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Effect of weather on GP home visits:

a cross-sectional study

Abstract

Background
GPs in the UK conduct >13 million home visits each year. The visits, which are resource intensive, are usually to the frailest patients who are least resilient to adverse weather.

Aim
To explore the relationship between meteorological variables (temperature, rainfall, sunshine) and temporal variables (day of the week, season) with GP home visits (HVs).

Design and setting
A cross-sectional study using data provided by Herts Urgent Care for its GP acute in-hours visiting service and UK Meteorological (Met) Office weather data for the Herts & South East region of the UK.

Method
The association between the number of GP HVs and weather and temporal variables was explored using univariable and multivariable negative binomial regression.

Results
There was a significant 0.4% decrease in HVs per degrees Celsius increase in minimum temperature (incidence rate ratio [IRR] 0.996, 95% confidence interval [CI] = 0.993 to 0.999), and a 0.4% decrease per hour increase in sunshine (IRR 0.996, 95% CI = 0.992 to 1.000), as well as significant decreases in weekday HVs compared with Mondays (Thursday IRR 0.824, 95% CI = 0.790 to 0.859). There were 6.2% fewer HVs in summer compared with winter (IRR 0.938, 95% CI = 0.902 to 0.975). Multivariable negative binomial regression showed non-significant relationships between meteorological variables and HVs, but a significant day-of-the-week relationship.

Conclusion
GP HVs increased on cold days and fell on sunnier days. The effect sizes were small so it is unlikely that there is any clinically significant effect of weather on HVs in this acute GP visit setting. A tentative conclusion might also be that GPs in this system can deliver care to frail housebound patients in most weather conditions.

Keywords
consultation; general practice; Hertfordshire; home visits; meteorology; weather.

INTRODUCTION

Treating patients at their own home has always been part of a UK NHS GP's workload. As home visits are estimated to represent >13 million consultations throughout the UK each year, any associations with weather patterns might have implications for GPs' workload and, due to the volume of care delivered by primary care (90% of NHS activity), any small effect may have an amplified impact on the wider NHS, such as A&E attendance and ambulance usage.

GPs are under increasing pressure with regards to their workload. Between 1998 and 2014 there was a 24% increase in GP consultations (including an increase of 40 million since 2008), with 340 million annual consultations delivered by a primary care workforce of 42 000.[1]

GP home visits are a fundamental aspect of UK primary care and are usually reserved for those who are housebound, permanently or temporarily through illness. These are more likely to be those who are frail and older, who are less mobile, and who may experience difficulties accessing GP services during adverse weather, such as when it is very cold or wet. Ensuring delivery of effective community-based care to this group is often cited as key to models of long-term sustainability of the health service.[2]

Home visits accounted for around 2–4% of the 340 million annual GP consultations conducted in 2014,[3] and are the most time-consuming type of consultation. On average, they take 23.4 minutes versus 11.7 for surgery consultations (2006/7 data).[4] GP visit rates have decreased steadily by about 2% per year.[5] At the same time, more older patients are living in the community.

Winter pressures present a major challenge for the NHS, with an increased burden of respiratory infections in primary care,[6] increased proportions of older people attending A&E, a reduced ability of social services to provide care to the vulnerable during adverse weather,[7] and increased proportions of patients needing to be admitted to hospital.[8] Part of winter pressures is the effect of flu, with the older frail more susceptible to influenza-like illness, and its more serious consequences, which peaks in winter months.[9]

Cold temperatures in the UK have been shown to have an impact on population mortality,[10] but are thought to have little direct temporal relationship with primary care consultation rates.[11] There is, however, a strong association with temperature levels 15 days previously, suggesting a relationship with cold weather and infection.[11] This delayed effect of cold weather has also been seen in warmer countries, such as Greece.[12] Conversely, the Greek study found a positive correlation between relative humidity and the proportion of house call visits for respiratory infections. More widely in primary care, a relationship has been demonstrated (in Birmingham, UK) between extreme weather — both hot and cold — and increased ambulance call-out and response

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How this fits in

Winter pressures on the NHS (particularly on A&E services) have been studied extensively in the UK. Previous research has found an association between cold weather and respiratory infections in primary care, and the number of ambulance call-outs and weather. This paper examines links between weather throughout the year and the provision of acute GP home visits, and suggests this is a robust model that appears to deliver a key NHS service in most weather conditions.

times.[13] Internationally, adverse weather affects emergency ambulance service calls in Hong Kong.[14] Weather factors predict the demand for emergency ambulance services by older people, people with more severe conditions, and those from lower social economic groups.[14]

Other research has looked at the impact of the weather on people with specific health conditions such as asthma.[15] Studies looking at the association between thunderstorms in 1994 and acute asthma found that epidemics of acute asthma consultations related temporally and spatially to thunderstorms throughout England, Scotland, and Wales.[16,17]

There is evidence of an impact of weather on specific groups and those with specific health conditions impacting on UK GP services, and international research that suggests a broader impact of adverse weather on primary care/emergency services, but there is no research exploring whether adverse weather impacts on GP home visiting, a key element of NHS service resilience.

