SEASONAL VARIATION OF ACUTE STROKE IN A TROPICAL AFRICAN LOCALITY: A RETROSPECTIVE STUDY FROM SUB-SAHARAN AFRICA

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ABSTRACT

Background: **Seasonal variation has been shown to affect hemorheological mechanisms and blood pressure regulation which may contribute to stroke incidence. An understanding of the seasonal variation of acute stroke may guide the design of a year-long pragmatic acute stroke care plan, especially in regions with meager resources. We investigated the seasonal pattern of acute stroke admissions and outcome in Ibadan, Southwest Nigeria.**

Methods: **A multi-center retrospective study was performed. Anonymized information on stroke admissions from Jan 01, 2022 – Dec 31, 2022, was extracted from each hospital's admission records. According to the Nigerian Meteorological Department guidelines, using the average monthly temperatures, the year was divided into the wet (rainy) and dry (harmattan) seasons. The student t-test was used to assess differences between groups. The level of statistical significance was fixed at P<0.05**

Results: **Of 3001 acute medical admissions, there were 406 (13.5%) acute stroke admissions. Stroke admissions had two peaks: early to mid-wet season and mid-dry season. The proportion of stroke admissions was slightly higher in the wet season 207 (51%) than in the dry season 199 (49%). While stroke admissions, subtype, and outcome did not differ significantly by season, the mean (SD) ischemic stroke count vs hemorrhagic stroke count was slightly higher in the wet season [Ischemic:18.00 (4.15)], hemorrhagic: 18.50 (4.60)] compared to the dry season [ischemic: 14.67 (4.63), hemorrhagic: 16.50 (7.34)], p value 0.218 and 0.584 respectively.**

Conclusion: **Acute stroke has two seasonal peaks – mid-dry (harmattan) and early to mid-wet seasons. Besides prevailing variations in ambient temperatures and humidity, the bi-annual peaks may also be due to suboptimal risk factor control/surveillance, as the two peaks are incidentally the yuletide seasons in Nigeria. Our findings may therefore help acute care planning during risk periods requiring varying adaptations in local infrastructure and resource allocation.**

Keywords: Seasonal variation, Stroke, West Africa, Tropical Africa, Stroke subtype, Seasons

INTRODUCTION

Of all hypertension-mediated vascular events, stroke remains a significant cause of mortality, disability, and lost productive years.[1,2,3] In most African countries, where six persons develop a stroke every minute[2], the resources to tackle the menace of stroke are often not enough or unevenly allocated.[4] Healthcare providers and policymakers often grapple with minimal resources/data to make the most efficient acute care decisions. An understanding of the seasonal variation of a stroke may help the judicious allocation of scarce resources (viz thrombolytics, stroke unit bed spaces, staff strength), better organization of stroke care/services, improved year-long budgeting/planning, and complement existing preventive strategies.[4]

Seasonal variation has been shown to affect hemorheological mechanisms and blood pressure regulation[5,6] which may contribute to stroke incidence and subtype.[1,7,8] While literature is replete with varying reports[9 10] on the role of seasonal changes in stroke, it is worthy of note that most of these studies are done in temporal climates.[11] There has however been a handful of studies in sub-tropical regions, albeit with inconsistent findings.[12,13] Nigeria is a tropical African country with clear seasonal variations in climatic and weather conditions ranging from tropical monsoon climate in the south, hot desert and semi-arid climates in the north, and tropical savannah climate in the central parts of the country. In Nigeria, authors have documented the relationship between seasonal changes and common disorders[14] including hypertension, heart failure[15] as well as chronic kidney disease (CKD).[16] There is however no study that has yet explored the association between stroke admissions/subtype and prevailing seasons of the year.[17] We investigated the seasonal pattern of acute stroke admissions, and its relationship with stroke subtype and outcomes in Ibadan, Southwest Nigeria.

METHODOLOGY

Study design/site

A retrospective observational study was carried out in two randomly selected political administrative wards of the Ibadan North Local Government Area (IBNLGA) using hospital admissions for the year 2022. The year 2022 was chosen as the initial point of data extraction as there were no industrial actions or pandemic situations that punctuated in-hospital admissions.[18-21] This study was undertaken in Ibadan North LGA of Ibadan city. It is a densely populated urban LGA with a population of about 4 million people. Ibadan North shares boundaries with Akinyele LGA in the north, Ido LGA in the west, and the Ibadan Northeast LGA in the east. Like Ibadan city itself, IBNLGA is multicultural, and divided into twelve political wards by the National Populations Commission. This study was undertaken in wards 9 and 10. Data on stroke admissions were reviewed from selected hospitals within the locality as they have the same seasonal variations.

