

Does the Weather Contribute to Admissions of Neck of Femur Fractures?

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Abstract

Background: The effects of weather on overall mortality are well documented. Anecdotally, icy conditions are perceived to result in more falls and admissions for neck of femur (NOF) fractures. The aim of this pilot study was to determine whether relationships could be extracted or at least not ruled out by analysing a small dataset, and so give impetus to a larger project. **Methods:** Seven trauma units across North West London were identified and NOF fracture data extracted for 5 years. Visual inspection of the time series, consideration of the weather on specific days and correlation analysis were used to assess associations between fracture numbers and a variety of weather parameters (temperature, rainfall, wind and ice risk). **Results:** Overall, 10929 individuals with hip fractures were admitted over the 5-year period. The highest number of admissions in a day was 14. No clear association was found between a weather parameter and daily admissions. However, when accumulated to a weekly timescale, a negative relationship with maximum temperature was found. No seasonal cycle was detected. **Conclusion:** The lack of a daily relationship and presence of a weekly relationship points to a possible delayed response to weather or insufficient daily data to extract a signal. The inconclusive results also indicate a larger data sample is required in future studies. In addition, even in cold weather an urban environment may not create icy conditions, being ameliorated by the heat island effect and gritting.

Keywords

neck of femur fracture, hip surgery, weather

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Introduction

The relationship between weather and health is long standing. Cold weather is related to increased mortality and higher numbers of admissions to hospital.¹ This is increased during times of protracted cold weather.² Myocardial infarction incidence is affected by extremes of weather, both hot and cold.³ A number of studies describe a V-shaped relationship with higher mortality rates at temperature extremes, improving as temperature normalizes.⁴⁻⁶ Atherton et al (2003) showed a relationship between paediatric and total number of trauma admissions with daily rainfall, the minimum and maximum temperature as well as day and month of year.⁷ Others have shown that when temperature goes below 1 degree Celsius the risk of falling, particularly in women, increase.⁸

A prospective study of 35 to 59 year old women identified increased forearm and hip fractures in colder climates.⁹ Similarly Lau et al (1995) identified seasonal trends in hip fracture admissions in New South Wales, with a trough in the summer and peak in winter.¹⁰ Other studies have highlighted the increase in

admissions around December and January, and postulated meteorological factors, slower reaction times and winter bone loss.¹¹ Rowe et al (1993) identified the reverse when looking at 405 fractures in Korea, with peaks being seen in the summer and autumn months, postulating that it may be related to increase in activities carried out during these months.¹² Recently, Johansen et al (2020) identified a winter peak 8% higher than the summer, as well as a higher 30 day mortality.¹³

Weather sensitivity analysis addresses the correlation of weather variables with other variables (for example from healthcare or business) to enable demand prediction and allow

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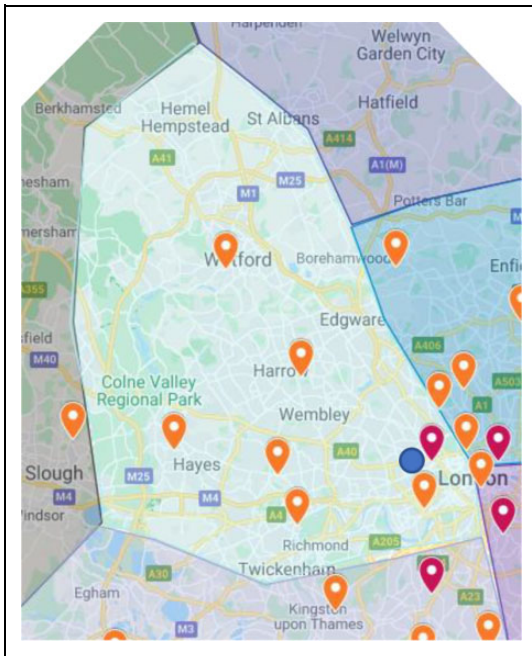


Figure 1. Map depicting the 7 hospitals within North West London Trauma Network. Orange markers depict Trauma Units. Red marker depicts Major Trauma Centre. Blue dot depicts the weather point where data was collected.

Image taken from Google Maps ©.

operational and strategic planning. Both actual amounts can be forecast or the probability of exceeding a key threshold. Weather sensitivity analysis also permits underlying trends to be exposed clearly and confidently by removing the generally short period impacts of changing weather. Applying weather information to clinical demand data can provide critical information for planning services according to clinical need. The UK Meteorological Office (Met Office) has worked with healthcare providers to create a warning system for patients with respiratory conditions.¹⁴ Weather information such as changes in temperature, which may result in an exacerbation of underlying respiratory problems, are used as prediction aids to warn the patients.

