

Weather Forecasting as a Public Health Tool

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Overview



- Excessive UV exposure, particularly during childhood, is associated with an increased risk of skin cancer. There are around 65,000 new cases of skin cancer reported each year in the UK.
 - Sunlight may hold moderate mental health benefits, contributing to an individual's sense of well-being.
 - Levels of alcohol consumption increase on hot and sunny days.
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- Lightning strikes injure on average 49 people a year in England and Wales and cause around three deaths.
 - Thunderstorms can trigger asthma attacks when there are very high levels of grass pollen or fungal spores. A thunderstorm in South East England in June 1994 saw 640 patients presenting with asthma to hospital casualty departments in the area, ten times the usual number of patients with this condition.
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- Heavy rainfall is commonly found preceding outbreaks of diseases associated with drinking water such as cryptosporidium.
 - When heavy rainfall is followed by flooding, this can bring an increase in deaths from drowning, heart attacks and injuries, an increased risk of infections such as gastroenteritis, and mental health problems such as anxiety and depression.
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- Deaths and injuries from the direct and indirect effects of gales are small in the UK, but on average between 1962 and 1993 caused six deaths and 144 minor injuries each year.
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- Levels of fractured wrists, arms, and hips increase dramatically during periods of ice, snow, and freezing rain. During one incident of freezing rain in Berkshire in 1995, an Accident and Emergency department reported a threefold increase in fractures of the hip and a sixfold increase in fractures to the forearm.

High ambient temperatures see:

- An increase in mortality from cardiovascular, cerebrovascular and respiratory diseases, particularly for those aged 65 and over. An estimated 800 people in the UK die each year from a heat-related illness.
- An increase in non-fatal illnesses such as dehydration, heat exhaustion and heat stroke, particularly among people with underlying medical conditions.
- An increase in food poisoning.
- Elevated levels of suicide.
- An increase in the rate of violent crime such as assaults and domestic violence.



Low ambient temperatures see:

- An increase in mortality from cardiovascular diseases, cerebrovascular diseases and respiratory diseases, particularly for those aged 65 and over. Total excess winter mortality is between 20,000 and 50,000 each year in England and Wales.
- An increase in non-fatal illnesses, particularly respiratory diseases such as asthma and the common cold.

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Foreword

The belief that weather and health are connected dates back to Hippocrates more than 2,000 years ago, who first recognised that epidemics were related to seasonal changes in weather. Despite this, meteorological variables were largely neglected in modern medicine until the 1970s, when scientific research focused for the first time on the dramatic rises in mortality each winter and smaller rises in unusually hot weather (Keatinge, 2002). At roughly the same time, psychological and criminological researchers were also beginning to take an interest in the influence of meteorological variables on mental health and criminal activity. Since then, interest in the effects of weather for all of these disciplines has grown a great deal, helped to some extent by a raised awareness of global warming and concern about the public health impact of climate change. There is now a growing body of research that suggests that changes in weather have a direct and indirect influence on human health and behaviour.

Knowledge of the influence of weather on health and behaviour is valuable, and contributes to our understanding of epidemiology, the occurrence of accidents and injuries, and of public health issues such as levels of alcohol consumption and violence. With the aid of meteorological forecasts, such information can be used to time health promotional activities, plan health protection strategies and manage rises in demand for health services and other public services such as police. In the longer term, awareness of how weather impacts currently on health and behaviour can help understand and prepare for the impact that future climate change may have on public health.

This report aims to present an overview of how weather influences health and behaviour, and to highlight how meteorological forecasts can be used as a public health tool. It is not a comprehensive document on all aspects of weather and health but should be used as one tool to help:

- Time public health initiatives so that they are likely to have maximum impact
- Prepare for and respond to periods of heat, cold or other weather extremes
- Work with treatment and care services in order to prepare for weather-related peaks in demand.

Section one examines the impact of weather on health, and looks at ways in which meteorological information is currently being developed to improve health and health services. Section two considers some wider public health issues such as levels of road traffic accidents, alcohol consumption and violent crime. Lastly, given that the usefulness of meteorological information depends upon accurate and timely forecasts, section three takes a look at how far in advance weather can be predicted and the accuracy of such information.

Section 1: The impact of weather on health and health services

Globally, the frequency and severity of extreme weather events such as floods, droughts, storms and hurricanes appears to be increasing (WMO World Meteorological Organization, 2003). In the UK, four of the five warmest years on record have occurred since 1990, with the highest temperatures ever recorded seen during August 2003. Whether or not these recent changes are attributable to global warming remains debatable. However, what we do know is that current weather conditions, regardless of global warming, have important public health effects that are often ignored.

