GS Leonardi[1, 2], S Hajat[2], RS Kovats[2], GE Smith[3], D Cooper[3], E Gerard[4]

[1] *Health Protection Agency, Chemical Hazards & Poisons Division (Headquarters), Oxon, Great Britain*
[2] *Public and Environmental Health Research Unit, London School of Hygiene and Tropical Medicine, London, Great Britain*
[3] *Regional Surveillance Unit, Health Protection Agency West Midlands, Birmingham, Great Britain*
[4] *NHS Direct, London, Great Britain*

Syndromic surveillance use to detect the early effects of heat-waves: an analysis of NHS Direct data in England

Submitted: 7 April 2005
Accepted: 6 March 2006

Abstract

Objectives: To investigate the effects of high ambient temperatures, including the summer 2003 heat-episode, on NHS Direct usage and its suitability as a surveillance tool in heat health warning systems.

Methods: Analyses of data on calls to NHS Direct in English Regions in the period Dec 2001–May 2004. Outcomes were daily rates of all symptomatic calls, and daily proportion of calls for selected causes (fever, vomiting, difficulty breathing, heat-/sun-stroke)

Results: Total calls were moderately increased as environmental temperature increased; this effect was greatest in calls for young children and for fever. Total calls were moderately elevated during two summer heat episodes in 2003: calls specifically for heat/sun stroke increased acutely in response to these episodes. No association was apparent between environmental temperature and proportion of calls for vomiting and difficulty breathing.

Conclusions: Calls to NHS Direct are sensitive to daily temperatures and extreme weather. NHS Direct is timely and has great potential in health surveillance. Calls for heat- and sun-stroke are now routinely monitored as part of the UK Heat-wave plan

Keywords: Temperature – Heat-waves – NHS Direct – Primary care – Surveillance.

The European heat-wave of August 2003 had major effects on mortality in many countries across the continent (Eurosurveillance special issue 2005; Martinez Navarro et al. 2004; Valleron et al. 2004; Vandentorren et al. 2004; Conti et al. 2005; Grize et al. 2005). An important aspect of the event was the late detection of health effects. The extreme heat was increasing mortality in older persons throughout Paris, and northern France. The French Minister of Health told the Parliamentary Commission "We did not notice anything" (Lagadec 2004). It was not until August 7 (one week into the heat-wave) that funeral homes reported being full, and on August 8 an official public health response began (Senat 2004).

The heat-wave was less extreme in England and Wales, where mortality increased by 16% during the 10-day event (Johnson et al. 2005a). High maximum temperatures (greater than 30 °C) were sustained for 9 to 10 days throughout the South East and many station records were broken (Met Office 2005). The effect on mortality was greatest in London, and in the over 75 age group. However, 11% excess mortality was also observed in deaths in persons under 65.

There is relatively little information on heat-related morbidity. Emergency hospital admissions in the South of England increased during the heat-wave, but these were smaller in magnitude compared to the mortality excess, and largely confined to London (Johnson et al. 2005b). High temperatures have previously been shown to increase respiratory admissions in the elderly in London (Kovats et al. 2004).

Information on cause-specific heat-related morbidity would provide important information on the mechanisms of mortality, and identify vulnerable groups. Studies of emergency admissions and ambulance call-outs during individual heat-wave events indicate that persons with diabetes and neurological disorders are at increased risk (Ellis et al. 1980; Semenza et al. 1999).