Hip fractures are common and frequent and carry a high mortality and morbidity.¹⁵ Most patients are managed following a hip fracture with an operation; this stems from the greater mortality in those patients not operated.¹⁶ The National Hip Fracture database (NHFD) guidelines state that early operative management (within 36 hours) results in optimal outcomes.¹⁷ The author's hospital has a dedicated hip fracture team and rely on one operating theatre. If more than one patient is admitted simultaneously with a hip fracture, there is pressure on hospital services to provide continuous elective and emergency care; this occurs frequently throughout the year. An accurate balance in demand and resources is needed for safe, cost-effective care.

If hip fracture admission patterns can be correlated with a dynamic variable such as weather, then healthcare providers can balance demand accordingly. The authors set out to

conduct a pilot weather sensitivity analysis to determine if hip fracture admissions could easily be explained by a link with only the weather or at least not dismissed, when using a small, localized sample of data. We hypothesized that some component of increased hospital admissions were related to weather conditions, with those leading to ice being intuitively the most obvious.

Method

An analysis approach was chosen that was appropriate for a pilot study working with limited data. This took the form of using an established dataset of weather parameters applicable to North West London. We did not correct for the many other factors which may influence risk of hip fracture, such as age, socioeconomic status, ethnicity, bone health, local terrain, holiday periods and national holidays.

Data

a. Daily Data

Hospital hip fracture admission data from 7 hospitals across the North West London Trauma network were analysed (Figure 1). The daily totals from all of the hospitals were aggregated to create a daily admissions dataset.

Observed weather from meteorological data archives which the Met Office maintain were used in the study. The weather data used was forecast analysis which is a term used to refer to a dataset which is used to set initial conditions in numerical weather prediction models, comprising of observations interpolated onto a spatial grid and can be treated as a proxy for weather conditions at a given point in time. The weather data was then extracted for a single site for the Kensington postcode area in West London, selected as it was deemed to be a central location for the various hospitals included in the study. Therefore, would be representative of the weather conditions across West London.

Meteorological parameters that were considered were maximum and minimum temperature (°C), total rain (mm), average wind speed (m/s), total sunshine (hours), maximum and minimum relative humidity (%). In addition, there were a number of derived parameters calculated including: time lagged and time averaged temperature; “feels like” maximum and minimum temperature which take into consideration wind chill and relative humidity; number of hours of rain for each day, which is calculated discretely as the number of hours during which it rained at some point during the hour (not total duration), and daily change in maximum and minimum temperature from the previous day.

An indicator for the potential risk of ice has also been calculated by considering days when any amount of rainfall is followed by the minimum temperature reaching below 1°C within a 6-hour time frame. This was used to identify when conditions were conducive to there being a risk of ice forming on road or pavements, not as an analysis component.