This section presents a brief overview of how different weather variables directly and indirectly affect levels of mortality, morbidity, and mental health, and subsequent demand for health services. It examines the way in which meteorological data are currently being developed by public health professionals and health services to alleviate and prevent health problems, and how health forecasting using meteorological data can inform health promotion, reduce morbidity, and allow more consistent quality of health service delivery throughout the year.

1.1 Sunshine

Probably the best-known association between weather and health is the link between exposure to sunlight and skin damage. Excessive exposure to Ultra Violet light from the sun causes immediate damage including reddening, tanning, blistering or peeling of the skin, and repeated short-term damage can eventually cause conditions such as skin cancer. There are around 65,000 new cases of skin cancer reported each year in the UK, with numbers increasing annually (Cancer Research UK, 2004). The majority of these cases (around 62,000 a year) are non-melanomas (Squamous and Basal cell carcinomas), which are nearly always curable. These are related to total lifetime exposure of Ultra Violet light and appear in areas of the body that would have been exposed such as the face, neck and hands.

The remaining cases are malignant melanomas, the most serious form of skin cancer. During 2002, 1,644 people died from malignant melanoma in the UK (Cancer Research UK, 2004). While this form of skin cancer is fairly rare in children, childhood exposure to Ultra Violet light before the age of 10 years along with severe sunburns and intense intermittent exposures are believed to be the most critical factors in its eventual development (Mancini, 2004).

Exposure to sunlight is not always a threat to health; moderate exposure can hold important physical and mental health benefits. For instance contact with sunlight on the skin produces Vitamin D, and reduces the risk of certain cancers, including colon, breast and prostate cancer (Garland, 2003). The enjoyment and relaxation experienced from lying or sitting in the sun (Ness et al, 1999) and the perception of attractiveness and health associated with a suntan (Manning and Quigley, 2002) can contribute to a sense of well-being. Furthermore, a lack of sunshine in the winter months is thought to be associated with the onset of Seasonal Affective Disorder (SAD), a form of depression usually occurring during the winter months (see Box 1 for more information).

1.2 Temperature

Another well-known association between weather and health is the increase in mortality and morbidity seen with very high and very low ambient temperatures. Most research has focused on the effects of extreme temperatures on mortality. Much less is known about the effects of temperature on morbidity levels in the population, or about the effects of less extreme temperatures on health. Daily mortality in London has been found to be lowest at an average daily temperature of around 19°C - 22°C. For each degree Celsius rise above 21.5°C, mortality increases by 3.34%, and for each degree Celsius fall below 18°C, increases by 1.37% (Hajat et al, 2002; The Eurowinter Group, 1997).

High ambient temperatures

An estimated 800 people in the UK die each year from a heat-related illness¹ (Donaldson et al, 2001). The most severe effects of heat occur during heat waves, when temperatures are not only high, but occur over a prolonged period of time. Excess deaths have frequently been reported following heat waves both in the UK (e.g. Rooney et al, 1998), and abroad (e.g. Huynen et al, 2001; Keatinge et al, 2000). During the most recent heat wave in Europe in August 2003, temperatures in the UK rose to record levels, with maximum temperatures reaching over 38° C in some parts of the country. A total of 2045 excess deaths were reported in England and Wales, an increase of 16% above the expected number of deaths for that time of year (Kovats et al, 2004). France was harder hit, with maximum temperatures in some parts of the country exceeding 40° C. Over the month of August there was a 60% increase in mortality, and a consequent surge of admissions to hospital emergency departments (Dhainaut et al, 2003).

¹ Heat-related deaths are defined as the number of deaths that occur in excess of the number that would have been expected for that population in the absence of hot weather.

The number of deaths seen during a heat wave and the corresponding impact on health services has been found to vary in the UK, depending on heat wave intensity, duration, and time of year. Heat waves that report higher maximum temperatures, are of longer duration, and occur earlier in the year rather than later have the greatest mortality effects (Hajat et al, 2002). Furthermore, the risk of death from heat is higher among several vulnerable groups. These include people aged 65 and over, those living in urban areas, those with a known medical condition, those with little social contact and those with lower income levels (Naughton et al, 2002; Semenza et al, 1996). The effect of summertime heat is immediate, and deaths can occur with less than a 24 hour lag (Hajat et al, 2002). However, this is often followed by a temporary fall in the number of deaths in subsequent weeks, suggesting that heat, at least in part, affects those people that would have died in the short term anyway (Kunst et al, 1993).

