mortality figures that were relatively less dramatic. The temporarily increased death rates are only partly due to a forward shift of mortality. Heat-related mortality was most pronounced among the elderly in nursing homes.

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Introduction

Since the beginning of the 19th century, 33 spells of exceptionally warm weather in the Netherlands have been officially labelled heat waves by the Koninklijk Nederlands Meteorologisch Instituut (Royal Dutch Meteorological Institute). For this purpose, Dutch meteorologists use a definition that is, in view of the generally mild, maritime climate of the Netherlands, less demanding than those of countries at lower latitudes. A warm spell qualifies as heat wave if it consists of at least five days with a maximum temperature of 25°C or above, including at least three 'tropical' days with a maximum temperature of 30°C.

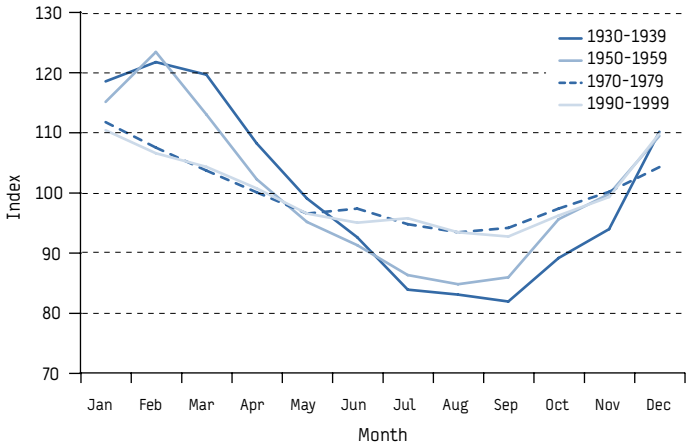
The summer 2003 heat wave amply satisfied these criteria: it lasted from 31 July to 13 August, a total of fourteen days, including seven tropical days, and it was preceded by four tropical days in mid-July. This earlier warm spell failed the heat wave requirements, as the tropical days were interrupted by a single cool day.

The recent heat wave is neither the longest, nor the hottest on record. Of the 33 heat waves on record, one lasted eighteen days (1975) and two seventeen days (1947 and 1976, the latter including ten tropical days). Nor did it break the record for the highest maximum temperature: the 7 August 2003 maximum of 35.0°C has twice been surpassed in the past century, with an all time high of 36.8°C in 1947.

The relationship between climate and excess mortality is a complex one. It can be represented in a V-shape, with the lowest all cause mortality rate in the Netherlands at an average daily temperature of 16.5°C [1]. As the average summer temperatures are much closer to this optimum than average winter temperatures, the mortality risk is normally below average in summer, and well above average in winter. As shown in Figure 1, the effect of climate on mortality has strongly decreased between the 1950s and 1970s, but does not seem to have changed significantly since then. This trend has only been influenced by climate change over the past century to a very minor extent. The indices in Figure 1 show the degree to which the monthly number of deaths in the relevant decade is higher or lower than the number that would be expected if deaths were spread evenly over the year (a value of 110 representing a 10% higher mortality). The lower summer indices in earlier periods are largely caused by the detrimental effect of cold weather, inflating the average mortality risk. In the Netherlands, as in all other countries with mild climates, annual cold-related mortality is higher than heat-related mortality [2].

FIGURE 1

Mortality risk (all ages and causes combined) by month, various periods (monthly average = 100)



Data, method of estimation and results

The Centraal Bureau voor de Statistiek (Statistics Netherlands) collects information on the cause of death for all persons who are considered official residents of the Netherlands. By linking this information to more detailed demographic data provided by the municipal population registers, it is possible to determine the various relationships between personal characteristics and cause of death. Unfortunately, this procedure is inappropriate for the study of heat-related mortality, both in the Netherlands and elsewhere. Even in unusually hot summers, very few deaths are directly or indirectly attributed to these external causes. In 2003, only four deaths were attributed to exposure to excessive natural heat (ICD-10 code X30,

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including hyperthermia, heatstroke and heat exhaustion) or to the effects of heat and light (T67) as a primary or secondary cause of death.

