Effect of Climatological Variables for all Seasons on the Frequency of Incident Stroke Hospitalizations in Scotland.

Arsalan Moinuddin[1], Anjali Verma[2], James Lewsey[3], Sally Inglis[4], Nidhi Sharma[5]

[1]Assistant Professor, Department of Physiology, NIMS University, Jaipur, India.
[2]Assistant Professor, Department of Physiology, Teerthanker Mahaveer Medical College, Moradabad, U.P, India.
[3]Associate Professor, School of Medicine, University of Glasgow, Scotland, U.K.
[4]Honorary research fellow, Institute of Cardiovascular & Medical Sciences, University of Glasgow, Scotland, U.K.
[5]Assistant Professor, Department of Anatomy, Teerthanker Mahaveer Medical College, Moradabad, U.P, India..

ABSTRACT

Background: Stroke is a disease, which has a complex multi-factorial etiology. Non-modifiable risk factors are genetics, familial history, age, sex, ethnicity and race, whereas smoking, drinking, physical activity and diet can be modified to reduce the risk of stroke significantly. **Aims:** The aim of the present study was to see the association between climate variations and incidence of stroke in Scotland. **Methods:** We have obtained the stroke data as SMR01 (Scottish Morbidity Record 01) as 1,57,639 incident stroke hospitalization in Scotland between 1986 and 2005. To observe for variation in weather parameter, with first stroke incidences per day, daily mean temperature, total rainfall and average daily atmospheric pressure were compared with the frequency of incident strokes per day using ANOVA (Analysis of Variance). **Result:** An overall meteorological analysis of incident strokes per day reveals an inverse statistically significant relationship for average daily temperature (P<0.001) whereas total daily rainfall (P=0.03) and average daily atmospheric pressure (P=0.05) exhibit borderline significance. Correlation of low temperature with stroke might be due to the concurrent occurrence of respiratory infections. We suggest some precautionary measures to minimize the chance of stroke i.e. protection from cold weather, decrease alcohol consumption and maintaining blood pressure within a safe range during winter season. **Conclusion:** Overall, high stroke incidence during winter season is a combined effect of temperature, rainfall, atmospheric pressure.

Keywords: Stroke, hospitalization, subarachnoid hemorrhage, intracranial haemorrhage, ischaemic stroke.

INTRODUCTION

Stroke is defined as “abrupt impairment of brain function by a variety of pathological changes involving intracranial or extra-cranial blood vessels.[1] Prognosis after an attack of stroke seems to be very poor. Good number of people (25% to 30%) expires in the initial three weeks and 33% to 66% in the 1st year following stroke incidence.[2] In U.K. itself about 111,000 stroke incidents are reported every year.[3] Yearly deaths in U.K. were reported to be 53,000.[4] A decline of 21.2% between 1999/00 and 2008/09 for stroke incidence rate was noted in Scotland.[5] Though there has been remarkable decline in the age-standardized stroke mortality rates since 1968 a lot of variability is still present within U.K. The rates are highest in Scotland, followed by North England, Ireland, Wales and South England.[6]

A study in Barcelona, Spain, demonstrated some variations in stroke frequency (overall, ICH and IS) with atmospheric pressure.[7] But another work on SAH and atmospheric pressure in the same geographical location found no correlation at all.[8]

Name & Address of Corresponding Author
Dr Nidhi Sharma
Assistant Professor,
Department of Anatomy,
Teerthankar Mahaveer Medical College,
Moradabad, U.P., India.
E mail drnidhivarshney@gmail.com

Even in American studies there has been a lot of variability in stroke incidence which may be due to large weather diversity in different regions of this continent. The temperature ranges from +57 ^{0}C in California to -62 ^{0}C in Alaska.[9] Other climatic parameters fluctuate heavily as well making results inconsistent. Although overall climatological variability of stroke is appreciable in Europe and other continents like America, it is difficult to establish a specific trend, especially for subtypes due to large area-wise weather differences and pathophysiological metamorphism. The aim of the present study is to assess whether there is any association between different weather conditions (temperature, rainfall and atmospheric pressure) and incidence of stroke in Scotland (1986 – 2005) and suggest measures to reduce them.

MATERIALS AND METHODS

Stroke data related to all incident hospitalization for stroke in Scotland between 1986 and 2005 was obtained. The data set comprises of a sample size of 1,57,639 incident hospitalization. Following service divisions provided information about patient's details year-wise.

1. National Health Service (NHS)
2. Information Service Division (ISD)
3. Scottish Morbidity Record (SMR)

Following four types of stroke proposed by international classification of diseases[10] were considered in the present study.