Following the 2003 heat-wave, the UK Government implemented a "Heat Wave Plan" in July 2004 (Department of Health 2004). This plan suggests that calls to NHS Direct be used to monitor the impact of heat-waves in England, and provide evidence for the effectiveness of response measures. NHS Direct is a nurse–led helpline which provides health-related information and advice and directs callers to the appro-

Soz Praventiv Med. 51 (2006) 194–201
0303-8408/06/040194–08
DOI 10.1007/s00038-006-5039-0

	Mean	10th percentile	90th percentile
Daily total symptomatic call rate (per 100000 people)			
– England	18.5	15	24
• Greater London	23.6	18.3	31
• Kent, Surrey and Sussex	14.0	10.9	17.6
• South West	19.9	15	26
• Eastern	20.5	16	27
Daily total symptomatic call rate – England (per 100000 people)			
• 0–4 years	64.8	46	92
• 5–14 years	13.7	10	18
• 15–64 years	16.9	14	21
• 65+ years	10.7	7	17
Call symptoms – England (as % of all calls)			
• Vomiting	4.7%	3.5%	6%
• Fever	4.1%	2.9%	5.8%
• Difficulty breathing	1.1%	0.8%	1.4%
• Heat/sun-stroke*	0.2%	0%	0.6%

* NHS Direct heat/sun stroke calls summarised from 6 NHS Direct sites: North West Coast, East Midlands, West Country, Kent/Surrey/Sussex, East Anglia, South London; and only for the period 1st July 2003 – 31st August 2003.

Table 1 Summary statistics of total symptomatic calls to NHS Direct per 100000 people and symptom-specific calls as percentage of all calls in the period from 7th January 2003 to 23rd May 2004

priate health service or self care. The helpline is available 24h a day, 365 days a year. There are 21 NHS Direct sites in England (plus one in Wales) covering populations ranging from 1 to 4.5 million people. The NHS Direct syndromic surveillance system currently monitors calls on a daily basis from all 22 NHS Direct sites in England and Wales. Daily syndromic surveillance data may be potentially useful for early warning of adverse environmental events (Harcourt et al. 2001; Baker et al. 2004). To investigate the potential of incorporating "real time" health surveillance into the UK heat-wave plan, we investigated the association between NHS Direct call rates and high temperatures, including the severe heat episodes during summer 2003.

Methods

We obtained NHS Direct call data from 19 December 2001 to 23 May 2004 for the whole of England and for the 12 NHS Direct sites covering the Eastern, South West, South East and London regions of England. NHS Direct nurses use clinical decision support software, the NHS Clinical Assessment System (NHS CAS), to respond to calls. The NHS CAS contains over 200 algorithms used in assessing clinically the symptoms of the person about whom the call is made. The NHS Direct syndromic surveillance system records calls by the algorithm (primary symptom/syndrome) used to handle the call. The time-series of call data is limited because NHS Direct data have only been collected from all 22 NHS Direct call centres since December 2001 and only for a limited selection of symptoms. Summary statistics of total call rates for the whole of England and for selected regions in the South of England and the proportion of symptom-specific calls for England are provided in Table 1. For London, the total symptomatic call rate, and the proportion of calls for fever and vomiting (not shown) were higher in this region compared to other NHS Direct regions in the midlands and the north of England, however the proportion of calls for breathing difficulties were comparable across regions.

We identified three of the ten routinely monitored NHS Direct algorithms of plausible relevance based on the pathophysiology of heat-related illnesses and their primary care and emergency medicine presentation: nausea/vomiting, difficulty breathing, fever (Wexler 2002; Hart 2003). Heat/sun stroke is not a routinely monitored algorithm, but we were able to obtain data about such calls from 6 NHS Direct sites from 1 July to 31 August 2003.

Daily meteorological data on mean value of the maximum and minimum temperature of each day and relative humidity were obtained for the South of England region (Heathrow weather station) from the British Atmospheric Data Centre. Daily mean air pollution data from an 'average' series created from nine sites across London for 8hr O_3 (ozone – in parts per billion) and six sites for mean PM_{10} (particulate matter of less than 10µm – in µg/m^3) were obtained from the archives of the National Air Quality Monitoring Network maintained by the National Environmental Technology Centre, Culham.

