THE PREDICTED NUMBER OF AIR POLLUTION RELATED DEATHS IN THE UK DURING THE AUGUST 2003 HEATWAVE

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ABSTRACT

There was a major heatwave across much of Europe in the first two weeks of August 2003, during which temperatures peaked at a new record of 38.5 C in the UK. The UK Office for National Statistics have reported an excess of 2045 deaths in England and Wales for period from 4 to 13 August 2003 above the 1998-2002 average for this time of year. Here we estimate, using previously established dose-response functions, that there were between 423 and 769 excess deaths in England and Wales during the first two weeks of August 2003 associated with the elevated ambient ozone and PM_{10} concentrations. This represents 21 – 38% of the total excess deaths. This has implications for the mitigation of the health effects of heatwave conditions. It reinforces the advice to the public on keeping cool, reducing exposure to outdoor air pollutants and indeed possible measures to reduce atmospheric pollution. The predictions presented here could be verified by conducting a specific epidemiological study of deaths during this heatwave.

INTRODUCTION

There was a major heatwave across much of Europe in the first two weeks of August 2003, during which temperatures peaked at a new record of 38.5 C in the UK. The UK Office for National Statistics have reported an excess of 2045 deaths in England and Wales for period from 4 to 13 August 2003 above the 1998-2002 average for this time of year. Previous studies have suggested that a significant proportion of the excess deaths during heatwave conditions can be associated with the elevated concentrations of air pollutants rather than a direct effect of the high temperatures[6]. Here we use previously established dose-response functions to calculate the predicted number of air pollution related deaths in the UK during the August 2003 heatwave.

METHOD

Measurements of the ambient air concentrations of both ground level ozone and particulate matter (PM_{10}) are available from the UK's extensive monitoring networks (data are available from www.airquality.co.uk). Ozone concentrations measured using UV absorption analysers at 78 monitoring sites and PM_{10} (particulate matter of diameter less than 10 μm) concentrations measured at 53 monitoring sites using Tapered Element Microbalance (TEOM) instruments were used in this study. Measurement data from roadside monitoring sites were not included in the analysis. Air quality monitoring data are described as provisional when initially collected and are subsequently ratified up to six months after the initial collection, following monitoring site audits and detailed checking of the data. The final ratified monitoring data for August 2003 are not available at the time of writing (October 2003). Site audits and calibrations have, however, been completed and the monitoring data re-scaled as required so significant changes to the dataset on final ratification are not expected.

We have previously used a mapping based method to quantify the health effects of ozone concentrations in the UK in 1995[7]. The expansion of the number of monitoring sites in the UK since 1995 enables us to adopt a much simpler and rapid assessment approach.

The UK has been divided into a total of geographical 43 zones for air quality assessment within the EU 'Framework'[3] and subsequent 'Daughter' Directives[4]. We have the estimated population exposure to ozone and PM_{10} concentrations during the episode period by calculating the mean concentration across all monitoring sites in each zone. Concentrations have been compared with those measured during the same period in 2002 to provide an estimate of the excess above 'normal' concentrations in 2003. Concentrations during this period in 2002 were not elevated due to photochemical episodes and mean concentrations were close to typical mean values for this time of year. The population-weighted means of daily concentrations across the UK or across regions of the UK were than calculated using population estimates for each zone derived from the 1991 census. Figures 1 and 2 show the hourly ozone and PM_{10} measurements at the two sites that recorded the highest concentrations. The daily maximum of running 8-hour mean ozone concentration and the 24-hour mean of PM_{10} concentration are the metrics that have been used in the time-series epidemiological studies that provide dose response functions relating deaths brought forward with air pollutant concentrations[2]. Figures 1 and 2 also show these metrics for the two individual sites and the UK population- weighted means for both 2003 and 2002.

The peak running 8-hour mean ozone concentration during this period was 221 $\mu g\ m^{-3}$ at Lullington Heath in East Sussex. The peak 24-hour mean PM_{10} concentrations at sites not directly impacted by local industrial emissions was 62 $\mu g\ m^{-3}$ at London Bloomsbury. The population-weighted mean ozone concentration for the UK over the first two weeks of August was 103 $\mu g\ m^{-3}$ in 2003 compared with 58 $\mu g\ m^{-3}$ in 2002. Corresponding concentrations of PM_{10} were 29 and 16 $\mu g\ m^{-3}$. Concentrations of CO, NO_2 and SO_2 were not elevated above typical concentrations during the episode. Light winds brought the precursors of ozone and secondary particles from source areas in both the UK and continental Europe to the UK during the episode, as is typical of photochemical ozone episodes in the UK[8,9].