1. Ischaemic stroke (IS)

2. Intracerebral haemorrhage (ICH)
3. Sub-arachnoid haemorrhage (SAH)
4. Non specific

Weather data was obtained from the Met Office-UK's National Weather Service in the form data sets which provide information about average temperature, total rainfall and average atmospheric pressure on a daily basis from 1986 – 2005. Temperature is measured at a height of 1.25 meters above ground level over a grass surface. The values of temperature are noted in degree Celsius and tenths and values below 0^0 C are preceded by a minus sign.[11] Rainfall is measured hourly, followed by totalling them up. The values of rainfall are noted in millimeters (mm), 25.4 mm=1 inch).[12] Atmospheric pressure at any point on the Earth's surface is proportional to the weight of the air above it. It is measured using a precision aneroid barometer (PAB). The daily average air pressure is corrected to sea level and averaged out over the daily period 0.001 to 2400 GMT/UTS. The pressure unit used in meteorology was previously the millibar (one bar=1000 millibars). However, this has been replaced by the SI unit of pressure – the pascal (Pa) and one hectopascal (hPa) = 1 millibar (mb).[13]

SPPS (Statistical Package for Social Sciences, 15.0 versions for Windows) was used for statistical analysis. To observe for variation in weather parameters with first stroke incidences per day, daily mean temperature, total rainfall and atmospheric pressure were compared with the frequency of incident strokes per day using ANOVA (One-way analysis of variance). Graphically, it was presented by 95% confidence interval plots with the number of strokes in a day on x-axis and weather parameters on y-axis.

Ethical approval was granted from Faculty of Medicine Ethics Committee for Non-Clinical Research involving human subjects, University of Glasgow (Project No- FM00609). The retrospective data were approved by Privacy Advisory Committee (PAC).

RESULTS

Temperature: The 95% CI plot [Figure 1] indicates that as the daily average temperature decreases the number of strokes per day rises. In the most part, the average temperature in Scotland remains constant around 9 ^{0}C when the number of strokes is between 1-6 per day, but with further lowering of temperature the stroke frequency almost increases three folds (15 per day) with a drop of one and half ^{0}C (7.5 ^{0}C). The 'p' value (<0.001) from ANOVA is highly significant and the slope of best-fitted regression line 'β' is estimated as -0.064 ^{0}C for each additional incident stroke increase on a given day. This supports the hypothesis of an inverse and statistically significant relationship (β=0.064) between the number of strokes per day and daily average temperature.

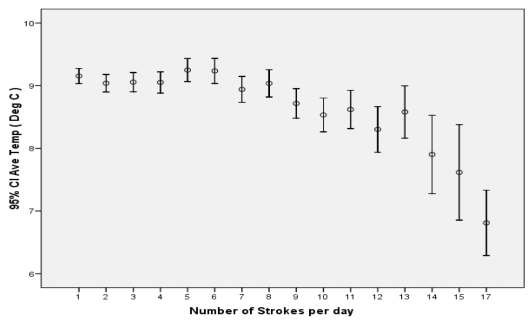

Figure 1: Daily mean temperature by number of strokes on a given day.

Rainfall: The pattern of the 95% CI plot [Figure 2] illustrates that the quantity of rainfall varied between 2.8 mm and 3.6 mm as the stroke frequency increases from (1-15) strokes per day. A borderline 'p' value of 0.03 (ANOVA test) suggests some evidence of a difference in the quantity of rainfall across increasing stroke volume. The slope of the best-fitted regression line 'β' is estimated as 0.02 which means that the total daily rainfall increases by 0.02 mm for each additional incident stroke increase on a given day. But the pattern of the plot, and R^2 values of 0.00 indicates that no variation in the stroke frequency can be explained by its dependence on rainfall. The evidences are not conclusive enough to establish a statistically significant relationship between incident stroke frequency and daily total rainfall.

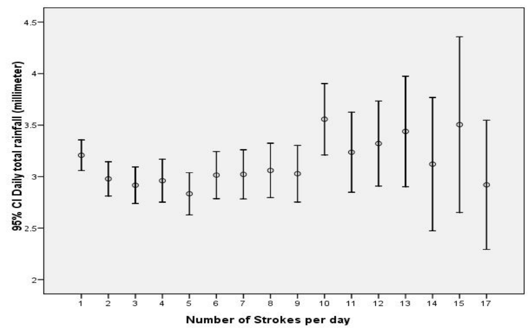

Figure 2: Daily total rainfall by number of strokes on a given day.