The most direct cause of death from heat exposure is heat stroke, characterised by a core body temperature of above 40° C and altered mental status (Barrow and Clark, 1998). However, deaths from heat stroke are rare in the UK. In fact, the most common causes of death due to hot temperatures are cardiovascular disease, cerebrovascular disease and respiratory disease, suggesting that heat exacerbates these conditions (e.g. Huynen et al, 2001; Rooney et al, 1998). Heat related mortality due to cardiovascular and cerebrovascular diseases can be explained, in part, by the loss of salt and water in sweat that increases the concentration of blood and the risk of coronary or cerebral thrombosis (Keatinge, 2002).

High ambient temperatures also see an increase in non-fatal illnesses. A study looking at excess hospital admissions and treatments for medical conditions during a week long heat wave in Chicago in 1995 reported an additional 1072 (11%) hospital admissions above average and 838 (35%) more than expected for those aged 65 years or over (Semenza et al, 1999). The majority of this excess (59%) was due to dehydration, heat stroke and heat exhaustion. There were no significant increases in admissions for cardiovascular diseases or respiratory diseases, despite these conditions being a cause of death in mortality studies. However, when existing medical conditions were considered alongside the primary reason for admittance, there was a significant increase in the number of people with cardiovascular disease and respiratory disease, along with diabetes, renal problems, epilepsy and emphysema. Thus, during heat waves people with underlying medical conditions are more at risk of being admitted for a heat-related illness.

An additional illness associated with high temperature is food poisoning. Hot weather can directly affect rates of food poisoning by increasing the multiplication of pathogenic micro-organisms such as salmonella in food (Bentham, 2001). Indirectly, high temperatures and sunny weather can induce a change in diet and

method of food preparation (e.g. an increase in barbecues) that increases the risk of food poisoning (Bentham, 2001). There is also some evidence that hot weather affects food early in the production or distribution system, as the effects of high ambient temperature on food poisoning appear strongest two to five weeks after the temperature increases (Bentham and Langford, 2001; D'Souza et al, 2004).

Hot temperatures have also been found to affect mental health. The seasonality of mental health is well known, and is likely related to changes in weather (see Box 1). Some studies for instance report an increase in suicide with high temperatures (e.g. Deisenhammer et al, 2003), and several neurobiological and psychosocial theories have been suggested to explain these findings (see Deisenhammer (2003) for a review). Furthermore, several studies report that this association is stronger for violent suicides than for non-violent suicides (e.g. Maes et al, 1994).

Low ambient temperatures

The number of deaths due to low temperatures is considerably higher than those due to excessive heat, with excess winter mortality² in England and Wales estimated to be between 20,000 and 50,000 a year (ONS, Office for National Statistics, 2003). The most direct cause of death from cold temperatures is hypothermia, when the body becomes unable to generate sufficient heat to function properly. However, deaths from hypothermia are fairly low, with an average of 491 deaths per year in England and Wales occurring between 1982 and 1997 (Chantler and Kelly, 1999). As with heat-related mortality, the most common causes of death due to low ambient temperatures are cardiovascular disease, cerebrovascular disease and respiratory disease (e.g. The Eurowinter Group, 1997). However, the effects of cold temperatures are more gradual than those seen with heat, with cardiovascular deaths occurring two days after a cold peak and deaths from respiratory disease occurring 12 days after (Keatinge, 2000). Deaths from cardiovascular disease are the result of the blood thickening in cold weather, which increases the risk of coronary and cerebral thrombosis (Keatinge, 2002). The increase in deaths from respiratory disease is thought to be due firstly to people gathering together in confined and poorly ventilated spaces, which increases the opportunity for cross-infection, and secondly to the cooling of the upper respiratory tract, which reduces its ability to counter infection (Keatinge, 2002). Elderly people are particularly at risk of a cold-related death, but this risk appears to be widely distributed across the elderly and does not depend on socio-economic status (Wilkinson et al, 2004).

²Excess winter mortality is calculated as winter deaths (deaths occurring in December to March) minus the average of non-winter deaths (April to July of the current year and August to November of the previous year); ONS (2003).

