

Mortality and Morbidity in Birmingham during the 1976 Heatwave

F. P. ELLIS*, H. P. PRINCÉ*, G. LOVATT† AND
R. M. WHITTINGTON‡

*From the *Department of Medicine, Queen Elizabeth Hospital, Birmingham,
†Area Health Authority, Birmingham, and ‡Coroner's Court, Birmingham*

Accepted 10 July 1979

SUMMARY

The total deaths by day in Birmingham were analysed in relation to several weather variables from 24 June to 8 July, 1976 when the mean daily dry-bulb temperature remained continuously above 22 °C, and for the preceding and following cooler fortnights. The average number of daily deaths reported to the Registrar increased significantly by nearly 20 per cent during this hot fortnight and by over 30 per cent from 3 to 5 July. The excess deaths were mainly of elderly men and women with cardiovascular or cerebrovascular disease. The daily mortality correlated best with the maximum daily dry-bulb temperature and then with the mean temperature compared with the five other weather variables tested. The mean wet-bulb temperature on days one and three before death was the only measure of humidity tested to correlate significantly with daily deaths. The smaller number of these deaths which were also reported to the Coroner were analysed separately. There was a threefold and statistically significant increase during the heatwave in deaths of women aged 70 to 79, but deaths of men in this age group and of men and women over 80 did not increase. There was a notable increase in deaths from violence of men aged 20 to 39. Morbidity in the working population, judged by new sickness benefit claims, did not increase during the hot weather. There were significantly more hospital emergency admissions from 24 June to 8 July 1976 than for the same period in 1975 or 1974. Episodes of sickness in two large Birmingham general practices showed a modest increase.

INTRODUCTION

The summer of 1976 was the hottest and sunniest since daily records were instituted at the Edgbaston Observatory, Birmingham, in 1886, and probably the hottest in Central England for 250 years (Round, 1976). The British Broadcasting Corporation reported nearly 23 000 deaths in England and Wales in the first two weeks of the hot weather, whereas in the previous fortnight there were fewer than 20 000. 'Something like 200 people a day were apparently dying who would not have died if the weather had been normal' (Wilkinson, 1976). Deaths of geriatric patients at the University Hospital, South Manchester, increased threefold at the height of the heatwave (Lye and Kamal, 1977).

Correspondence to R. M. Whittington, Coroner's Court, Newton Street, Birmingham B4 6NE.

The deaths by day in Birmingham, the second largest city in Britain (estimated population, mid-1976, 1 061 800), were analysed to identify the age groups most at risk, the disease groups most affected and the relation of the daily deaths to the daily weather conditions. The related morbidity was also examined.

MATERIALS AND METHODS

The deaths reported to the Chief Superintendent Registrar of Births, Marriages and Deaths were tabulated by day of death and under broad disease categories which have been shown to be heat-sensitive, namely, ischaemic heart disease, other heart disease, cerebrovascular accidents, malignant neoplasms, respiratory disease, diabetes and perinatal deaths (Ellis, 1972; Schuman, 1972) and under 'all other causes of death and injury', for males and females 65 years of age and older and 64 and younger for the two weeks when the heatwave was at its height (24 June to 8 July) and for the two-week periods which preceded and followed the heatwave.

The deaths by day were analysed first in relation to the mean of the maximum and minimum daily dry-bulb temperatures which Rogot and his colleagues found to be the weather variable which correlated best with deaths from coronary disease (Rogot and Blackwelder, 1970; Rogot, 1973; Rogot, 1974; Rogot and Padgett, 1976).

Linear regression analysis was then carried out to examine the correlations between the total daily deaths and cardiac and cerebrovascular deaths and other measurements of thermal environmental change—the maximum and minimum dry-bulb temperatures, the mean wet-bulb temperature (recorded with the Stevenson screen), the mean humidity mixing ratio, the mean absolute humidity and the total hours of sunshine—on the day of death and for days one to five before death. The following equation was tested:

$$Y = BX + C$$

where Y is the dependent variable (daily number of deaths), X the independent variables (the seven weather variables on the day of death and the five previous days) and B and C are the calculated constants with their standard errors.