METHOD

This is an exploratory study using a cross-sectional analysis comparing the absolute numbers of GP visits delivered by an acute GP visiting service and weather data provided by the UK Meteorological (Met) Office.

Setting

Hertfordshire is a UK county on the outskirts of London, and is home to >1 million residents. The out-of-hours (OOH) provision for Hertfordshire is provided by Herts Urgent Care (HUC). It also provides a unique service that offers (and systematically records) GP home visits for new and acute problems for this population. The service is called the acute in-hours visiting service (AIHVS). Within the service, calls are triaged against eligibility criteria, before details (a clinical summary and the clinical problem from the patient's GP) are passed to a GP in a HUC car with a driver. The service does not cover all home visits for pre-planned or ongoing issues, for example, palliative care. Practices can elect not to use the service, and there is a cap on workload (usually two visits per practice per day), which may be reduced if HUC has staffing issues. Home visits are conducted on weekdays only from 8.00 am to 6.30 pm. The OOH service operates separately, and the OOH data are not included in this study.

Weather data

Weather data were obtained with permission from the UK Met Office. The data related to that available from two weather stations, Rothamsted and Heathrow. Rothamsted is within the Hertfordshire region. The weather variables that were taken from this station were:

- daily minimum temperature (°C);
- daily total rainfall (mm), and
- number of hours with relative humidity ≥90%.

Heathrow weather station gathers comprehensive weather data and was used to collect information on hours of sunshine. This weather station is the closest that could provide this data and is located around 40 miles (64 km) south of Hertfordshire.

Minimum temperature was divided into two groups, cold and not cold, for analysis, with 4°C the cut-off between the two groups based on changes in physical activity in older patients.[18] The data were also combined to compare home visits on days with rain versus no rain. For rainfall, no rain was defined as the number of millimetres of rain being zero. Conversely, days with rain were defined as days with any rain.

Statistical analysis

Statistical analysis was performed using IBM SPSS Statistics software (version 24) and Stata (version 14). Negative binomial regression was used to investigate associations between weather conditions, temporal factors (season [based on the equinoxes] and days of the week), and home visits. Univariable analysis of each weather and temporal variable was carried out, and then a multivariable analysis was performed.

RESULTS

In all, >2 years of data were retrieved (from 2 February 2015 to 31 March 2017), with