Low ambient temperatures also see a large increase in non-fatal illnesses, particularly respiratory diseases that place a huge burden on health services. Among the elderly, each degree Celsius decrease in temperature below 5° C sees a 10.5% increase in respiratory consultations to GPs up to 15 days later (Hajat and Haines, 2002). There also appears to be variation within the UK with a 5% increase in the South East and a 15% increase in Norwich and Newcastle (Hajat et al, in press). The strongest effects are seen for asthma but increases in consultations are also seen for the common cold, acute sinusitis, acute pharyngitis and acute tonsillitis.

Work between the Met Office and London School of Hygiene and Tropical Medicine has found that cold temperatures combined with other meteorological factors may influence the timing and amplitude of respiratory infections in the winter. It appears that low wind speed and low boundary layer (lowest level of the troposphere) may contribute to the rise in winter infectious disease.

1.3 Thunderstorms

Thunderstorms have been found to affect health for a number of reasons. Direct effects on health such as being struck by lightning are relatively uncommon, injuring on average 49 people a year in England and Wales and causing around three deaths (Elsom, 2001). However, indirect effects can be substantial. There have been numerous reports of increased asthma attacks during and following thunderstorms both in the UK (e.g. Venables et al, 1997) and abroad (e.g. Dales et al, 2003). Typical thunderstorms alone do not seem to increase rates of asthma seen by hospital departments (Newson et al, 1997). Reports of thunderstorm-related asthma suggest that high levels of grass pollen (Marks et al, 2001) or fungal spores (Dales et al, 2003) in the days preceding the thunderstorm are important contributors.

A prime example of thunderstorm-related asthma in the UK occurred in June 1994 when a thunderstorm in South East England saw 640 patients presenting with asthma to hospital casualty departments in the area, ten times the usual number of patients with this condition (Wallis et al, 1996). The daily average pollen count was exceptionally high for London two days before the epidemic and remained high until the thunderstorm occurred. Pollen released during the days before the thunderstorm would likely have been deposited on surfaces in the city and been resuspended by gusting winds. It is likely that this high concentration of pollen triggered asthma among certain people (Wallis et al, 1996). Case control studies looking at risk factors for thunderstorm-related asthma report that an allergy to grass pollen, a history of hayfever, and not having taken inhaled steroids during the thunderstorm increases the risk of an asthma attack (e.g. Wardman et al, 2002). Consequently, inhaled steroid use may be effective in preventing severe attacks during spring and summer thunderstorms (Girgis et al, 2000).

1.4 Heavy rainfall and flooding

Periods of heavy rainfall have the potential to indirectly affect both physical and mental health. For instance, heavy rainfall is commonly found preceding outbreaks of diseases associated with drinking water such as cryptosporidium. Between 1948 and 1994, 51% of the 548 outbreaks of waterborne disease reported in the US were preceded by an extreme rainfall event (Currierco et al, 2001). Increases in rainfall may lead to changes in the direction of flow of water systems, causing water to flow through channels that would not normally occur (Hunter, 2003).

In some cases, an increase in rainfall is followed by flooding, which brings its own set of health problems. Immediate effects are caused by floodwater, and can include deaths from drowning, heart attacks and injuries (WHO, 2003). Floodwater entering the home may be contaminated with sewage or animal waste, causing an increase in the risk of infections such as gastroenteritis (Reacher et al, 2004). Injury rates may increase as people return to their homes to clean up damage and debris (WHO, 2003). However, the major health hazard of flooding comes from the stress of temporary relocation, damage to the home, and loss of possessions, which can cause long term mental health problems such as anxiety, depression and psychosocial disturbances (WHO, 2003; Reacher et al, 2004).

1.5 Strong winds

Deaths and injuries from the direct and indirect effects of gales are small in the UK, and on average between 1962 and 1993 caused six deaths and 144 minor injuries each year (Buller, 1993). Injuries can arise directly, from people being blown over in high winds, or indirectly, from falling trees or flying debris. However, the most severe injuries occur from road traffic accidents, as trees fall into roads, or as vehicles are blown over or into one another (Baxter et al, 2001) (see also road accidents, Section 2.1). On 1st February 1983, the injuries resulting from severe gales in two main hospitals in Leeds were analysed. A total of 116 patients were treated in the hospitals as a result of the high winds, and three people died. The majority of injuries occurred when people were blown over whilst walking outside, and could have been avoided if people had been warned to stay inside (Illingworth and Illingworth, 1984).