A common method for estimating the extent of excess mortality during a certain period involves the comparison with mortality rates in one or more earlier years. A drawback of this method is the fact that unusually low or high temperatures during these earlier periods affect the estimate and are difficult to adjust for. We therefore followed a different indirect estimation procedure that is independent of both mortality rates in earlier years and the official Dutch definition of heat wave.

We first calculated the average maximum daily temperature per month in the period June-September for the most recent 30-year period (June 19.8°C, July 22.1°C, August 22.3°C and September 18.7°C). The temperatures were those recorded by the Royal Dutch Meteorological Institute at De Bilt, which is located in the centre of the Netherlands.

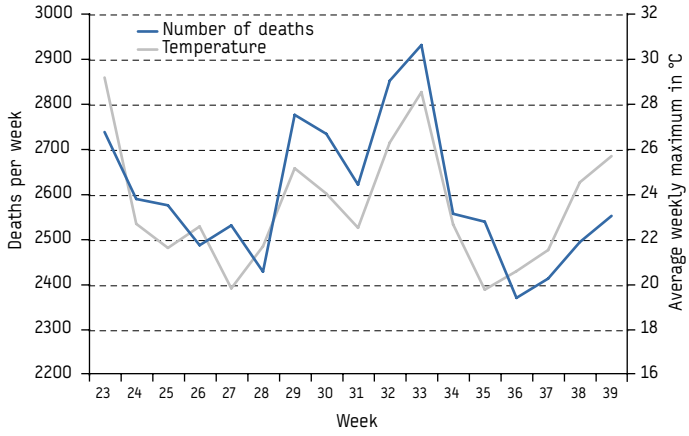
We then calculated the weekly averages of the daily maximum temperatures and carried out a linear regression analysis between the weekly temperature curve (independent variable) and the weekly mortality curve (dependent variable). A linear regression was considered appropriate because the period of observation is relatively short, and all temperatures were higher than the optimum temperature of 16.5°C. For the purpose of this analysis, weekly values were selected as the optimal trade-off between daily values (with high random fluctuations) and monthly values (in which variations in temperature tend to obscure the effect of hot spells). As temperature does not usually have an immediate effect on mortality, we estimated the average time lag between both variables by determining the best fit between the mortality and temperature curves.

Allowing for the resulting time lag of three days, we obtained an estimate of the regression coefficient of 33.5 deaths per week per degree Celsius [Figure 2] ($r^2 = 0.57$). The standard error (7.5 deaths per week per degree Celsius) was used to obtain a low estimate of the absolute number of heat-related deaths per degree Celsius (26.0) and a high estimate (40.9), with a two thirds probability. The total excess mortality in the period June-September 2003 was finally estimated at between 1400 and 2200 deaths, implying an increase of approximately 3% to 5% above the number normally recorded during this period. The number of excess deaths during the heat wave of 31 July – 13 August may have been around 500.

The effect of heat on mortality shows a strong increase with age (0-64 years $r^2 = 0.16$; 65-79 years $r^2 = 0.43$; 80+ years $r^2 = 0.65$).

Figure 2

Mortality and average maximum temperature per week, The Netherlands, June-September 2003



A numerical example illustrates the estimation procedure. Week 33 (11-17 August) had an average daily maximum temperature of 30.6°C, 8.3°C higher than the 30-year average for August (22.3°C). The estimated number of excess deaths is therefore 8.3 times 33.5 (the estimated regression coefficient), hence 278 deaths. The actual number of deaths during this week was 2826. This would imply that almost 10% of all deaths during this hot spell were heat-related.