Time-series methods were used to investigate any association between temperature and NHS Direct calls. These techniques

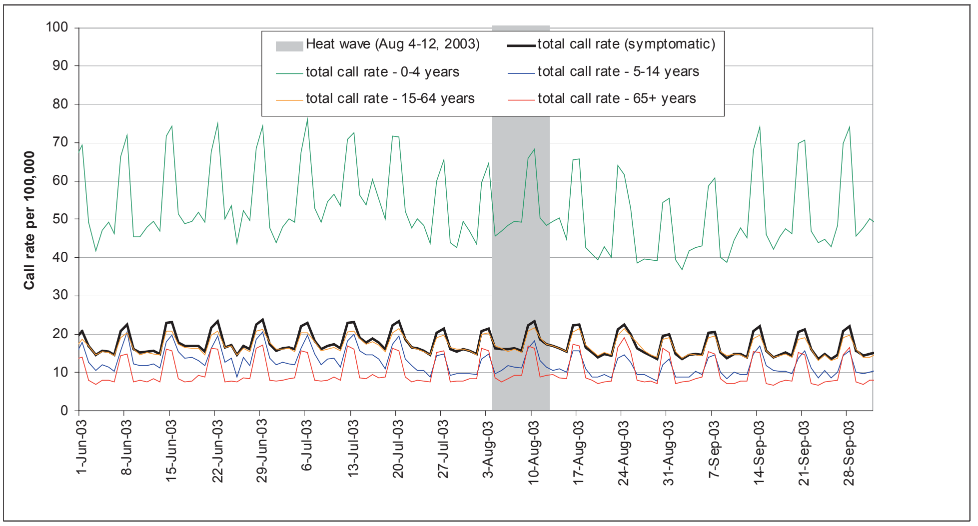

Figure 1 Total symptomatic call rate per 100 000 people to NHS Direct in Greater London during summer 2003.

allow assessment of any short-term effects of temperature on the health outcome. Generalised linear models were constructed for each series, using Fourier terms up to the sixth harmonic to control for confounding from seasonally varying factors other than temperature. A linear term for time was used to control for any trend in the series, and indicator variables were used to allow for day-of-week and holiday effects. Daily levels of air pollution (O_3 and PM_{10}) and relative humidity were also added to all core models as potential confounders. Sensitivity analyses were undertaken on all models to examine the influence on results of replacing the Fourier terms with cubic B-splines of time (7 degrees of freedom per year – roughly equivalent to a 2 month moving average) to control for seasonality.

Once all potential confounders had been included in the models, the relationship of the NHS Direct outcome data with temperature was assessed. This was achieved by adding to each model natural cubic splines of temperature – using 1 degree of freedom for every 5 degrees Celsius of temperature (ISOTHURM 2005). These allow the temperature-outcome relationship to be summarized and allow judgment on whether the relationship with temperature is linear across the temperature range, or has a threshold response at high temperatures. Because the effects of heat are likely to be immediate, the temperature measure was averaged across values on the day of call (lag 0) and the day before (lag 1) (ISOTHURM, 2005). The procedure was conducted for total symptomatic calls to NHS Direct as well as proportion of calls for fever, vomiting and difficulty breathing separately. In order to quantify the relationship between temperature and each outcome, the natural cubic splines of temperature were replaced with a linear term for the temperature measure.

Heat-wave episodes were also investigated separately, as sustained exposure to high temperatures may have additional health effects other than those of individual hot days (as investigated using the first method). For two pre-defined "severe heat periods", a comparison was made between the expected rate of calls to NHS Direct, predicted from the core regression models above, and the observed values. The two severe heat periods were defined as 10–19 July (10 days) and 4–13 August 2003 (10 days), when daily temperatures were unusually elevated (mean temperature above 19 °C for the July episode and above 23 °C for the August episode). The latter August period is the same as that used to estimate the mortality excess in the study of the effects of the 2003 heat-wave in the UK (Johnson et al. 2005a). The core models included control for general temperature effects (natural cubic splines with 1df per 5 degrees Celcius) in order to assess the effect of the specific heat-wave periods over and above the seasonal 'norm' predicted from the regression model. This approach allowed us to construct a baseline for each call centre region studied, and each available age group (0–4 years, 5–14 years, 15–64 years and 65+ years). All analyses were conducted in Stata 8.2 (Stata 2005).