1.6 Snow, ice and freezing rain

Levels of fractured wrists, arms, and hips increase dramatically during periods of ice and snow (Ralis, 1981), and freezing rain. During one incident of freezing rain in Berkshire in 1995, an Accident and Emergency department reported a threefold increase in fractures of the hip (10 cases over two days), and a six fold increase in fractures to the forearm (50 cases over two days) (Bird et al, unpublished). Other

injuries that have been reported to increase during freezing rain are fractures to the ankle and injuries to the back (Smith and Nelson, 1998).

Heavy snowfall, along with other extreme weather events such as severe gales, has the potential to affect access to health care, deterring people who are ill from visiting health services, and preventing health care professionals from visiting and treating people in their homes. Additionally, with severe weather affecting the flow of transport, adverse conditions may also impinge on the timely provision of medical supplies to health services.

1.7 Use of meteorological information to improve health and health services.

The ability to predict weather offers valuable information that can be used in health promotion to advise the public, and by health services to help predict and manage fluctuations in health care demand. Appropriate use of meteorological intelligence should help:

- Improve health by reducing mortality rates, reducing health inequalities, and tackling the determinants of ill health and health inequalities;
- Improve health outcomes for people with long term conditions;
- Improve access to services including predicting pressures on Accident and Emergency units and Primary Care access; and consequently
- Improve patient and user experience.

(Public Service Agreements 2005-2008; HM Treasury, 2004)

Meteorological information is currently being used in a number of ways within public health. An awareness of the relationship between meteorological variables and health has prompted numerous seasonal campaigns such as the 'SunSmart' campaign, run by Cancer Research UK, and the 'SunSafe' campaign, run by the Department of Health. These campaigns utilise websites, the media and other printed material to raise awareness of skin cancer and to offer practical advice about protection in the sun. Additionally, the Department of Health's 'Keep Warm, Keep Well' campaign targets advice to the elderly on staying warm during the winter months.

Meteorological forecasts of extreme or severe weather issued by the Met Office³ are often used to ensure that the public receives advice when it is needed most. Following warnings of heat waves for instance, the Department of Health often issues advice to the public via the media on coping with increased temperatures and exposure to the sun (e.g. Department of Health, 2003b).

³See <http://www.met-office.gov.uk/publicsector/nsws/warnings.html> for information on warnings provided by the Met Office.

Box 1: Seasonal trends in health

There are a number of well-known seasonal trends in health that are at least partly related to changes in weather. The use of meteorological data may offer greater understanding of the epidemiology of these conditions. These include:

Infectious diseases:

Influenza is perhaps the best-known seasonal disease, with sharp peaks occurring during the winter months. The virus can lead to huge increases in the number of consultations made with GPs, and a rise in the number of people admitted to hospital with complications such as pneumonia (HPA, Health Protection Agency 2003a). Respiratory syncytial virus (RSV) and meningococcal disease also see seasonal variations, with rates increasing during the winter months. (HPA, 2003b; HPA, 2003c).

Sexually Transmitted Infections (STIs) show a biphasic seasonal pattern. There is a substantial peak in diagnoses for chlamydia, gonorrhoea, herpes, syphilis and trichomoniasis at Genitourinary Medicine (GUM) clinics during the third quarter of the year, and a less pronounced peak during the first quarter of the year for all conditions other than gonorrhoea (Wellings et al, 1999).

Abortions:

Terminations of pregnancy reach a peak in the first quarter of each year, and see the lowest rate in the fourth quarter of the year (ONS, 2001).

Birth weight:

There is a seasonal pattern in birth weight, with babies born during late spring and summer months having a lower mean birth weight than those born during winter months (Murray et al, 2000).

Mental health:

Seasonal Affective Disorder (SAD) is a unipolar or bipolar mood disorder that follows a strict seasonal pattern and is characterised by symptoms such as excessive sleeping, increased appetite and weight gain. A lack of sunlight during the winter months may contribute to the onset of SAD, affecting levels of serotonin (a neurotransmitter involved in depression) in the brain, which can alter mood (Lambert et al, 2002).

Suicide levels also display a seasonal trend, although some studies suggest that this pattern is only evident for violent (and not non-violent) suicides (Preti and Miotto, 1998). In general, levels of suicide show a peak in the late spring and early summer months (e.g. Preti and Miotto, 1998; Salib and Gray, 1997).