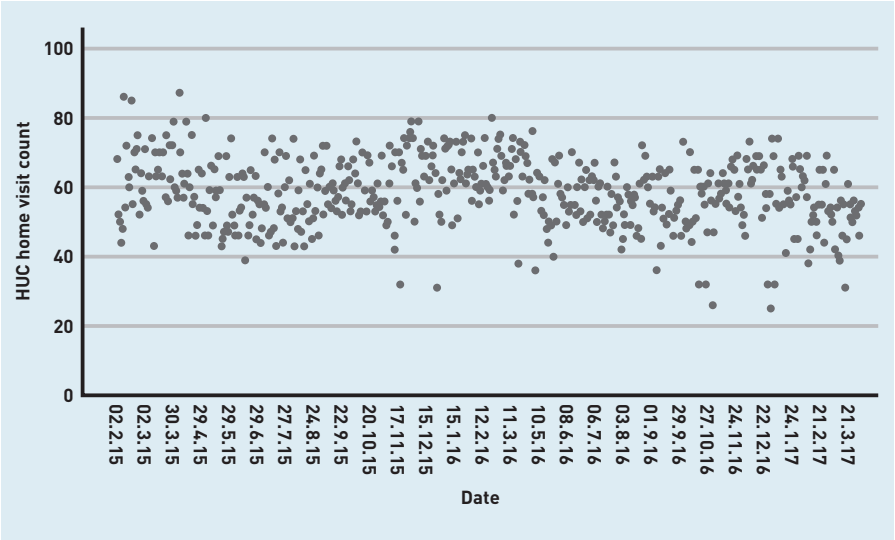


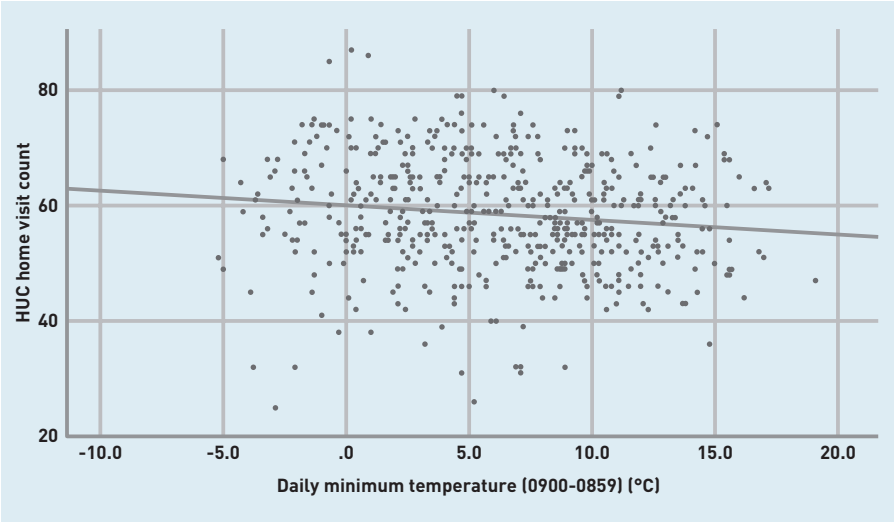
Figure 1. Herts Urgent Care GP visits by date.
HUC = Herts Urgent Care.

one missing period (from 5 April 2016 to 2 May 2016), providing information on 531 weekdays of home visits, with a mean of 58 visits per day (standard deviation [SD] 11) (Figure 1). The minimum number of visits was 25 and the maximum was 87 visits per day. The highest mean number of visits was on Mondays (*n* = 66, SD 7), whereas the lowest was on Thursdays (*n* = 55, SD 9). There were two extreme data outliers (1 and 126 visits), which have been removed from analysis as they are likely to be erroneous.

Home visits and temperature

There was a statistically significant 0.4% decrease (incidence risk ratio [IRR] 0.996, 95% confidence interval [CI] = 0.993 to 0.999) in the likelihood of a home visit for each degree Celsius increase in minimum daily temperature (Figure 2).

Figure 2. Daily home visits by minimum temperature.
HUC = Herts Urgent Care.



Cold versus not cold

In the univariable analysis, there was a 4.3% increase (IRR 1.043, 95% CI = 1.013 to 1.075) in the likelihood of a home visit when it was cold, compared with when it was not cold.

Home visits and number of hours of sunshine

There was a statistically significant 0.4% decrease (IRR 0.996, 95% CI = 0.992 to 1.000) in the likelihood of a home visit for every 1 hour increase in total sunshine.

Home visits and rainfall

There was a non-significant 0.1% increase (IRR 1.001, 95% CI = 0.997 to 1.004) in the likelihood of a home visit for each mm increase of rainfall per day (Table 1).

The authors found a non-significant 1.5% increase in the likelihood of a home visit when it rained compared to when it did not (IRR 1.015, 95% CI = 0.986 to 1.044) (Table 1).

Home visits and number of hours with relative humidity ≥90%

There was a non-significant 0.2% increase (IRR 1.002, 95% CI = 1.000 to 1.004) in the likelihood of a home visit for every 1-hour increase in duration of high relative humidity (Table 1).

Home visits and temporal variables

There was a significant day-of-the-week effect, with an 18% decrease (IRR 0.824, 95% CI = 0.790 to 0.859) in the likelihood of a home visit on a Thursday compared with a Monday. Similar findings were shown for Tuesday, Wednesday, and Friday. There was a significant decrease (6.2%) in the likelihood of home visits in summer compared with winter (IRR 0.938, 95% CI = 0.902 to 0.975) (Table 1).

Multivariable analysis

The multivariable model including all meteorological variables as continuous and temporal variables showed that there was no statistically significant effect on the number of GP home visits conducted when compared with all of the available weather variables. Minimum temperature, daily total sunshine, daily total rainfall, and relative humidity showed no significant effect. However, there was a strong day-of-the-week effect, with Tuesday to Friday showing a lower likelihood of a home visit compared with Monday. There was no significant effect of season (Table 2).