Ellis (1973) and Bridger, Ellis, and Taylor (1976) analysed deaths during a severe heatwave in Saint Louis, Missouri in July 1966 and found that the Coroner's reports provided a better assessment of deaths due to excessive warmth than the city's health reports. In Birmingham in 1976 the Coroner was notified of all sudden and unexpected deaths, when the attending doctor was uncertain of the cause or was otherwise unable to issue a death certificate and most deaths within 24 hours of admission to hospital. The Coroner's deaths for the same three periods, which are included in the Registrar's deaths, were therefore analysed separately by 10- or 20-year age groups, sex, marital or solitary status and the same disease groups as for the deaths reported to the Registrar.

Morbidity was examined by (a) the numbers of new claims by employed persons each week for sickness benefit reported by the Department of Health and Social Security for the West Midlands, which includes Birmingham, (b) medical and

surgical emergency admissions to the five main Birmingham Hospitals (c) heatstroke and heat exhaustion cases admitted to 31 hospitals managed by the Birmingham Health Authority and (d) episodes¹ of sickness in two large general practices in the Birmingham area which were included in the figures for 18 practices in England and Wales in 1976, abstracted from the National Morbidity Study by the Royal College of General Practitioners, the Office of Population Censuses and Surveys and the Department of Health and Social Security.

RESULTS

The heatwave. The heatwave was considered to have begun on 24 June when the mean ambient dry-bulb temperature was 22.3 °C (72.1 °F). It remained above 22 °C until 8 July, reaching 25 °C (77 °F) on 3 July, a record for continuous very hot weather for the city (Figure 1a). The differences between the average mean daily dry-bulb temperature during the heatwave (23.4 °C) and during the two-week periods which preceded (15.9 °C) and followed (17.5 °C) the heatwave were highly significant ($p < 0.001$, two-tailed significance using Student's *t* test).

Total daily mortality and mean daily dry-bulb temperature. The mean number of daily deaths from all causes between 24 June and 8 July was 32.7, which was significantly higher than the mean for the preceding two weeks, 27.4 ($p < 0.01$), but was not significantly different from the mean for the two weeks which followed the heatwave, 29.5 (Fig. 1a, b).

The majority who died were men and women who were 65 years of age or older, but the daily average of these deaths of the elderly during the heatwave, 22.2, was only marginally greater than for the two weeks before the heatwave, 18.9 ($0.05 < p < 0.1$), and it was not significantly greater for the two weeks which followed, 20.8.

The greatest concentration of deaths occurred on 3, 4 and 5 July after over a week of hot weather. On these days a similar number of men and women died (58 and 57 respectively) and only 18 men and 10 women were under 65 years of age.² Vascular disease of the heart and brain and 'other' heart diseases combined, referred to below as cardiovascular diseases, were the most prominent causes of death (Fig. 1c). The average daily deaths during the heatwave, 14.6, was significantly higher than for the two preceding weeks, 11.4 ($p < 0.05$) but not for the two weeks which followed, 13.1. The deaths from cardiovascular disease in both sexes considered individually correlated significantly with the daily variation in the mean air temperature throughout the six-week period ($p < 0.02$). This was not so for deaths due to malignant neoplasms, respiratory disease, perinatal deaths, diabetes or those due to other diseases and injuries. The upsurge of deaths from 16 to 19 July was only apparent for the cardiovascular diseases.

Heatstroke and heat exhaustion were never reported as the primary cause of death and 'effects of heat' were only reported as a contributory cause on three death certificates.

¹ 'Episode'—'an instance or a period of sickness during which there may be the necessity for a number of consultations.'

² Populations at risk estimated to be male 523 900 female 537 900 (City of Birmingham Statistics Office, based on OPCS census).