We have used an annual baseline death rate for the UK population of 1023.7 per 100,000 (derived from national statistics for 2001,[5] and dose response functions for deaths brought forward of 0.6% and 0.75% for a 10 $\mu g\ m^{-3}$ increase in ozone and PM_{10} concentrations respectively recommended by COMEAP[2]. It is generally accepted that there is no threshold for the health effects of particulate matter[2]. The evidence is less clear cut for ozone. We have therefore calculated the number of deaths brought forward by ozone for two cases, with thresholds for effect of 0 and 100 $\mu g\ m^{-3}$ as previously suggested[2]. An estimate of the number of deaths brought forward on each day has been calculated as the product of the pollutant concentration, the dose response function, the baseline death rate and the population in each zone.

RESULTS AND DISCUSSION

Tables 1 and 2 show the results of the analysis for the two ozone and PM_{10} calculations. The analysis suggests that there were between 225 and 593 additional deaths brought forward due to ozone and 207 due to PM_{10} in the UK during the episode in August 2003 in comparison

with the same period in 2002. The results for England and Wales correspond to 21-38% of the total reported excess deaths during the heatwave.

We have assumed that the effects of ozone and PM_{10} are independent and can thus be added together. The dose response coefficients that we have used have been derived from single pollutant models. There is therefore a possibility that our estimate includes some double counting because the coefficients from multi-pollutant models could be lower. A recent report from the WHO, however, suggested that adjusting for the effect of particles within short-term morality studies had little effect on the coefficients for the effect of ozone[10]. WHO also concluded that experimental studies show the potential of ozone itself to cause the observed effects on health. While episodes of high primary particle concentrations are not associated with the same type of weather conditions as photochemical ozone episodes, elevated secondary particle concentrations can occur at the same time as ozone episodes or independently[8,9,1].

Our results are broadly consistent with the estimates derived by Rooney[6] of approximately 190 excess deaths associated with ozone and 175 associated with PM_{10} during a five day photochemical episode in mid summer 1995. Similarly, an estimate of between approximately150 and 300 excess deaths associated with ozone in England, Scotland and Wales can be derived by comparing the results for this five-day period with those for the whole summer of 1995 in our previous study[7]. The range in results for ozone in our previous and this current study reflects the uncertainty as to whether there is a threshold for the effects of ozone. The air quality monitoring networks in the UK in 1995 included 32 sites for ozone and 16 sites for PM_{10}. The much expanded network of sites available for 2003 enables a more complete analysis to be carried out, without the need for complex interpolation models and the additional uncertainty associated with using data from a sparse network.

These results have implications for the mitigation of the health effects of heatwave conditions. They informs on the balance of advice to the public on keeping cool, reducing exposure to outdoor air pollutants and indeed possible measures to reduce atmospheric pollution. It should be emphasised that we have not attempted to relate actual deaths data during the August 2003 heatwave to air pollutant concentrations. The relevant data on deaths are still provisional at time of writing and not available on a regional basis. It would be interesting, however, to compare our predictions derived from the results of previous studies with the results from a specific epidemiological study of this period.

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	2003	2002	Difference
Scotland	83 (3)	64 (0)	20 (2)
Wales	67 (8)	43 (0)	24 (8)
Northern Ireland	28 (1)	21 (0)	7 (1)
London	212 (46)	88 (0)	124 (46)
Rest of England	959 (167)	541 (0)	418 (167)
UK	1350 (226)	756 (0)	593 (225)
England & Wales	1239 (222)	672 (0)	567 (221)

Totals may not add up due to rounding

Table 1. The number of deaths brought forward attributable to ozone during the first two weeks of August in 2003 and 2002 in the UK, threshold concentration of 0 $\mu g\ m^{-3}$ (threshold concentration of 100 $\mu g\ m^{-3}$).

	2003	2002	Difference
Scotland	23	20	4
Wales	22	9	13
Northern Ireland	7	6	2
London	85	42	43
Rest of England	334	187	146
UK	471	264	207
England & Wales	440	239	202

Totals may not add up due to rounding

Table 2. The number of deaths brought forward attributable to PM_{10} during the first two weeks of August in 2003 and 2002 in the UK.