Results

Figure 1 illustrates the weekly pattern of NHS Direct data in the Greater London area. As with all regions, a higher number of calls are observed at weekends. Figure 2 shows the estimated relationship in London between symptom-specific NHS Direct outcomes and temperature after control for confounding factors. The x-axis on each graph represents the temperature measure averaged across values on the day of the call (lag 0) and the day before (lag 1). The thick centre line summarises the basic relationship, and the thick lines either

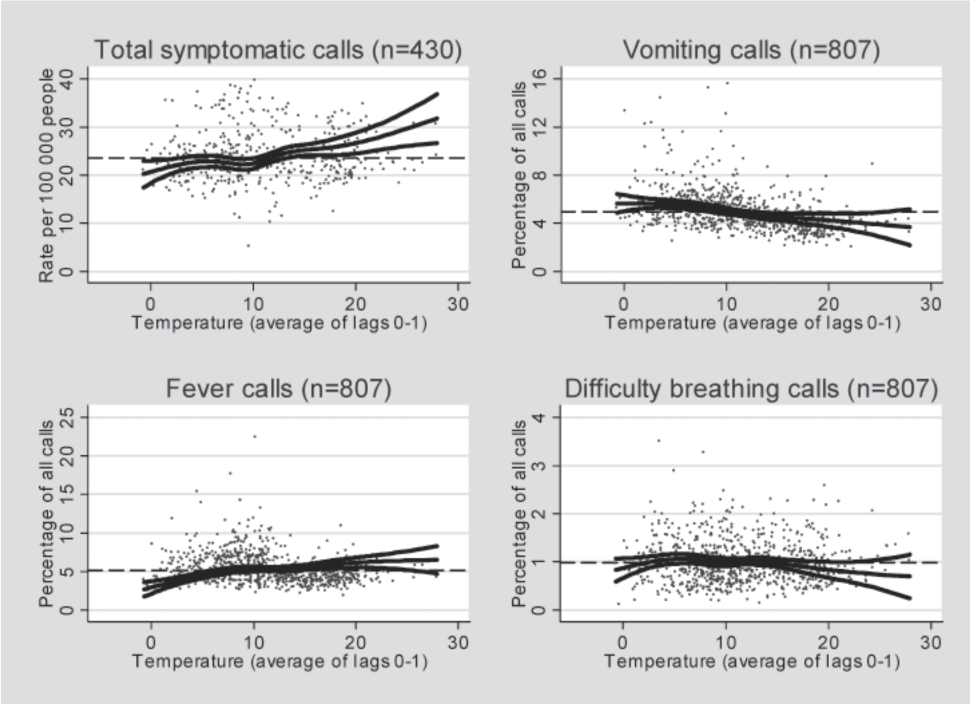

Figure 2 Seasonally-adjusted relationship of daily total call rate (Jan 2003–May 2004) and daily percentage of symptom-specific calls (Dec 2001–May 2004) with daily temperature in Greater London area. Thick central black line on each graph is a summary estimate of the relationship, and the lines either side are 95% confidence limits

Table 2 Effect of temperature on fever calls to NHS Direct Greater London and South East, by age-group

Outcome	Mean daily fever calls (as percentage of all calls)	Percentage change in proportion of fever calls per 10 degree Celsius increase in temperature (95% CI)
Fever calls in London and South East		
– 0–4 years	13.3%	2.5% (1.8, 3.3) P < 0.001
– 5–14 years	7.1%	0.4% (–0.4, 1.3) P = 0.33
– 15–64 years	1.2%	0.1% (–0.0, 0.2) P = 0.13
– 65+ years	1.0%	0.5% (0.2, 0.8) P = 0.001

side of this are 95% confidence limits for this summary estimate. These graphs show that total symptomatic call rates and the proportion of fever calls were positively linearly associated with temperature across the whole range. There was little suggestion of a threshold value in either case. A rise in the proportion of vomiting calls was associated with low temperatures, but not with heat. Calls for difficulty breathing appear not to be associated with temperature.