Discussion

The effect of extreme temperatures on mortality has been demonstrated in numerous studies. Although the media regularly inform the public of this fact during episodes of exceptionally warm weather, public calls for action to prevent heat-related deaths have been rare in the Netherlands. Interest in the possible excess mortality in the Netherlands was largely fuelled by reports from France, where much higher temperatures resulted in about 15 000 heat-related deaths in August 2003 [3]. Considering the difference in population size between the two countries, heat-related mortality in France may therefore have been about three times higher than in the Netherlands.

As far as we are aware, the publication of this estimate prompted only a little activity to investigate the specific conditions that led to the excess mortality, and no large-scale public actions to prevent heat-related deaths in the future. The general feeling that the only victims of the extreme summer temperatures were very elderly and frail people who would anyway have died within a few weeks (this is sometimes referred to as 'harvesting') may partly account for this equanimity.

The Netherlands should not be complacent about taking actions to protect those at increased risk of heat-related mortality simply because excess mortality among the elderly was much lower than in a number of other countries, particularly France. Even if very high temperatures, unlike very low temperatures, result in 'harvesting', this cannot account for all the excess deaths. Some researchers have demonstrated a temporary fall in the number of deaths following a heat wave [4-7], but the findings of recent research on heat-related excess mortality in the Netherlands are less conclusive: a forward shift of mortality was found in some heat waves, but not in others [2]. The French heat wave mortality peak of 2003 was not counterbalanced by a trough in the remaining months of the year [3]. Figure 3, representing average and observed mortality among persons aged 80 years or above in the period May-November 2003, suggests that some forward shift may have taken place in the Netherlands, but this shift does not fully compensate the heat-related excess mortality.

FIGURE 3

Observed and expected number of deaths in patients aged 80 years or more, The Netherlands, May-November 2003

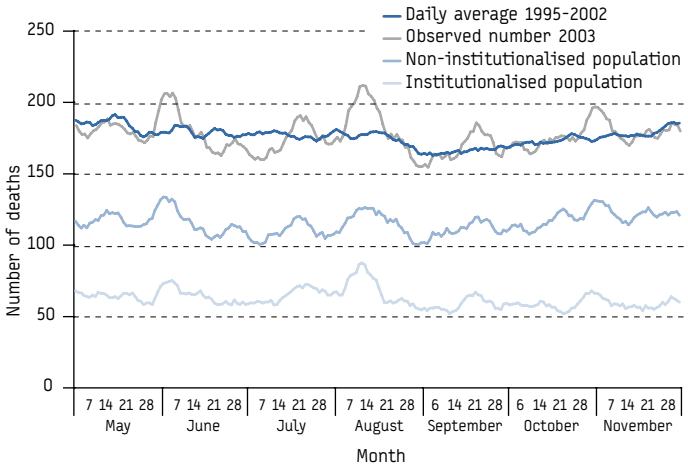
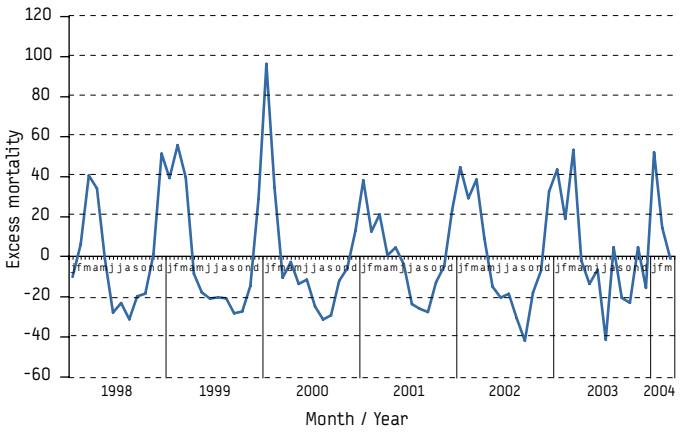


FIGURE 4

Difference between observed and expected daily number of deaths, per month, The Netherlands, 1998-2004



Also, above-average mortality during hot weather is most pronounced among the elderly, but not restricted to them. The observed number of deaths in August 2003 among persons aged 40-59 years was 11% higher than the expected number calculated on basis of data for the period 1995-2002. Mortality did not increase in the younger age groups.