Further to this, in July 2004, a comprehensive national plan for heat waves was issued by the Government (Department of Health, 2004a), with the aim of setting out the preparations needed to be able to cope with a severe heat wave in England. The plan highlights the responsibilities of health and social care professionals at a national and local level in reducing the risks associated with severe hot weather. A 'heat-health watch system' is central to the plan, based on predicted and actual temperatures recorded from the Met Office. Thresholds vary between regions, ranging from 28°C in the North East to 32° C in London, and trigger responses from a range of collaborating organisations including the Met Office, the Department of Health, the Health Protection Agency, Primary Care and NHS Trusts, Strategic Health Authorities and Local Authorities. Responses include: issuing advice to the public and health care professionals, monitoring levels of heat-related illness, identifying and providing daily contact with those individuals most at risk of a heat-related illness, preparing hospital equipment and services, and ensuring that utility companies do not suspend water or power supplies to homes during this period. The system started for the first time in August 2004.

Forecasts of other types of weather are currently utilised within public health, but to less of an extent. Following warnings of a cold spell from the Met Office, the Department of Health will sometimes issue advice to the public via the media about keeping warm during low temperatures. Additionally, recognising that deprivation impacts significantly on the level of cold-related illnesses, the Government issues cold weather payments to provide extra help towards heating costs for the poorest and most vulnerable members of society during cold periods. A payment of £8.50 is issued automatically to people on lower incomes when the average temperature is recorded as, or forecast to be, 0° C or below over seven consecutive days (Department for Work and Pensions, 2004). Cold weather warnings could be effectively used alongside seasonal campaigns such as 'Keep Warm, Keep Well' to provide timelier, targeted advice to the public, and alongside current winter preparations for the NHS (e.g. Department of Health, 2004b) to better prepare health services for increases in illness and mortality during cold spells.

Heavy rainfall and severe weather warnings from the Met Office are used by the Environment Agency to provide advanced notification of the likelihood of flooding. Since 1996, the Agency has been operating a flood warning system across much of England and Wales, disseminating warnings to affected communities, so that they can take action to protect themselves and their properties. Warnings are disseminated directly via flood wardens, loud hailers and telephone calls, and indirectly through local media.

Looking more specifically at the impact of weather on demand for health care services, the Met Office has been piloting a health weather forecast model in many parts of England and Wales that aims to use weather and climate data to predict

fluctuations in workload within the NHS, and aid effective delivery of healthcare services.

A Hospital Forecast model utilises meteorological forecasts alongside other information such as air quality, levels of aeroallergens, current respiratory infection data and real time NHS workload data, to provide information to hospitals and other emergency services on expected levels of emergency admissions, and the predicted average length of stay of patients. The model allows services to predict periods of low demand for treatment, as well as rises in demand to enable more efficient management of treatment and necessary staffing levels. In addition, the system allows hospital and GP services to be warned about rare events such as asthma-triggering thunderstorms that may require an increase in specific medication.

During the winter of 2004/05 the Met Office will work with eight Strategic Health Authorities in forecasting Chronic Obstructive Pulmonary Disease (COPD) admissions. A full time health professional, employed by the Met Office, will work with Primary Care Trusts (PCTs) to target vulnerable COPD patients before the weeks of high risk. This allows the PCTs to target high-risk patients before their risk increases.

In addition to aiding the management of staffing levels within health services, meteorological forecasts also have the ability to predict the health of the staff themselves. For instance very high and low temperatures may increase demand for treatment within hospitals and GP practices, requiring greater numbers of health care professionals, but may also reduce the number of staff fit for work. Little empirical work is currently available on this issue.

Section 2: Wider public health impacts

Fluctuations in weather also have wider public health impacts, influencing levels of road traffic accidents, alcohol consumption, and crime and violence. This section briefly summarises relevant literature, examines how meteorological data are currently being used within some wider public health settings and examines ways in which meteorological intelligence could be better exploited.

2.1 Road traffic accidents

Different weather conditions influence the risk of a road traffic accident occurring, affecting driver capability, vehicle performance, friction on the roads and pavements, and the total number of vehicles on the road. However, since information about the proportion of people travelling in different conditions is not easily determined, it is difficult to estimate the actual level of risk associated with different weather conditions.