The hospitals where patients were recruited included the University College Hospital, (UCH), Ibadan, Redeemers Health Center, Molly Specialist Hospital, Oluyoro Catholic Hospital, Bamby Specialist Hospital, and Redeemers Health Center Annex. All the selected hospitals had neurologist coverage and acute stroke care pathway with brain computed tomography (CT) access either in-hospital or within a 30-minute drive. Ethical approval was obtained from the University of Ibadan/University College Hospital Institutional Review Board (IRB) with approval number: NHREC/05/01/2008a.

Study population/procedure

Details of patients aged 18 and above with a clinical and/or radiologic diagnosis of acute stroke were obtained. All patients had random blood glucose done to exclude hypoglycaemia. Patients with clinical suspicion of a stroke mimic e.g., brain tumors or seizures were excluded in the absence of neuroimaging. The years 2020, 2021, and 2023 were excluded due to incessant industrial actions in Nigeria's health sector (2021 and 2023)[18–20] and the COVID-19 pandemic (2020 and 2021)[21] that affected in-hospital admissions. Stroke was defined, using the updated definition of stroke for the 21st century proposed by the American Heart Association/American Stroke Association (AHA/ASA).[22]

Data were retrospectively extracted from the hospitals, emergency department, and ward records. All patients with an initial clinical diagnosis of stroke were included in the study with final diagnosis and radiological findings noted. The date of the stroke, time of stroke onset, time of hospital admission, stroke subtype, and final clinical outcome were obtained using a structured questionnaire. Baseline sociodemographic (such as age, and sex) and clinical variables (such as vascular risk factors) were similarly noted. Presence of significant neuroimaging delay (>12 hours from time of presentation) was documented.

The month of stroke onset was analysed according to the two predominant seasons in Nigeria – rainy season and dry season. The rainy season is characterized by high humidity, high rainfall (precipitation), and sometimes thunderstorms with average surface air temperatures ranging between 22 - 32°C.[23,24] The onset of the rainy season varies across the country, with coastal areas experiencing it earlier than inland and northern regions. The dry season is marked by lower humidity, less rainfall (precipitation), and the influence of the Harmattan wind, which brings dust with average surface air temperatures ranging between 17.5 to 37°C.[23,24] In southern Nigeria, the dry season typically starts from October/November and ends February/March, while the rainy season usually starts April/May and ends September/October.[23,24] For this study, dry season was specified as January, February, March, then October, November, December, while rainy season as April, May, June, July, August, and September. The categorization of months into seasons was according to the Nigerian Meteorological Department guidelines.[24,25] Since each season (dry/wet) captured six months each, the first two months were specified as early, second two months mid and last two months as late. For instance, early wet was April-May, mid-wet was June-July and late wet was August-September while early dry was October-November, mid dry December-January and late dry February-March.

Data analysis

Data were presented in frequencies, means, and percentages. Descriptive and inferential statistical methods involving the determination of means, standard deviations, and frequencies were used to define patient characteristics. Proportion of stroke admissions relative to total medical admissions was obtained. The student t-test (for mean acute stroke count, stroke count per subtype, mortality count) was used to assess the difference between groups (dry and wet seasons). The level of statistical significance was fixed at P<0.05. All analyses were performed using Stata version 12.1 (Stata Corp LP, College Station, TX) and SPSS version 23 (IBM SPSS, Chicago, IL).

RESULTS

Of a total of 3001 acute medical admissions seen between January and December 2022, there were 406 (13.5%) acute stroke admissions (Table 1). The proportion of stroke admissions was slightly higher in the wet season 207 (51%) than in the dry season 199 (49%) (Table 1). The mean (SD) age of patients with stroke was 56.7 (14.4 years) and predominantly males (59.6%). The median (IQR) time to presentation was 24.4 (29.5) hours and most patients presented late evenings (61.5%) and early mornings (24.6%). Of the stroke participants, 44 (11%) had no neuroimaging done at admission while 326 (90%) of those that had neuroimaging done experienced significant delay (>12 hours from time of presentation).