Atmospheric pressure: From the 95% confidence intervals plot [Figure 3], initially the average atmospheric pressure is quite consistent between 1011 and 1013 hPa as the number of strokes per day rises from 1 – 13 per day. The borderline 'p' value of 0.05 (ANOVA test) means there is some evidence of difference in daily atmospheric pressure with increasing stroke frequency. The slope 'β' of best the fitted regression line is estimated as 0.013 which means that average atmospheric pressure increases by 0.13 hPa for a rise of every incident stroke on a given day.

However, the pattern of plots and R^2 value of 0.00 suggests that no variability in the stroke frequency can be explained by its dependence on average atmospheric pressure. Hence, evidences are not conclusive enough to establish a statistically significant relationship between stroke frequency and daily average atmospheric pressure.

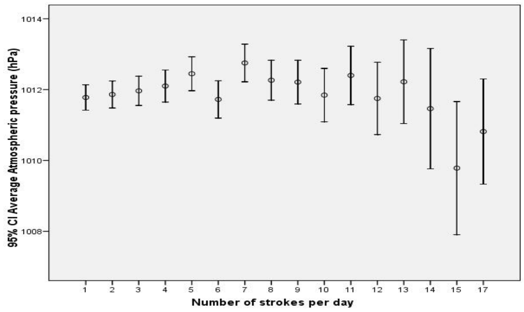

Figure 3: Daily average atmospheric pressure by number of strokes on a given day.

DISCUSSION

Temperature appears to be the only meteorological variable which showed significant variation with stroke frequency throughout all seasons. Our results showed an inverse statistically significant ($p<0.001$) relationship between average temperature and first incident stroke (a temperature drop of 1.5 ^{0}C saw a three times increase, 5 to 15 in stroke frequency per day) in our results. This negative correlation is in accordance with a lot of studies in the past.[14-16] It is worth paying attention, whether stroke frequency was analyzed using long term temperature change or sudden temperature variation, a difference of choice between the two may alter results to some extent due to variance in mechanics. Some studies even reported discrepancy in results between calculating temperature on the day of stroke and before the day of stroke.[17]

No specific trend in the pattern of total rainfall was observed throughout increasing frequency of stroke per day a borderline 'p' value of 0.03 was observed. To the best of our knowledge so far, no study has found significant variation in the amount of rainfall with increasing stroke[18] although a couple of studies noticed heavy rainfall during the season of high stroke frequency.[19] This is ambiguous and actually an artifact of low atmospheric pressure which instigates cloud formation and rain through the inflow of ascending current.[19]

Similarly, for atmospheric pressure, a specific trend in the pattern was not found and we again obtained a marginal 'p' value of 0.05, which constrained us to establish a significant relationship between atmospheric pressure and increasing frequency of strokes per day. The result concurred with some of the previous work.[7]

Citing the mechanistic basis of overall temperature variation in stroke incidence, the term winter season was used instead of low temperature in this section. It was hypothesized that an overall high stroke incidence during winter season is a combined effect of temperature[14-16], rainfall[18,19], atmospheric pressure[7], hours of sunshine, wind velocity and humidity[20,21] together via different patho-physiological pathways. These climatological variables interact with each other, instigate certain physiological and biochemical changes in the body and thus mechanize stroke onset.[22-24] It is assumed that respiratory infections such as influenza, pneumonia, bronchitis played a role in the etiology of stroke. Some evidences supported the view that influenza causes complications in atherosclerotic disease by producing a hypercoagulable state.[25] Serum concentration of plasma fibrinogen enhance with lowering of temperature.[26] Previous report shows increased serum total cholesterol concentration (STCC) with a prominent rise in winter season and relatively lower level in summer[23] C-reactive protein too exhibited a peak during winter.[27] Also there is appreciable rise in plasma aldosterone level during winter season is worth exploring its mechanistic basis.[28] Thus, the aforementioned pathophysiological processes to some extent worth in exploring the mechanistic dependence of stroke on weather parameters.

Our study has a large sample size (1,57,639) and is conducted over a period of 20 years, thus the results are highly unlikely to be a product of chance. Overall the meteorological analysis of incident strokes per day revealed an inverse and statistically significant relationship for average daily temperature whereas total daily rainfall and average daily atmospheric pressure exhibited no specific trend. Correlation of low temperature with stroke might be due to concurrent appearance of respiratory infections. Some precautionary measures suggested to minimize the chance of stroke instead protection from cold weather, decrease alcohol consumption and maintaining blood pressure within a safe range during winter season

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