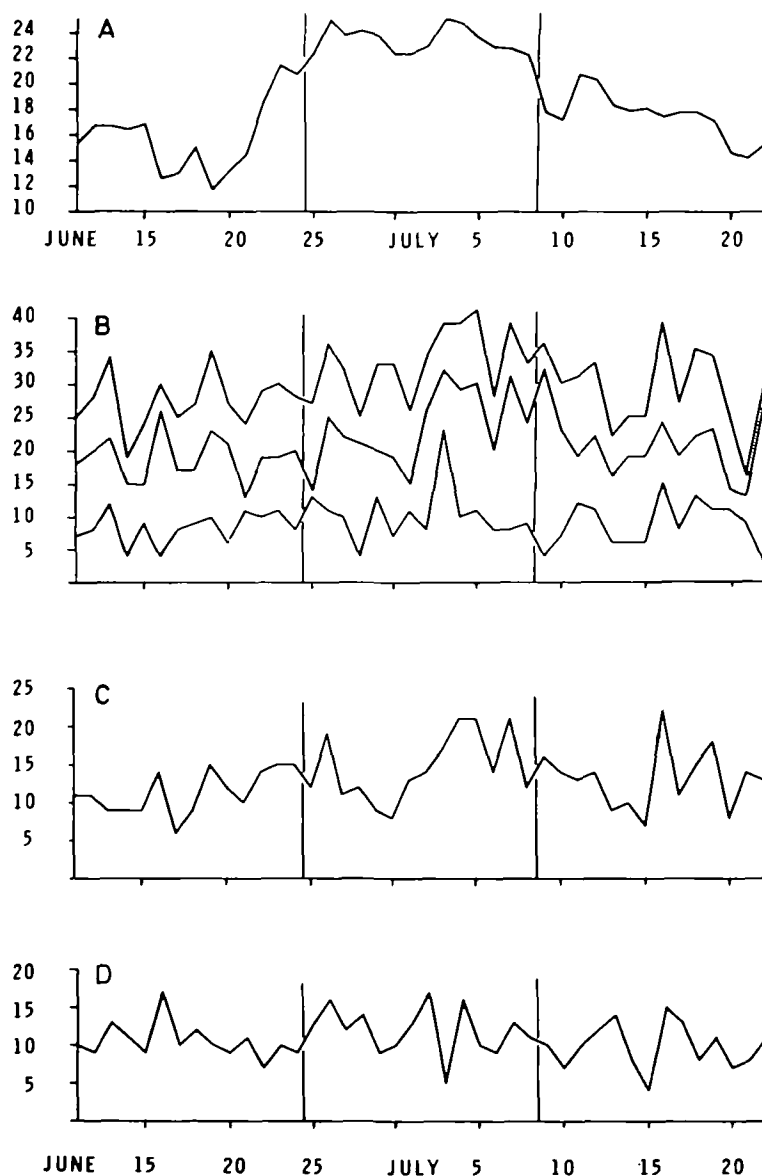


FIG. 1. Daily air temperatures and mortality.

- A. Mean daily dry-bulb temperature ($^{\circ}\text{C}$).
- B. Total daily deaths (top), daily deaths of persons 65 years old and older (middle), daily deaths of 64 years old and younger (bottom).
- C. Daily deaths from ischaemic heart disease (IHD), cerebrovascular diseases (CVD) and 'other' heart diseases (OHD).
- D. Coroner's deaths by day.

The three periods considered in the text are delimited by vertical lines. Horizontal axis—days 1976. Vertical axis—number of deaths.

WEATHER VARIABLES

Linear regression analysis indicated the maximum daily dry-bulb temperature one day before death as the weather variable which correlated best with total mortality ($B = 0.46 \pm 0.13$ $p < 0.001$) and cardiovascular mortality ($B = 0.32 \pm 0.11$ $p < 0.01$). Total mortality correlated, but less significantly, with the mean daily dry-bulb temperature one day before death ($B = 1.27 \pm 0.41$ $p < 0.005$) and cardiovascular mortality correlated best with the mean daily dry-bulb temperature on the day of death ($B = 0.46 \pm 0.16$ $p < 0.01$). Three measures of atmospheric humidity were tested, namely, the wet-bulb temperature, humidity mixing ratio and absolute humidity. A significant correlation with the daily deaths was found only with the wet-bulb temperature on days one and three before death ($B = 0.94 \pm 0.33$, 0.90 ± 0.31 $p < 0.01$). Thus humidity was a less important factor than air temperature in this heatwave.