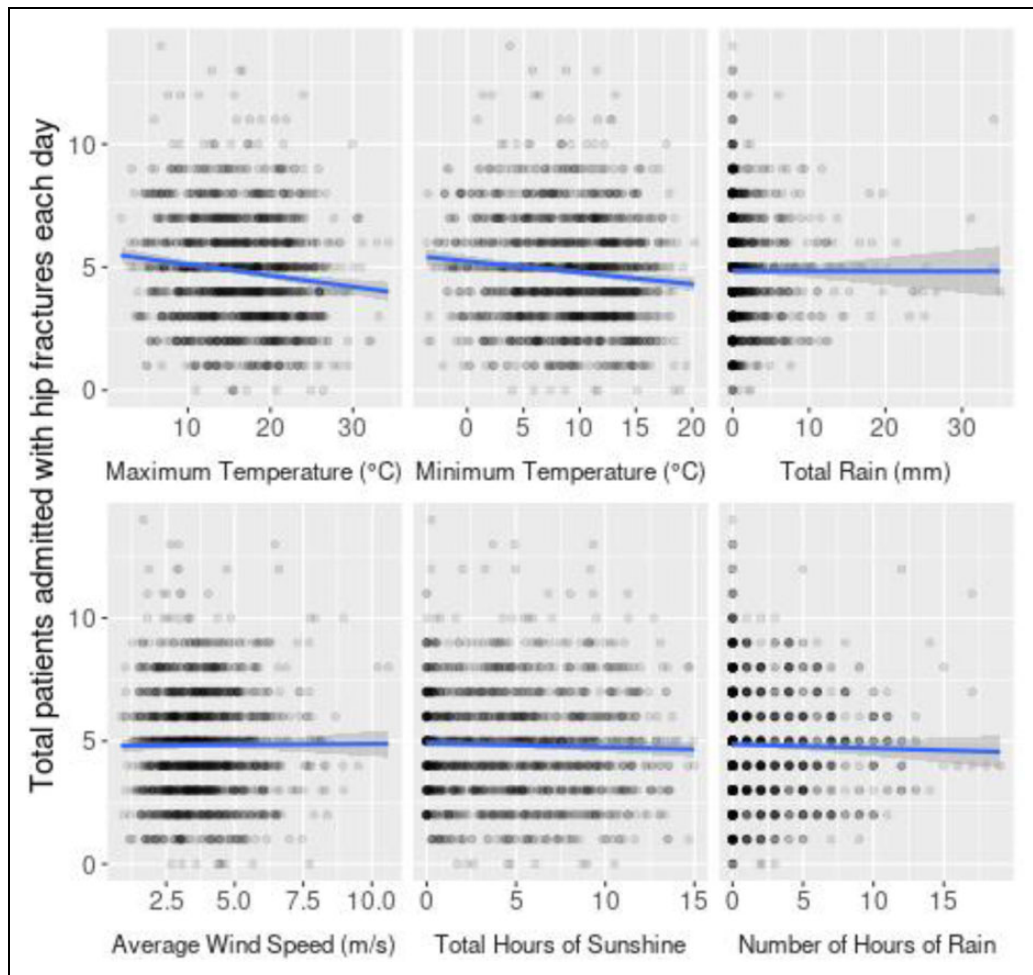


Figure 2. Admissions compared to temperature, rainfall, wind and sunshine. No statistically significant relationship between weather patterns and admissions.

b. Weekly data

To assess the presence of a relationship between hip fracture admissions and the weather over long time scales and amplify its temporal count structure, the hospital admissions data were accumulated to obtain weekly totals. An appropriate weekly transformation method was selected for each weather parameter: weekly maximum/minimum and average weekly maximum/minimum temperature, average weekly wind speed and weekly rainfall totals.

Analysis

In order to carry out a weather sensitivity analysis, both daily and weekly hip fracture admission totals were combined with the associated weather information applicable to the same time scales.

Methods employed to assess the presence of a relationship between the weather and hip fracture admissions include visual inspection of the data, making comparisons against individual weather parameters and supplementary correlation analysis to assess the strength of any relationships.

In order to understand whether there is any feature in weather conditions that may be driving days with the highest number of admissions, archived Met Office weather summaries were extracted for days which saw admissions of 13 and 14, the maximum. In addition, the weather summary was also extracted for the previous day to assess whether some change in weather conditions could also be having an influence in these cases.

Statistics

Pearson's Correlation coefficient was used for assessment of the relationship between admissions and weather parameter. For all statistical analyses, we used open source software.

Results

Overall, 10929 cases were admitted to the 7 hospitals in total over the 5-year period. Across all 7 hospitals the maximum number of neck of femur (NOF) fractures in one day was 14. Less than 1% of the days had no NOF fracture admissions across all sites.

Table 1. Description of Weather on Days With the Highest Number of Admissions.

Date	No. of admissions	Daily weather summary
10/02/2015	14	Max temp 7, min temp 0, Max temp 7, min temp 0, Dense cloud throughout the day but remained dry Previous day (09/02/2015): warmer max temperature but still very cold minimum temps ,sunny spells during the day
29/04/2014	13	Max temp 12, min temp 6 Misty start brightening up with sunny spells by midday Some showers later in the day Previous day(28/04/2014):Slightly warmed , heavy slow moving, Showers later in the day
17/02/2017	13	Max temp 14,min temp 12,cloudy start with some bright or sunny spells later on, light wind Previous day(16/02/2017):much the same
05/10/2016	13	Max temp 18, min temp 10 Fairly benign day, fine and sunny, South westerly breeze making it feel cool Previous day(04/10/2016)): much the same

Table 2. Summary Statistics of Admissions Subdivided into Seasons.

	Winter	Spring	Summer	Autumn
Mean	5.1	4.8	4.6	4.8
Max	14	13	12	13
Min	0	0	0	0
Standard deviation	2.3	2.2	2.2	2.3

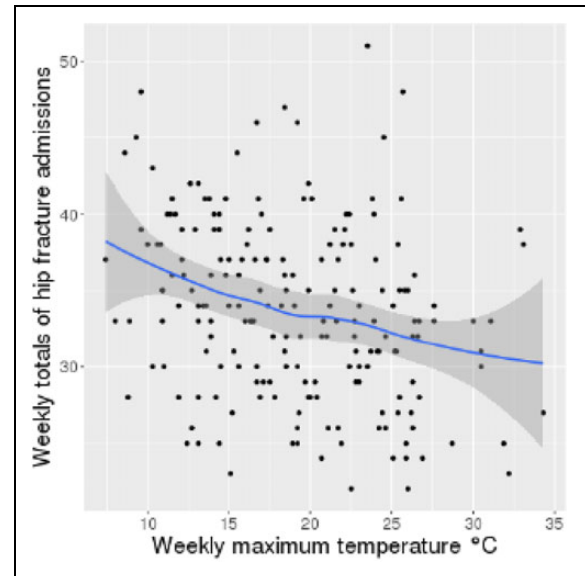
Table 3. Admission Number on Days Identified as Risk of Potential Ice.

