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Air pollution related deaths during the 2003 heat wave in the Netherlands

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Abstract

In the Netherlands an excess of 1000–1400 deaths was estimated due to the hot temperatures that occurred during the 2003 summer period. We estimated the number of deaths attributable to the ozone and Particular Matter (PM_{10}) concentrations in the summer period June–August 2003. Our calculations show that an excess of around 400–600 air pollution-related deaths may have occurred compared to an 'average' summer.

These calculations suggest that in the Netherlands, a significant proportion of the deaths now being attributed to the hot summer weather can reasonably be expected to have been caused by air pollution.

Keywords: Air pollution; Heat wave; Deaths; Summer; Climate changes

Recently, the Dutch Central Bureau of Statistics (CBS) estimated that during the hot summer of 2003 (which included a 14 day heat wave in August), an excess of 1000–1400 deaths had occurred in the Netherlands compared what would have been expected in an average summer (http://www.cbs.nl/nl/publicaties/artikelen/algemeen/webmagazine/artikelen/2003/1275k.htm). The estimation was based on the correlation between temperature and deaths over several years of observations. Of the estimated 1000–1400 excess deaths due to the summer heat in the Netherlands, 400–500 were estimated to have occurred in the July 31–August 13 heat wave. In the UK and Wales (population about 52,000,000) Stedman (this issue) reported an excess of about 2000 deaths during the same period. This is not strikingly different, proportionally, from the numbers estimated for the Netherlands (population about 16,000,000) in the same period. In the UK, all time temperature records were broken with a maximum of about 38°C on many stations in the densely populated greater London area (http://www.met-office.gov.uk/climate/uk/2003/august.html). No records were broken in the Netherlands, and the highest temperature recorded at the centrally located station of De Bilt, which is close to the main cities in the west, was 35°C. The somewhat lower estimated number of heat wave related deaths in the Netherlands may have been due to the fact that temperature extremes were slightly lower than in the UK (http://www.knmi.nl/voorl/weer/).

Several studies have shown that daily variations in ozone and airborne particulate matter (PM10) are also associated with daily numbers of deaths (Hoek et al., 2000; Touloumi et al., 1997; Katsouyanni et al., 2001), after adjusting for the independent effect of high temperatures. Ozone is a photochemical air pollutant which is readily formed under warm and sunny conditions. It is therefore likely that during the last summer period also ambient ozone levels were elevated. Hot weather also tends to increase PM concentrations. Thus, part of the deaths attributed to high temperatures are conceivably caused by photochemical and particulate air pollution, acting alone or in conjunction with high temperatures.

We estimated the number of deaths attributable to the ozone and PM10 concentrations in the summer period

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Table 1
Estimated number of ozone- and PM_{10}-related deaths in the summers of 2000, 2002 and 2003 in the Netherlands

Period	Estimated number of deaths related to ozone	95% confidence interval	Estimated number of deaths related to PM_{10}	95% confidence interval
June–August 2000	990	700–1260	1290	640–1930
June–August 2002	1140	820–1460	1380	690–2060
June–August 2003	1400	1000–1780	1460	730–2180
Excess 2003 vs. 2000	410	380–450	160	70–260
Excess 2003 vs. 2002	250	220–290	80	−20–180

June–August 2003 and compared this with the estimated number of deaths for the same period in an average summer and for the previous year. We used the temperature adjusted relative risk for daily deaths and ozone or PM10 which we published in Hoek et al. (2000). We used a relative risk of $1\cdot074$ per $150\,\mu g/m^3$ for the 8 h average (between 12 and 20 h) ozone concentration with a 95% confidence interval of $1\cdot052$–$1\cdot096$, and a relative risk of $1\cdot104$ per $80\,\mu g/m^3$ weekly average PM10 concentrations (confidence interval $1\cdot050$–$1\cdot161$). Air pollution levels were obtained from 14 (urban) background measurements stations of the National Air Quality Network of the National Institute of Public Health and the Environment (RIVM). The measurements stations were distributed over the whole country. For our calculations we used preliminary ozone data which have not yet passed routine validation checks. However, based on careful inspection of the data and past performance of the Network, we do not expect that the results of our calculations will materially chance when the validated data become available. Average daily 8 h O_3 concentrations for the period June–August 2003 were $87\,\mu g/m^3$, compared to $71\,\mu g/m^3$ in 2002 and $61\,\mu g/m^3$ in 2000. Weekly average PM10 levels were $35\,\mu g/m^3$ (2003), $33\,\mu g/m^3$ (2002) and $31\,\mu g/m^3$ (2000). The year 2000, according to the Dutch Royal Meteorological Institute (KNMI), is the most recent year with 'average' summer weather based on temperature, precipitation and hours of sunshine (www.knmi.nl/voorl/kd/).

In Table 1 the results of the calculations are presented.

Our calculations show that in the Netherlands in the period June–August 2003, about 1400 people were estimated to have succumbed due to ambient ozone exposure and about 1460 due to PM10. As PM10 and ozone are varying independently of one another in summer (Hoek et al., 2000), these numbers can be added. This is some 8% of the total deaths in this 3 months period. For the same period in 2000 (in which no noticeable heat wave episodes have occurred) it is estimated that around 1000 people died due to the ambient ozone levels and 1300 due to PM10. This means an excess of around 400–600 deaths in 2003, compared to the average summer of 2000. The 2002 summer was also relatively hot, with higher ozone concentrations but only slightly increased PM10 concentrations, and the estimated number of air pollution-related deaths was also higher than in the year 2000.

These calculations suggest that in the Netherlands, a significant proportion of the deaths now being attributed to the hot summer weather can reasonably be expected to have been caused by ambient ozone and, to some extent, particles. As ozone concentrations tend to be high during hot summer weather in large areas of Europe, this reasoning likely applies to those other areas as well. The heat wave and smog period of 2003 were of longer duration than in the past. The relationship of mortality with temperature and ozone or PM10 from "normal" summers may not fully apply. An analysis from Athens suggests that high temperature and air pollution concentrations may also interact to produce a greater effect than each factor acting alone (Katsouyanni et al., 1993). The trend in temperature due to climate changes suggests that long-term periods with high summer temperatures are likely to occur more frequently than in the past. Further analyses of existing databases are indicated to establish the contribution of air pollution to excess deaths occurring in hot summers in more detail.

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