The mortality figures of the Netherlands were less dramatic than those of France, but this may be because a smaller proportion of the population were exposed to extreme temperatures, and not because the Netherlands provides superior care for people at high risk. While the heat wave in France strongly affected the metropolitan areas (Centre and Ile-de-France), the maximum temperatures in the Netherlands were far lower than in France, and occurred in the relatively less densely populated regions. The absolute maximum temperature in the Netherlands was registered at the weather station of Maastricht, in the far southeast (36.2°C, as opposed to 42.6°C in Orange, France). In the far northwest, the highest value only once surpassed the 30-degree barrier (30.2°C in Den Helder). As the western coastal provinces are more densely populated than the eastern landlocked provinces, the lower temperatures in these provinces may have had a substantial downward effect on the overall mortality rates for the Netherlands. Compared to the average number of deaths in August for the period 1995-2002, the number of deaths in August 2003 was indeed 13% higher in all eastern provinces taken together (Groningen, Drenthe, Overijssel, Gelderland and Limburg). In the western coastal provinces (Noord-Holland, Zuid-Holland and Zeeland) the August 2003 mortality rate was 2% lower.

Therefore, even in a small country like the Netherlands, regional differences in climate contribute to evening out the harmful effect, measured at the national level, of hot weather on health. This effect, in absolute terms, is furthermore less noticeable, as the upward influence of heat waves takes place when the general mortality risk is lower than the yearly average. Therefore, even during the heat wave of 2003, the number of deaths in August was hardly above the number that would be expected if deaths were spread evenly over the year [FIGURE 4].

This does not mean that there is no need for policy actions, however, or for keeping a more watchful eye on particular risk groups. Among these risk groups are people suffering from dementia, who need to be prompted by others to take preventive measures in order to avoid dehydration and hyperthermia [8]. The lowest curve in Figure 3 shows that the effect of the August 2003 heat wave was more marked in the elderly in nursing homes than in the non-institutionalised elderly population. This institutionalised population has a much higher share of frail and demented persons than the non-institutionalised population.

References

1. Huynen MMTE, P Martens, D Schram, MP Weijenberg and AE Kunst. The impact of heat waves and cold spells on mortality rates in the Dutch population. Environ Health Perspect. 2001 May;109(5):463-70.
2. Keatinge WR, GC Donaldson, E Cordioloi, M Martinelli, AE Kunst, JP Mackenbach et al. Heat-related mortality in warm and cold regions of Europe, observational study. BMJ. 2000 Sep 16;321(7262):670-3..
3. Pison G. 60 million people in metropolitan France. Population & Societies 2004; 399:1-4.
4. Kunst AE, WNC Looman and JP Mackenbach. Outdoor temperature and mortality in the Netherlands: a time-series analysis. Am J Epidemiol. 1993 Feb 1;137(3):331-41
5. Eng H and JB Mercer. Seasonal variations in mortality caused by cardiovascular diseases in Norway and Ireland. J Cardiovasc Risk. 1998 Apr;5(2):89-95.
6. Rooney C, AJ McMichael, RS Kovats and MP Coleman. 1998. Excess mortality in England and Wales, and in greater London, during the 1995 heatwave. J Epidemiol Community Health.1998; 52:482-486.
7. Braga ALF, A Zanobetti and J Schwartz. The effect of weather on respiratory and cardiovascular deaths in 12 US cities. Environ Health Perspect. 2002; 110:859-863.
8. Mackenbach JP, V Borst and JM Schols, Heat-related mortality among nursing-home patients. Lancet 1997; 349:1297-1298.