Table 2 shows the change in the proportion of fever calls in the London and South East regions by age-group as the temperature rises. The estimates are based on a linear assumption and so show the % change in outcome per 10 degree increase in mean temperature. The largest rise was seen for children 0–4 years: 2.5% increase in the proportion of fever calls (95% CI 1.8, 3.3) for every 10 degree Celsius increase in mean temperature. A small, but statistically significant, increase was also observed in the elderly (p = 0.001). Sensitivity analysis indicated that results were largely unchanged when the Fourier terms were replaced with cubic B-splines of time to control for seasonal patterns (not shown).

Summer 2003 episodes

The observed levels of total symptomatic calls were moderately elevated during the two heat episodes in 2003, although few of the excesses were statistically significant when examined for the whole of England or individually in Greater London and other southern English Regions (table 3). However, the proportion of calls to 6 NHS Direct centres for heat/sun stroke increased dramatically during the two heat episodes in 2003 (Fig. 3). The impact appeared to be greater during the July episode than during the August period, even though temperatures were comparatively lower. It was not possible to quantify the effect of temperature on the heat/sun stroke calls due to lack of power to create sufficiently robust models.

Table 3 Percentage excess (95% CI) in daily total symptomatic call rates to NHS Direct in England during the summer 2003 severe heat episodes

	'July heat wave' (10–19 July 2003) Mean temp in London: 21.4°C	'August heat-wave' (4–13 August 2003) Mean temp in London: 25.6°C
Total symptomatic calls		
England	3.5% (–0.8, 7.7)	3.3% (–2.0, 8.6)
– Greater London	5.0% (–6.2, 16.1)	8.1% (–5.8, 21.9)
– Kent, Surrey & Sussex	11.6% (–2.5, 23.7)	11.5% (–2.5, 25.5)
– South West	5.2% (–5.0, 11.7)	3.0% (–5.3, 11.3)
– Eastern	3.4% (–3.8, 10.7)	5.4% (–3.5, 14.4)
Total symptomatic calls – England		
– 0–4 years	8.4% (0.8, 16.0)	9.3% (-0.9, 19.5)
– 5–14 years	10.0% (2.3, 17.7)	10.3% (-0.5, 21.1)
– 15–64 years	2.4% (–2.9, 7.8)	2.6% (-3.9, 9.0)
– 65+ years	3.3% (–6.2, 12.8)	7.9% (-4.0, 19.7)

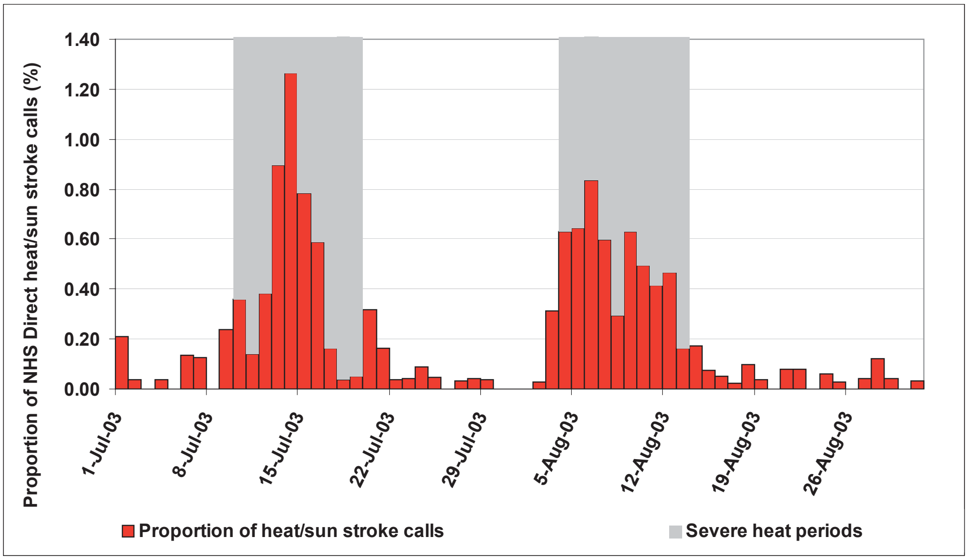

Figure 3 Daily proportion of "heat/sun stroke" calls to 6 NHS Direct sites, summer 2003