Overall, there were more medical admissions in the wet season, and this was statistically significant (Table 2). While the mean (SD) monthly acute stroke count was higher in the wet season 36.50 (7.40) than in the dry season 31.17 (10.26) in the dry season, this difference was not statistically significant (Table 2). Similarly, the mean (SD) ischemic stroke count vs hemorrhagic stroke count was slightly higher in the wet season [Ischemic: 18.00 (4.15)], hemorrhagic: 18.50 (4.60)] compared to the dry season [ischemic: 14.67 (4.63), hemorrhagic: 16.50 (7.34), p value 0.218 and 0.584 respectively] (Table 2). Stroke admissions

Table 1: Monthly distribution of acute stroke admissions, subtype and outcome

	Medical admissions	Stroke N (%)	Male, N	Ischemic, N (%)	Hem, N (%)	Stroke Mortality, N (%)
January	262	45 (17)	28	16 (8.2)	29 (13.8)	16 (10.8)
Feb	210	26 (12)	15	15 (7.7)	11 (5.2)	9 (6.1)
March	225	25 (11)	17	15 (7.7)	10 (4.8)	8 (5.4)
April	252	44 (17)	27	23 (11.7)	21 (10.0)	11 (7.4)
May	284	30 (11)	19	17 (8.7)	13 (6.2)	12 (8.1)
June	269	47 (17)	28	21 (10.7)	26 (12.4)	11 (7.4)
July	275	29 (11)	16	11 (5.6)	18 (8.6)	12 (8.1)
August	272	35 (13)	19	17 (8.7)	18 (8.6)	15 (10.1)
Sept	239	34 (14)	18	19 (9.7)	15 (7.1)	15 (10.1)
Oct	224	32 (14)	17	16 (8.2)	16 (7.6)	14 (9.5)
Nov	241	18 (07)	11	6 (3.1)	12 (5.7)	11 (7.4)
Dec	248	41 (17)	27	20 (10.2)	21 (10.0)	14 (9.5)
DRY	1410	199 (49.0)	115	95 (48.5)	104 (49.5)	69 (46.6)
WET	1591	207 (51.0)	127	101 (51.5)	106 (50.5)	79 (53.4)
Total	3001	406 (100)	242	196 (100)	210 (100)	148 (100)

Hem, hemorrhagic; Feb, February; Sept, September; Oct, October; Nov, November; Dec, December

Table 2: Seasonal variations in stroke admissions, subtype and outcome

	Total	Dry, mean (SD)	Wet, mean (SD)	Test statistics	P value
Acute medical admissions, N	3001	235.00 (18.86)	265.17 (16.56)	-2.944	0.015*
Mean stroke admissions, N	406	31.17 (10.26)	36.50 (7.40)	-1.033	0.326
Ischemic, N	196	14.67 (4.63)	18.00 (4.15)	-1.313	0.218
Hemorrhagic, N	210	16.50 (7.34)	18.50 (4.60)	-0.566	0.584
Males, N	242	19.17 (6.82)	21.17 (5.03)	-0.578	0.576
Mortality, N	148	12.00 (3.16)	12.67 (1.86)	-0.445	0.666
No CT scans, N	44	3.17 (1.32)	4.00 (1.67)	-0.995	0.362

**P value <0.05 was considered significant*
CT, computed tomography scan

however showed two seasonal peaks: early wet season: April - 44 (17%), June - 47 (17%); and mid-dry season: December - 41 (17%) and January - 45 (17%) (Figures 1). The crude mortality rate in the region was 36.7% with December-January and August-September showing the highest mortality rates (Table 2).

DISCUSSION

In this multi-center study, acute stroke accounted for one out of every eight medical admissions. Stroke admissions showed two seasonal peaks – mid-dry (harmattan) and early to mid-wet seasons. While there was a slightly higher proportion of stroke admissions in the wet season, there was no difference in average acute stroke admissions, subtype, and mortality in the wet season compared to the dry season. In Nigeria, the wet season is characterized by predominantly low ambient temperatures and high humidity while the dry season is characterised by high mid-day surface air temperatures and much lower ambient temperatures at night. Variations in temperature and humidity may account for the observed bi-annual peaks. Stroke incidence has been linked to variations in ambient temperature and humidity leading to changes in hemorheological mechanisms and blood pressure regulation.[15,6,26,27] However, the heterogeneity of climatic conditions (even within the same country), geographic variations in vascular risk factors amid other seasonal factors affecting vascular risk factor control and care may account for the discrepant findings in literature.[28–31]

Of note, the two peaks observed in our study are incidentally the yuletide seasons in Nigeria[32] – Christmas (December), New Year's day (January), Easter (April) and Islamic holidays (Eid El-Fitr, late April-early May). Hence, the observed seasonal peaks may additionally be related to worsening risk factor surveillance and control, as hypertension[33], diabetes mellitus[34], dietary control, medication adherence, stress and alcohol use[35,36] may worsen during yuletide or public holiday seasons.[35,37–40] Christmas, and midsummer holidays have been previously shown to be associated with higher risk of acute vascular events, particularly in vulnerable patients.[37,38] It is also likely that the observed bi-annual peaks in our study may be due to prevailing seasonal infections[41,42] which may serve as triggers for acute stroke, but this requires further study.