Date	Admissions
17/01/2016	3
25/11/2017	5
10/12/2017	5
11/12/2017	6

A comparison of the total daily number of patients admitted to the 7 hospitals against temperature, rainfall, wind and sunshine is depicted in Figure 2. There is little indication of a direct relationship between daily admissions and any of these individual parameters, with all having a Pearson's Correlation coefficient of less than 0.1.

Looking particularly at the days with 13 or 14 admissions across the north west London region no common feature of the weather could be identified (Table 1).

Summary statistics were calculated to assess whether any seasonality was present within the data (Table 2). While the

**Figure 3.** Scatterplot comparing weekly maximum temperature to weekly number of hip fracture admissions.

highest individual day and daily average occurred during the winter, as initially suspected, there is not a large difference between the daily average number of admissions between seasons.

Within the daily dataset, there were 4 days with conditions supporting a high potential risk of ice. The daily admission numbers for these dates have been provided in Table 3. These data give no clear indication that potentially icy weather had an impact on the number of admissions on that day, with all being very close to (and in only one case slightly above) the average number of admissions.

The data were also accumulated and subdivided into weeks. When comparing weekly maximum temperature to the number of NOF fracture admissions within a week, this identified a slight negative correlation (Figure 3) with a Pearson's Correlation coefficient of -0.25 (p-value of $p = 0.00002$).

Discussion

To our knowledge this is the first study to focus on the comparison between emergency hip fracture admissions and weather. We identified a weak negative correlation between weekly maximum temperature and the weekly total hip fracture admissions. However, our findings did not corroborate our hypothesis that cold (particularly icy) weather may result in more hip fractures.

The number of admissions remained at similar levels throughout the year. This suggests that weather only plays a weak or very occasional role. This could be because most neck of femur fractures occur in frail patients who fall at home and are unlikely to venture out regardless of the weather. Wild et al (1981) highlighted that most falls at home occur in frail patients and can be an indicator of ill health.¹⁸ Bastow et al (1983) highlighted that the peak number of cases seen during the

winter months were in underweight, extremely frail patients who had fallen indoors.¹⁹

A significant limitation of the study was that it incorporated only 7 hospitals in one urban region. London's climate is notably warmer and somewhat drier than most other parts of the UK, mainly related to its geographical position and influences of air masses. Additionally, icy conditions in London may be ameliorated by the heat island effect and gritting. Hospitals admissions from a catchment area more aligned with residential suburbia and towns may show a stronger weather signal. Moreover, the weather data came from a single location within the region (Kensington). Each of the 7 hospitals will be admitting patients within their catchment area, a distance from the weather data point. It is unlikely that weather conditions across the 7 hospitals will be dramatically different to the weather point but there is potential for some variation. Patients may also be missed, as they are admitted to alternative sites outside our trauma network.

To extend the project further we aim to gather and assess data from across England to identify whether a larger sample of data would enable a relationship with the weather to be identified and can therefore be used to predict admissions. The maximum admission on a single day within the data set was 14, we believe a larger sample size will be needed to truly identify a relationship with weather. However, it is likely that the small sample size is not the only limitation in this study. For instance, additional explanatory variables, such as socioeconomic factors and the catchment area demographics will have an influence, whilst a less urban environment should display more distinct cold weather drivers than those for North West London. It should be highlighted that the UK generally has mild winters and cool summers, containing only short periods of heat or cold. This may make extracting data to identify a link more challenging in the UK.

A prediction tool could play a valuable role in planning services during certain seasons, similar to predictive demand planning in respiratory services, therefore continued analysis of these data should take place. Current evidence from this study would not change service configuration but on a national scale, or in countries with more extreme weather this could be important.

Conclusion

In this initial regional study of 10,000 patients, we found little indication of relationships between daily hip fracture admissions and the weather, within an urban area in the UK. Therefore, limiting the ability to develop a useful admission forecasting tool. A larger scale detailed study over a wider area, particularly involving rural and urban localities is required.

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