The majority of road accidents in England and Wales (between 70% and 85%) take place in fine weather (Edwards, 1996). This could be due to the increased likelihood of people travelling in fine weather and the subsequent higher number of vehicles on the roads. The most common adverse weather condition recorded during accidents is rain, which accounts for between 12% and 17% of all road accidents in England and Wales (Edwards, 1996). This may be due to a combination of increased traffic volume (as road users choose to take their cars instead of walk or use public transport) as well as increased likelihood of skidding on wet roads (Edwards, 1998). The risk posed by rainfall depends to some extent on the length of time since it last rained; a long dry period before rainfall dramatically increases the risk of a road accident (Eisenberg, 2004).

Other adverse weather variables recorded during road accidents are fog, snow and ice, although total numbers of accidents occurring in these conditions is low in Great Britain compared to those occurring in fine or wet weather (Department for Transport, 2002), and this likely reflects the low incidence of foggy or icy conditions generally seen during the year. The use of grit on the roads greatly reduces the risk of an accident from ice, but untreated roads or rainfall that washes the grit away before freezing on the roads can cause high numbers of accidents (e.g. BBC, 2004). High winds can also cause problems for motorists, particularly for high-sided vehicles that have a higher risk of being overturned (Baker and Reynolds, 1992). Although certain adverse weather conditions appear to increase the risk of traffic accidents, the relationship is far from simple. Accident numbers often decrease in extreme weather such as snow, with drivers either taking more care on the roads, or cancelling their trips altogether (Edwards, 1998).

Weather warnings issued by the Met Office are used by a number of authorities to reduce the level of accidents seen in the community. Motoring warnings of weather that may cause disruption to traffic⁴ are issued to police control centres, and are disseminated via local and national media centres to road users. Additionally, forecasts of predicted ambient temperatures and road surface temperatures during the next 24 hours are issued to local councils during the winter months, to determine when roads in the area need to be salted.

2.2 Alcohol consumption

While moderate drinking can provide health benefits to an individual, high levels of alcohol consumption and associated harm is a concern for public health (Strategy Unit, 2004). Weather can affect levels of alcohol consumption, with sales increasing during hot and sunny weather as people seek out pub beer gardens in the sunny weather or stock up for garden parties and barbecues (Mintel, 2003a). During the 1976 heat wave for instance, more than two million additional pints of beer a day were sold compared to similar periods in 1975 or 1977 (British Beer and Pub Association, 2003). This could be due to greater numbers of people inclined to socialise and drink during sunny weather, but also to higher amounts of alcohol being consumed by individuals during hot weather to keep cool. Rises in alcohol consumption during hot and sunny days can generate associated problems such as a rise in the levels of drink driving (e.g. BBC, 2003) and potentially higher levels of crime and public disorder (see Section 2.3).

Increased awareness of the effects of hot temperatures on alcohol consumption has resulted in national and local summer campaigns for drink driving such as the Department of Transport's 'Think!' campaign, which uses television and radio advertisements, leaflets and posters to warn against the dangers and consequences of drink driving. Occasionally, the advice issued by the Department of Health before a heat wave will include limited information about the accelerated effects of alcohol in hot weather and advice on avoiding dehydration (e.g. Department of Health, 2003b).

In general, broader public health, especially on a local basis, has not utilised meteorological intelligence. Alcohol-related health promotion may prove most effective at reducing dangerous drinking if issued in advance of hot periods when bars and pubs see greater numbers of customers, and when higher quantities of alcohol are consumed. Greater availability of water and promotion of non-alcoholic drinks during these periods may reduce not just pressures on health services but also those on police. Equally, police may utilise meteorological data to predict increases in alcohol-associated problems such as drink driving and violence.

⁴ Warnings cover severe gales, heavy snow, blizzards, heavy rain, dense fog, glazed frost, or widespread icy roads.

Box 2. Seasonal trends in public health

There are a number of seasonal trends within public health that are likely related to changes in weather. These include:

Rates of fires:

Levels of fires occurring in the UK show a strong seasonal trend that is likely related to weather conditions. Seasonal trends are strongest for outdoor fires, with greater numbers of grassland fires reported during April than December (April 2002 saw an average of 514 fires a day compared to just 22 per day in December 2002). Total numbers of fires reported during the year depend to some extent on weather conditions experienced during the summer months. Years that experience hot and dry summers (such as 1995 - a total of 174,600 fires), report a greater number of fires throughout the year than those with wetter summers (such as 1998 - 40,900 fires; and 2002 - 65,700 fires). A different, less marked seasonal variation is seen for fires within dwellings, with higher numbers of fires per day occurring during the winter months than summer months (ODPM, Office of the Deputy Prime Minister, 2004).