Notably, the average monthly stroke count documented in this study is three to six times higher than that documented at the start of the millennium for all hypertension-mediated vascular diseases by two independent Nigerian authors.[15,43] This shows a significant increase in stroke burden over the past two decades. In our study, the average acute medical and stroke admissions were higher in the wet season than the dry season (p values 0.015 and 0.326 respectively). While authors have similarly documented a higher count of hypertension-mediated vascular events (heart failure, CKD) in the wet seasons, others have found no seasonal variation.[12,16] This increase has been attributed to worsening blood pressure control due to low ambient temperatures[6,44] and a high default rate to follow-up visits in this season when agricultural activity is intense and less attention is given to medical care.[15] In Nigeria, since both wet and dry seasons come with cooler ambient temperatures (during the day and at night respectively), the observed bi-annual peaks may be explained by worsening BP control in such low temperatures. Besides, acute stroke may be triggered by higher rates of acute viral infections and inflammatory conditions which are more prevalent in cooler temperatures.[45–47]

Overall, a higher proportion of our stroke population 210 (51.7%) had hemorrhagic stroke subtype with a relatively higher proportion in the wet season 106 (50.5%). Given the low ambient temperature in the wet season, our findings are similar to that by Wang in China[44] who documented higher ICH risk in winter. Our finding of a higher hemorrhagic stroke count is however in contrast to an expected higher relative burden of ischemic stroke (globally) and may be due to specific population demographics, documented prevalent hypertension in the region and referral bias.[2-4] Physicians in primary and secondary care facilities tend to refer patients with the more severe haemorrhagic stroke subtype to tertiary and post-secondary care facilities. Primary care physicians must be encouraged to refer acute ischemic stroke patients early for reperfusion therapy, which can help in planning thrombolysis solutions.

Approximately 362 (89%) of our study population had neuroimaging done. While this represents a significant uptake and availability of neuroimaging facilities, 326 (90%) of the patients still experienced significant delays in getting neuroimaging done. This was due, among other reasons to payment out of pocket and epileptic power supply across most facilities. Early access to brain imaging is central to planning thrombolysis solutions in the region and efforts should be made to improve time to neuroimaging.[48] The higher mortality observed in our study during the wet season, while not significant statistically, may be attributable to the higher overall stroke and medical admission counts during the wet season.[27,49]

Our study has several notable strengths, representing a major effort in documenting the seasonal pattern of acute stroke admissions in tropical sub-Saharan Africa, a region with no clear endovascular intervention plan and few resources. The findings will be key to guiding ongoing efforts to improve a year-long acute stroke plan in the region. Our study, being a multi-center study spanning secondary as well as tertiary care facilities, is reflective of findings in Southern Nigeria. We, however, acknowledge a few limitations. Our study was limited to the year 2022 and was not replicated over other years. This is due to incessant industrial actions in the Nigerian health sector, which meant that hospital admissions over other years would not accurately represent the yearly seasonal pattern of acute stroke admissions. However, it is worthy of note that seasons, unlike weather, is due to earth's rotation around the sun, remains relatively constant and do not change from year to year.

CONCLUSION AND FUTURE DIRECTIONS

Acute stroke accounted for one out of every eight medical admissions and showed two seasonal peaks - mid-dry and early to mid-wet seasons. Besides prevailing variations in ambient temperature and humidity, the bi-annual peaks may also be due to suboptimal risk factor control/surveillance, as the two peaks are incidentally the yuletide seasons in Nigeria. These findings could help acute care planning during risk periods requiring varying adaptations in local infrastructure and resource allocation. In the meantime, advocacy efforts should focus on risk factor identification and control, early presentation, and early referrals to tertiary care facilities; while policy drive should focus on improved staffing of regional hospitals and stocking of medications, during such peak seasons. As prevailing seasonal infections may serve as acute stroke triggers, our future efforts will explore the contribution of seasonal infectious conditions to the seasonal variation in stroke admissions and outcome.

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