Discussion

In London and the South of England, total symptomatic call rates to NHS Direct, as well as the proportion of calls about fever, were positively related to increases in ambient temperature. There was little suggestion of a threshold value in either case, but if one does exist then the splines suggested that it may be at a value lower than observed with mortality, where previous studies have estimated a threshold at about 20–22°C of mean temperature in UK populations (Keatinge et al. 2000; Hajat et al. 2002). This may suggest a relationship between temperature and the symptomatic calls indicator that is different to that observed with mortality. The association for fever calls was strongest for young children and the elderly, the population groups most at risk of heat stress. Calls for heat and sunstroke were very sensitive to the hot weather conditions as would be expected. No strong effect of environmental temperature was found on proportion of calls for vomiting or difficulty breathing although these are symptoms that are associated with heat illness. The effects of temperature on total calls are apparent at moderate values and no acute response to extreme temperatures was apparent except with calls for heat/sunstroke.

During the unusually hot weather conditions in the summer of 2003, total symptomatic calls to NHS Direct significantly increased for children aged both 0–4 years and 5–14 years during the July hot period. Calls to NHS Direct are disproportionately high in the 0–4 year age-group compared to the age distribution of the general UK population (Cooper et al. 2005) and therefore sensitivity to exposures such as ambient temperature may be overestimated in this age-group. However we suggest that the effects observed in both this group and the 5–14 year olds are likely to be a true reflection of mild morbidity in children. A time series analysis of emergency hospital admissions in London found a small increase in admissions in children as temperatures increase above approximately 12°C (Kovats et al. 2004).

The apparent moderate effect of high temperatures on morbidity in the elderly requires further investigation. Authors of a previous analysis of emergency hospital admissions concluded that many people who die in a heat-wave do not access health services (Kovats et al. 2004). Approximately 10% of NHS Direct calls are made by (or about) those over 65 years, whereas 16% of the population of England and Wales are over 65 years (Cooper et al. 2003). We feel that the results presented here may under-represent their morbidity, rather than constitute evidence of absence of a major heat effect. Older persons have a poorer perception of ambient temperature and may not realise they are suffering from heat stress (Worfolk 2000).

There was an increase in total symptomatic calls during the two severe heat episodes, however the excesses were generally not statistically significant and, in the case of London, only amounted to an average 2 extra calls per day per 100000 patients. The proportion of NHS Direct heat/sun stroke calls, however, rose much more dramatically during both the July and August heat periods. It is possible that the high level of media attention given to the heat-wave in August may have artificially increased the number of calls for heat/sunstroke. However, the large number of calls during the July heat-wave, when there was little or no publicity, supports evidence of a true heat effect. It is not clear why the level of heat stroke calls were higher during the July 2003 severe heat period than the hotter August period. Acclimatization (both physiological and behavioural) to the earlier heat-wave may have reduced some of the effect of the later episode.