Variations in diet:

A number of seasonal changes in diet have been reported in the UK. For instance, sales of barbecue foods such as burgers are highly seasonal, with a sharp increase seen during the summer months (Mintel, 2004). Fruit and vegetable consumption also shows a seasonal trend, with the percentage of men and women eating the recommended five portions of fruit and vegetables a day highest during the summer months (Department of Health, 2003a). Variations in vegetable consumption are dependent to some extent on the weather; years that experience a late start to the summer season see lower sales of salads than normal, while years that experience particularly hot summer weather report an increase in the salad market (Mintel, 2003b).

Levels of exercise:

Adults in the UK spend greater amounts of time per week engaging in physical activity during the spring and summer months compared to winter or autumn (e.g. Pivarnik et al, 2003), with the amount of time spent exercising peaking during July (Uitenbroek, 1993).

2.3 Violent crime

Variations in ambient temperature can affect the level of violent crimes seen in the community. Rates of assaults (e.g. Rotton and Cohn, 2000), domestic violence (e.g. Cohn, 1993), and collective violence⁵ (Carlsmith and Anderson, 1979) have all been reported to increase during hot weather. These rises, at least in part, may be related to rises in alcohol consumption during high temperatures, as alcohol intoxication increases a person's likelihood of being both a perpetrator and victim of aggression and violence (McClelland and Teplin, 2001). Thus, the relationship between temperature and violent crime is dependent on temporal factors such as time of day, day of week and season (Cohn and Rotton, 2000), with the relationship between temperature and assault being strongest during the evening hours and weekends (Cohn and Rotton, 1997). High temperatures may also have a direct influence on violence by increasing feelings of hostility and aggressive attitudes and beliefs, which reduce a person's tolerance for annoyances (Anderson, 2001).

In general, the application of weather forecasts to alleviate problems of violent crime has been relatively unexplored. However, heat warnings may be useful to police services as well as health services to predict increases in violent behaviour especially over weekends or holiday periods. Thus, in both health and judicial settings, meteorological data can help plan what interventions are required, where pressures on systems will develop, and how staffing levels might be managed to accommodate busy periods.

⁵ The use of violence by people who identify themselves as members of a group, against another group or set of individuals (WHO, 2002).

Section 3: Accuracy and source of weather forecasts

The usefulness of weather forecasting as a public health tool relies to a large extent on obtaining accurate and timely meteorological information. Temperature appears to have the most impact on health, and is also the easiest weather variable to predict, with a high degree of accuracy (greater than 80%), 3-5 days in advance, a moderate degree of accuracy (greater than 60%), 5-10 days ahead, and a low degree of accuracy (40-60%) more than 10 days in advance. The occurrence of localised events such as snowfall or thunderstorms can be predicted with a high degree of accuracy 1-2 days ahead, a moderate degree of accuracy 3-5 days ahead, and a low degree of accuracy 5-7 days ahead.

However, in some cases, the accuracy of a weather forecast would not necessarily be important. For example, the mean time between a temperature drop in winter and a peak in respiratory admissions in hospital is approximately 12 days (Keatinge, 2002) Thus, it is possible to predict an increase in health care demand from actual rather than forecasted temperatures.

Actual and forecasted weather conditions can be sourced directly from the Met Office web site (www.metoffice.com), and include a five day forecast for major towns and cities, and regional advanced warnings of severe weather events.

Conclusion

Weather forecasting has long been an under utilised tool within public health and other health services, but its ability to predict threats to health is beginning to be recognised and steps are now being taken to incorporate forecasting into public health practice. However, while meteorological information is beginning to be used effectively to manage health and health services, it is currently used to much less of an extent within other public health areas such as alcohol consumption and violent crime. Consequently local, regional and national services should explore the potential for meteorological forecasts to inform both health and judicial systems.

More research is needed to further understand the effects of weather on public health. To date, most of the research on weather and health has concentrated on the effects of extreme temperatures on mortality levels. Further research needs to focus on the effects of weather on morbidity, and on the health effects of less extreme temperatures. Additionally, for diseases with known seasonal trends, meteorological data may offer greater understanding of the epidemiology of these diseases.

The use of weather forecasting has the potential to contribute to attaining national standards for access and care, for issuing timely public health information on a

population basis, and taken together to reduce levels of mortality and health inequalities generated by fluctuations in the weather. Furthermore, with growing concern about the possibility of global warming, knowledge of the relationships between weather and health can help us predict the public health impact of future climate change.

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