CORONER'S DEATHS

Between 11 June and 22 July 453 deaths were reported to the Coroner. The cause of death was confirmed by examination *post-mortem* in 56 per cent of cases. There was an increase from 147 between 11 and 24 June to 168 between 25 June and 8 July (14 per cent) followed by a fall to 138 deaths (18 per cent) from 9 to 22 July. The deaths by day did not differ significantly, but the trend was consistent with the statistically significant increase in total deaths reported to the Registrar during the hot fortnight (Fig. 1*d*).

A rise in female deaths from 61 to 81 was identified as the main cause of the increase in Coroner's deaths during the heatwave in marked contrast with the male deaths, which showed little change between the first and second periods (86–87). The greatest effects were seen in women aged 70–79, the reported deaths rising from 11 in the first period to 32 during the heatwave and falling to nine in the next two weeks. This increased mortality was mainly attributable to cardiovascular disease. The heatwave had no effect on the numbers of deaths for men and women over 80. Solitary existence may have been a factor since 43 men and women living alone died during the heatwave compared to 34 in the preceding and 30 in the following fortnights.

Violent deaths in males aged 20–39 increased dramatically from one in the first fortnight (road traffic accident) to eight during the heatwave (hanging two, fire one, acute alcoholic poisoning one, road traffic accidents four), and fell to one in the third fortnight (road traffic accident). There were no homicides during the whole six weeks.

MORBIDITY

(a) New claims for sickness benefit. The average number of new claims in the working age groups for the three weeks including the heatwave ending on 29 June, 6 July and 13 July (13 809) was not significantly different from the average weekly number for all the summer months 1 June to 31 August (13 081).

(b) Emergency admissions. The total daily male and female surgical and medical emergency admissions to the five main Birmingham hospitals during the six-week

period did not correlate significantly with the mean daily dry-bulb temperature, and the average daily emergency admissions during the heatwave fortnight (94.6) did not differ significantly from the average daily admissions for the preceding (93) and following (94.9) fortnights. The emergency admissions by day per 100 000 population from 24 June to 8 July 1976, 8.97, were, however, significantly more numerous than during the same 14 days in 1975, 7.65, ($p < 0.05$), which was also an unusually warm summer, and even more so for the same 14 days in the cooler summer of 1974, 7.41, ($p < 0.01$).

(c) Heatstroke and heat exhaustion. There were only nine admissions to 31 Birmingham hospitals for acute heat illness in 1976, all between 26 June and 12 July, six being between 26 and 30 June. Four females and one male (aged nine, 12, 75, 86 and 71 years) were diagnosed as heat exhaustion and three males and one female (aged eight, 38, 71 and 26 years) as heatstroke. Only two were detained longer than three days and the longest stay was 10 days.

(d) General practice. There was only a modest increase in the total episodes of sickness in two large practices in Birmingham which still remained in the National Morbidity Survey in 1976, from 1028 (11–23 June) to 1071 (24 June–8 July) followed by a decline to 880 episodes (9–22 July) in the third fortnight.

Scrutiny of the figures for all 18 practices remaining in the Survey underlined this modest trend for the country as a whole, 6324, 6782 and 5697 episodes being reported for these three periods. Respiratory diseases caused more sickness than any other of the 18 disease groups examined but the number of episodes did not rise during the heatwave (1284, 1176, 872), whereas diseases of the nervous system and sense organs, which includes strokes (531, 606 and 513) and of the circulatory system (200, 246 and 187) increased during the hot weather, which agrees with the mortality trends found by analysis of the Birmingham death certificates.