A multivariable analysis with cold versus not-cold variables instead of a continuous measure of temperature (Table 3) produced a non-significant 2.5% increase in the

Table 1. Univariate association between home visits and weather and temporal variables

Weather variable	IRR	95% CI
Minimum temperature, °C	0.996	0.993 to 0.999
Cold/not cold	1.043	1.013 to 1.075
Daily total sunshine, hours	0.996	0.992 to 1.000
Total rainfall, mm	1.001	0.997 to 1.004
Any rainfall	1.015	0.986 to 1.044
Hours with humidity >90%	1.002	1.000 to 1.004
Monday	**Reference**	
Tuesday	0.855	0.820 to 0.891
Wednesday	0.873	0.838 to 0.910
Thursday	0.824	0.790 to 0.859
Friday	0.867	0.832 to 0.904
Winter	**Reference**	
Spring	0.971	0.933 to 1.011
Summer	0.938	0.902 to 0.975
Autumn	0.986	0.949 to 1.025

CI = confidence interval. IRR = incidence rate ratio.

likelihood of a home visit on cold days (IRR 1.025, 95% CI = 0.990 to 1.061). The day-of-the-week effect persisted.

DISCUSSION

Summary

There were weak but significant univariate associations between the daily home visit rates and daily minimum temperatures, as well as daily number of hours of sunshine. This was an inverse relationship with poorer weather, that is, the colder and less sunny it was, the higher the GP home visiting rate was. Grouping the temperatures into cold versus not cold gave only a slightly stronger association, whereas a rain versus no rain analysis showed no significant association. In the multivariable analysis, these associations disappeared. Since these are non-significant small increases or decreases in activity, it is unlikely that the meteorological variables have any clinically meaningful effects. The day-of-the-week effect was already known and factored into service capacity, as is the winter effect and the NHS response to these winter pressures.[8]

The numbers of home visits delivered is likely to be a complex relationship between service supply and patient demand. On the demand side, the factors that might influence activity include perceived and actual healthcare need by a patient (or their carer) and a perception by the patient that they are housebound. This perception of being housebound is likely to be sensitive to environmental conditions, so, for example, if a person is frail and has a high fever they may feel less able to attend a GP's surgery if it is very cold outside. On the supply side, home visit activity will be determined by the GP's perception of clinical need for a face-to-face consultation, based on the symptom or condition described, previous knowledge of the patient, and the ability to provide that service balanced against other clinical demands. The AIHVS model will add some complexity to this interaction in that the patient's eligibility criteria must also be met and HUC must have enough doctors/drivers available to provide the visit, which may again be weather dependent. Bad weather is also likely to impact on the efficiency of the service, as it will take longer to reach each individual, reducing service capacity. In view of this presumed non-linear relationship between supply and demand, it was unlikely that the authors would see a strong relationship between weather conditions and GP visits delivered.

Table 2. Multivariable analysis of weather and temporal variables against HUC home visits

Weather variable	IRR	95% CI
Minimum temperature, °C	0.998	0.994 to 1.002
Daily total sunshine, hours	0.998	0.994 to 1.002
Daily total rainfall, mm	1.001	0.998 to 1.005
Hours with humidity >90%	1.000	0.998 to 1.002
Monday	**Reference**	
Tuesday	0.856	0.822 to 0.892
Wednesday	0.874	0.839 to 0.910
Thursday	0.824	0.791 to 0.859
Friday	0.867	0.832 to 0.904
Winter	**Reference**	
Spring	0.988	0.946 to 1.032
Summer	0.959	0.907 to 1.014
Autumn	0.993	0.954 to 1.034

CI = confidence interval. HUC = Herts Urgent Care. IRR = incidence rate ratio.

Strengths and limitations

These acute GP home visits are coordinated by one central organisation, HUC, so obtaining the data for analysis was a simpler task than from multiple GP practices. GP home visit data are usually poorly recorded, as GPs are remote from IT systems;[19] HUC data are used by commissioners to monitor the service, and thus are likely to be more reliably coded. Use of HUC data allows for a geographically defined population, where weather conditions experienced by patients

Table 3. Multivariable analysis of weather and temporal variables against HUC home visits (cold versus not cold)

Variables	IRR	95% CI
Cold	1.025	0.990 to 1.061
Daily total sunshine, hours	0.998	0.994 to 1.002
Daily total rainfall, mm	1.001	0.998 to 1.005
Hours with humidity ≥90%	1.000	0.998 to 1.002
Monday	**Reference**	
Tuesday	0.856	0.822 to 0.892
Wednesday	0.873	0.837 to 0.909
Thursday	0.824	0.791 to 0.859
Friday	0.867	0.832 to 0.904
Winter	**Reference**	
Spring	0.991	0.950 to 1.034
Summer	0.958	0.915 to 1.003
Autumn	0.998	0.958 to 1.039