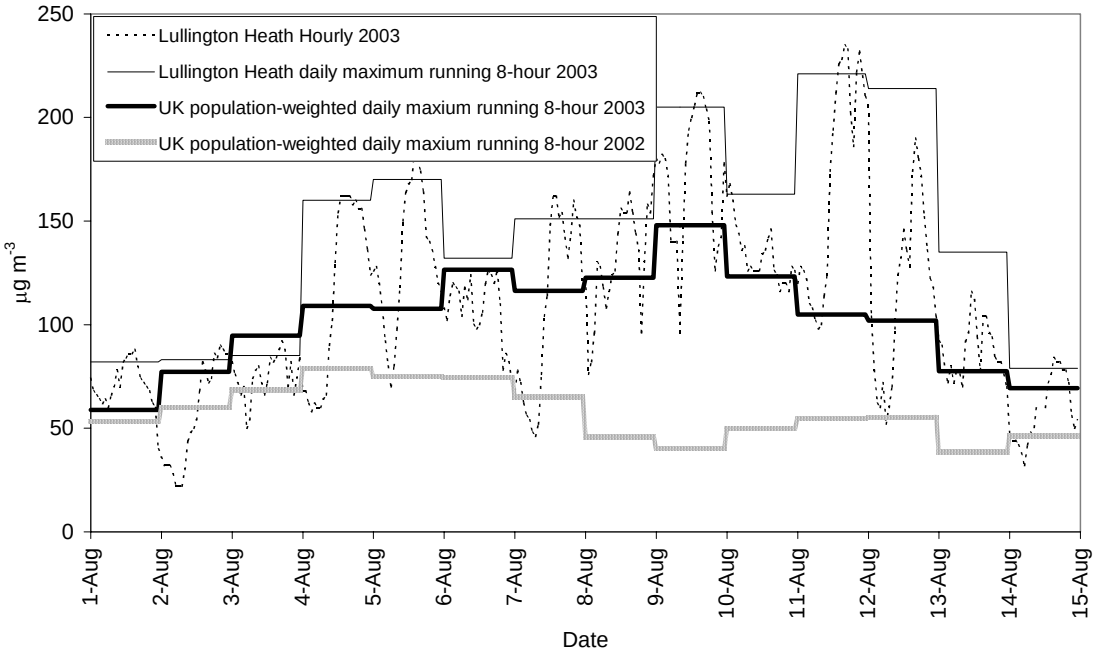

Figure 1 Ozone concentrations during the first two weeks of August 2003 and 2002

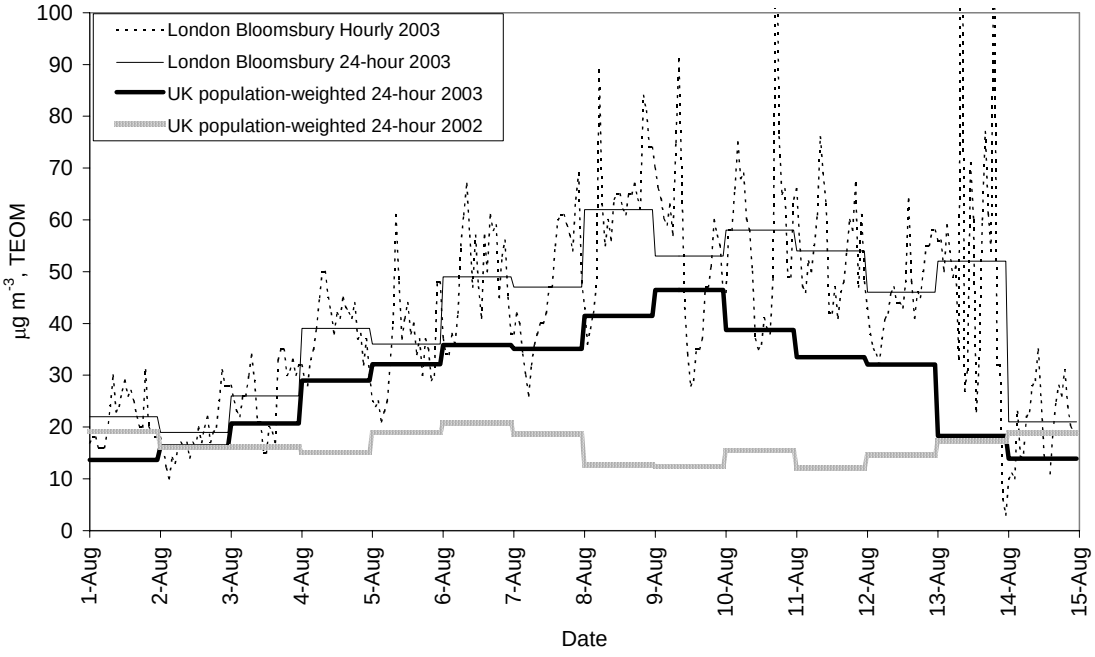

Figure 2 PM_{10} concentrations during the first two weeks of August 2003 and 2002