Since syndrome-specific calls, such as those for heat/sunstroke, are presented as a proportion of all calls, it is theoretically possible that changes in call rates for other categories could influence observed levels. However, it is known that the number of calls for any one NHS Direct syndrome is not sufficient enough to have a large effect on the denominator (total calls) and therefore on individual syndrome proportions. Common complaints, e.g. fever, abdominal pain, back-ache, comprise about 5% of total NHS Direct calls. Even if one or two of these suddenly increased to 10% this wouldn't affect overall call rates substantially. During national influenza epidemics total NHS Direct calls *can* increase by 5–10% due to increases in respiratory complaints, however this occurs only in winter and so wouldn't be a consideration in our heat/sunstroke analysis. Other causes of increased NHS Direct calls about specific syndromes (upsurges in gastroenteritis: NHS Direct diarrhoea & vomiting; pollen season: NHS Direct 'eye problems' calls; poor air quality: NHS Direct difficulty breathing calls) also have minimal effects on total calls. It has been demonstrated on NHS Direct diarrhoeal data that using proportional, as opposed to absolute count models, improved sensitivity and specificity of the data for detecting rises in syndromic calls (Reis et al. 2005).

We made an a priori decision to control for season using Fourier terms up to the 6th harmonic in each of our models. When, as a sensitivity analysis, we instead used the potentially more flexible option of cubic B-splines to control for time, the effect estimates remained largely unchanged. This suggested our original choice of smoothing had adequately adjusted for seasonal patterns.

One objective of this study was to better describe the burden of heat-related morbidity in the general population. The pattern of heat effects by cause-specific calls is not consistent with symptoms from classical heat illness, but in the UK very few persons are certified as dying from hyperthermia. Our results are consistent with emerging evidence from hospital admissions studies that high temperatures do not increase admissions for stroke or heart attack (Kovats et al. 2004). More research is clearly needed on the mechanisms by which heat-related morbidity occurs.

In view of the potential health burden of elevated temperatures in the UK, there is scope for further examination of NHS Direct data (including exploring other algorithms), other primary care datasets, and accident and emergency visits, to identify specific patterns of morbidity and vulnerable subgroups. Other than 'heat stroke' calls, the analyses reported here were restricted to symptoms routinely monitored by the NHS Direct syndromic surveillance system. However, based on the known spectrum of heat-related diseases (Kilbourne 2002), several other symptoms could be investigated (such as heat cramps) (Dematte et al. 1998). We were limited in our ability to examine specific symptoms because only certain syndromes are routinely monitored in the surveillance system and these syndromes are relatively non-specific. It may also be of interest to identify and track individuals who called NHS Direct because they were adversely affected by heat, thus permitting characterization of the severity of health outcome. The socio-economic status of an individual may also be an important factor. Ecological studies at 3 NHS Direct sites (West Yorkshire, West Midlands and the former South East London site) have indicated that NHS Direct call rates are highest in areas where social deprivation is just above the national average. The lowest call rates were observed in both the most affluent and most severely deprived areas (Burt et al. 2003; Cooper et al. 2005).

There is a need to develop timely and effective surveillance systems to facilitate responses to heat-wave events throughout Europe. Many cities in Europe have developed heat-wave response plans, which include some aspect of health surveillance. Health data can be used either to improve the heat-wave forecast (i.e. as an explanatory variable in the forecast model) or to provide early detection of the health impact in the population. In any case, health data need to be available within a day or so as heat-waves have rapid onset and short duration (5–10 days). The Office for National Statistics is only able to provide mortality data at weekly intervals with a minimum lag of two weeks. Some cities in Europe have established mechanisms to monitor mortality directly from funeral homes, with only 48h delay. In Budapest, Hungary, calls to ambulances are monitored and incorporated into their heat-wave plan. For the UK, the national coverage of NHS Direct data makes the system an attractive one in terms of providing real-time signals of acute environmental exposures. NHS Direct calls on sun/heatstroke are now monitored routinely as part of the UK heat-wave plan (Department of Health 2004).

Source of funding

SH and RSK were funded by the European Commission DG SANCO as part of the EUROHEAT project on improving public health responses to heat wave in Europe (Agreement – 2004322). GSL and GS are employed by the Health Protection Agency, and DC is also employed by the Health Protection Agency but his post is funded by NHS Direct. EG is employed by NHS Direct.