DISCUSSION

The increase in the average daily deaths from 27.4 for the pre-heatwave fortnight to 32.7 during the heatwave is similar to the increase reported by the B.B.C. for England and Wales (Wilkinson, 1976), but the daily deaths from 3 to 5 July showed an increase of more than 30 per cent above a high daily average for July. However, the total deaths for city residents reported to the Registrar for June, July and August (2816) were almost identical with those reported in 1975 (2833) and slightly less than in the cooler summer of 1974 (2980). This provides support for Lyster's conclusion (1976), based on deaths in London and South East England in 1975 and 1976, that if a heatwave kills off most of those at imminent risk of death fewer will die in the succeeding weeks, or perhaps months, although in Birmingham a significant compensatory fall in the mean daily deaths did not occur in the two weeks which followed the heatwave. It is particularly notable that neither heatstroke nor heat exhaustion were reported as the primary cause of death.

The increase in daily temperatures and in the daily mortality were both gradual. There were no sudden peaks in either temperature or mortality such as those reported in Greater London after a Sahara dust storm blanketed Southern England on 1 July 1968 (MacFarlane, 1976; MacFarlane & Waller, 1976), in Los Angeles

on 4 September 1965 when there was nearly a five-fold increase in deaths of elderly persons on one day only following an unexpectedly hot day during a short heatwave (Oechsli and Buechley, 1970) or during three recent heatwaves in New York City (Ellis, Nelson, and Pincus, 1975; Ellis and Nelson, 1978). It is possible that the relatively gradual onset of the heatwave enabled many elderly people to acclimatize and adjust to the warm weather. The peak dry-bulb temperature recorded in Greater London in 1968 was almost identical with the peak temperature recorded in Birmingham in 1976. It is the sudden onset of unusually warm weather which proves lethal for some elderly men and women, particularly those with overt or latent cardiac or cerebrovascular disease.

Although numbers are small, the increase of the Coroner's female deaths in the 70–79 age group compared to the males calls for some explanation. Perhaps some ageing women continued to exert themselves in domestic duties more than elderly men. Some women sweat less than men (Ellis, Exton-Smith, Foster, and Weiner, 1976; Foster, Ellis, Doré, Exton-Smith, and Weiner, 1976) and increased evaporative cooling from the skin surface was probably necessary for efficient thermo-regulation with indoor temperatures, which we frequently recorded were in excess of the high outdoor temperatures by 6 °C or more.

The increase in violent deaths of men aged 20–39 reported to the Coroner might be explained by the aggravation of depressive or aggressive tendencies in unstable individuals, increased consumption of alcohol or the effects of excessive warmth on efficiency or alertness. An increase in homicide rates was a feature of heatwaves in New York City in 1966 and 1972 (Ellis, 1972; Schuman, 1972; Ellis *et al.*, 1975), but there were no homicides in Birmingham during this heatwave.

During unusually hot weather advice should be given, particularly to elderly persons, that they rest more, wear less clothing, use more ventilation, take plenty of fluids and avoid direct sunlight and exertion in the heat of the day. Regular visits by neighbours, relatives, health visitors and social workers should be encouraged, especially to those living alone and those most at risk with known ischaemic heart disease or a history of strokes, to detect signs of early heat stress and continuing for a few days after the end of the heatwave. Lye and Kamal's (1977) recommendation that the body temperature of ill geriatric patients in hospital should be monitored during unusually hot weather should be supplemented to include the resting heart rate, as in Britain circulatory failure is more frequently a cause of death than thermoregulatory failure. Finally, the elderly and unfit should avoid unaccustomed exertion at times of sudden environmental change due to either unusually warm or cold (Whittington, 1977) weather.

ACKNOWLEDGEMENTS

We are indebted to Mr. F. Flowith, the Chief Superintendent Registrar, Birmingham Registration District, and the Birmingham Area Health Authority for authorizing the analysis of the death certificates and making them available, Dr. W. Nicol, the Area Medical Officer, Miss Mary Wall, Regional Statistician, West Midlands, and Mr. D. Birch of the Office of Population Censuses and Surveys for the morbidity data, Dr. E. T. Stringer and the Staff of the Edgbaston Observatory

for the meteorological data, Dr. A. C. Pincock who arranged the computer services, Professor R. Hoffenberg for supporting the study and commenting on the manuscript, and the secretaries of the Coroner's Court for typing the manuscript.

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