CI = confidence interval. HUC = Herts Urgent Care. IRR = incidence rate ratio.

are likely to be broadly similar to Met Office recordings. The service is busy, providing the authors with a large dataset that is less prone to random variation in daily home visit rates than might be seen in single practice populations. The authors were unable to analyse population visit rate as the at-risk population was highly variable depending on a practice's use of the service. This also means that the authors are unable to say anything about other potential confounders, such as practice demographics (age, nursing home coverage) or registered patients per GP. Official meteorological data come from automated stations run by the Met Office and are recognised to be reliable. Importantly, the authors are looking at a dedicated home visiting service and how it behaves in adverse weather; this might not be the same for normal GP home visiting provision that may be more or less robust.

Additionally, the authors are looking at GP visits delivered, not visits requested. There is a presumed ceiling effect in service provision because it is known that the service refuses visit requests when its capacity is exceeded, so an increased demand may not translate to increased service provision. The in-hours service is delivered between 8.00 am and 6.30 pm. However, there can be a delay of up to 6 hours, so later home visits are known to be delivered by the out-of-hours service (and recorded as OOHs activity) during periods of excess demand, meaning there is potential for some home visit data to be lost from analysis. The AIHVS service is only delivered on weekdays, so the authors lose 2/7 of their combined study home visit and weather data points. It is also possible that adverse weather and seasonal illness may impact on the availability of GPs and drivers in the same way as it does on patients, that is, adverse weather may impact on service delivery. The way in which HUC triages requests for home visits is complex. Though most requests will be accepted, some are signposted to other services, such as district nurses. It is unclear whether this is more likely to happen during adverse weather. Some visits may be deferred by practices late in the day, so the request may not always be linked temporally to the weather conditions.

There are also variations in visiting rate transferred by practices to AIHVS, so a practice effect may be apparent, and practices are periodically allowed to refer more during periods of stress, such as doctor sickness, which will not be weather linked.

This type of study is vulnerable to the 'ecological fallacy'; not every area in Hertfordshire, covered by HUC, will experience the same weather pattern. The Heathrow weather station is located around 40 miles south of Hertfordshire. Therefore, between these two areas there is room for local weather variability. This problem may apply more to rainfall, which is highly locally variable, but it is less likely to be an issue with temperature and hours of sunshine (measured by the more distant weather station). Weather is also not uniform during a day, so a short heavy rain storm may have less impact on behaviour than all-day driving rain, and rain at night should have no impact. However, the authors' visit data will only link data broadly to the weather data for the corresponding 24 hours. Similarly, longer periods of bad weather may influence activity patterns, with people being able to defer visit requests for a few days.

Comparison with existing literature

The authors were unable to find comparable studies looking at GP home visiting for unselected conditions and weather. There are little data on how primary care activity is related to weather beyond occasional reports, as a cause of missed GP appointments.[20]

Implications for research and practice

The results of the analysis largely point to no clinically important association between the meteorological variables and rate of GP home visits. The need for extra capacity on

Mondays and in winter is already known to these services, but there is only one pool of GPs; if extra cover is being provided in winter there is presumably less clinical cover elsewhere (such as within 'normal general practices'). Although there are some statistically significant univariate associations, the effect sizes are small and disappear in the multivariable analysis. The possible good news is that this might be a resilient service that is able to deliver a GP home visiting service to the most vulnerable, in most weather conditions.

The occurrence of a delayed effect seen in other studies needs examination to determine, particularly for colder temperatures, whether there is a more significant association with lags from 1–20 days in temperature. The association with influenza could be examined. Influenza rates are highly seasonal and can have an effect on the number of home visits, especially with frail elderly patients. There could potentially be an opportunity to use more meteorological variables, and even more extreme weather circumstances, for example, snow, ice, hail, storms, floods, and so on. These more extreme weather events are rare in Hertfordshire, and would only generate one or two data points, so they may not be amenable to this type of analysis.

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Ethical approval

This study was approved by NHS Health Research Authority (IRAS Project ID: 221078) and UCL Research Ethics Committee (UCL Project ID: 16/0762).

Provenance

Freely submitted; externally peer reviewed.

Competing interests

Melvyn Jones is a clinician for Herts Urgent Care, for which he receives an honorarium. All other authors have declared no competing interests.

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