Acknowledgements

We would like to thank all the NHS Direct Sites and the NHS Direct Health Intelligence Unit for supplying the NHS Direct data. We would also like to thank Mark Gibbs and colleagues at the Met Office Health Forecasting Unit, as well as 3 anonymous reviewers, for useful discussions and comments on early drafts of the paper.

Zusammenfassung

Beobachtung von Erstsymptomen im Zusammenhang mit Hitzewellen: Analyse der NHS Direct-Daten in England

Fragestellung: Untersuchung der Auswirkungen hoher Umgebungstemperaturen, inklusive der Hitzeepisode in Jahr 2003, auf die Inanspruchnahme von NHS Direct und dessen Eignung als Beobachtungsinstrument von Gesundheitswarnsystemen bei Hitze.

Methoden: Analysen von Daten aus Anrufen bei NHS Direct in England während der Perioden von Dezember 2001 bis Mai 2004. Ergebnisse bestanden aus Frequenzen aller symptomatischen Anrufe und den täglichen Anteilen von Anrufen zu ausgewählten Fällen (Fieber, Erbrechen, Atembeschwerden, Hitzeschlag/Sonnenstich).

Resultate: Die gesamte Anzahl der Anrufe stiegen leicht an mit dem Anstieg der Aussentemperaturen; dieser Effekt war bei Kleinkindern und für Fieber am grössten. Die gesamte Anzahl der Anrufe war während zwei Hitzeepisoden im Sommer 2003 moderat erhöht: besonders die Anrufe betreffend Hitzeschlag/Sonnenstich stiegen in der Folge akut an. Kein Zusammenhang konnte festgestellt werden zwischen Umgebungstemperaturen und dem Anteil von Anrufen für Erbrechen und Atembeschwerden.

Schlussfolgerungen: Anrufe bei NHS Direct sind sensitiv bezüglich täglichen Temperaturen und extremen Wetterbedingungen. NHS Direct ist zeitgemäss und hat ein grosses Potential im Bereich der Gesundheitsbeobachtung. Anrufe für Hitzeschlag und Sonnenstich werden nun im Rahmen des UK Heat-wave plan routinemässig erfasst.

Résumé

Surveillance des premiers symptômes liés aux vagues de chaleur: analyse des données du NHS Direct en Angleterre

Objectifs: Identifier les effets des températures élevées, dont la vague de chaleur de l'été 2003, sur le recours au NHS Direct; analyser l'utilisabilité de ce dernier comme outil de surveillance dans les systèmes d'alerte de santé en lien avec la chaleur

Méthodes: Analyse des appels effectués auprès du NHS Direct en Angleterre entre décembre 2001 et mai 2004 : nombre d'appels et proportions quotidiennes d'appels pour des causes spécifiques (fièvre, vomissements, difficultés respiratoires, coups de soleil ou de chaleur).

Résultats: Le nombre d'appels a modérément augmenté lors de l'élévation des températures; cette élévation était spécialement marquée chez les appels concernant de jeunes enfants et pour de la fièvre. Les appels ont été relativement plus nombreux durant les deux épisodes de canicule de l'été 2003, surtout ceux concernant spécifiquement des cas de coups de soleil ou de chaleur. Aucune association entre la température ambiante et la proportion d'appels pour vomissements et difficultés respiratoires n'a pu être décelée.

Conclusions: Le nombre des appels au NHS Direct est en lien direct avec les températures et les situations météorologiques extrêmes. Le NHS Direct possède un potentiel important en matière de surveillance. Les appels concernant des coups de soleil et de chaleur sont maintenant monitorés de manière systématique («UK Heat-wave plan»).

Soz Präventiv Med. 51 (2006) 194–201

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Address for correspondence
Dr S. Hajat
Public & Environmental Health Research Unit
Department of Public Health & Policy
London School of Hygiene & Tropical Medicine
Keppel Street
London WC1E 7HT
UK
Tel: +44 (0)20 7612 7844
Fax: +44 (0)20 7580 4524
e-mail: shakoor.hajat@lshtm.ac.uk