



## Original Article

## Seasonal Variations and the Incidence of Stroke: A Cross-Analysis of Meteorological and Epidemiological Data in a Sub-Saharan Africa Region with an Equatorial Climate

*Variations saisonnières et incidence des accidents vasculaires cérébraux: une analyse croisée des données météorologiques et épidémiologiques dans une région d'Afrique subsaharienne au climat équatorial*

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### RÉSUMÉ

**Background.** Recent studies have shown that the climate could influence on the occurrence of stroke. However, little is known about regions with an equatorial climate. We aimed to study the association between seasonal variation, meteorological parameters, and stroke in a Cameroonian region with an equatorial climate. **Methods.** We conducted a cross-sectional study on 252 records files of patients who had stroke consecutively and retrospectively collected from 2016 to 2018 at the Bafoussam regional hospital (Cameroon). Meteorological parameters were provided by the meteorological station of the Bafoussam airport. We compared the frequencies with the chi-square test, the student t-test was used for the comparisons of the means of the quantitative variables. The threshold of significance was set at 0.05. **Results:** The average age was  $66 \pm 14$  years, and 135 (53.6%) were male. Stroke incidence was 75.8 % during the rainy season and irrespectively of the season, ischemic stroke was more represented. There was no significant difference comparing the median incidence of stroke cases during wet and dry seasons  $p = 0.5$ . We also did not find a significant association between equatorial seasonal variations and stroke ( $p = 0.86$ ). As between the stroke and the monthly mean precipitation ( $p = 0.62$ ), the monthly mean daily temperatures ( $p = 0.12$ ), the monthly mean maximum temperatures ( $p = 0.06$ ), and the monthly average of minimum temperatures ( $p = 0.60$ ). **Conclusion.** There is no significant association between equatorial seasonal variation, meteorological parameters, and strokes in the Bafoussam regional hospital. The equatorial type climate thus may not influence the occurrence of stroke.

### ABSTRACT

**Contexte.** Des études récentes ont montré que le climat pouvait influencer la survenue d'un accident vasculaire cérébral (AVC). Cependant, on en sait peu sur les régions à climat équatorial. Nous avons étudié l'association entre les variations saisonnières et les AVC dans une région camerounaise au climat équatorial. **Matériels et méthodes.** Nous avons mené une étude transversale sur 252 dossiers de patients ayant subi un AVC consécutivement et rétrospectivement collectés de 2016 à 2018 à l'hôpital régional de Bafoussam (Cameroun). Les paramètres météorologiques ont été fournis par la station météorologique de l'aéroport de Bafoussam. Nous avons comparé les fréquences avec le test du chi carré, le test t de Student a été utilisé pour les comparaisons des moyennes des variables quantitatives. Le seuil de signification a été fixé à 0,05. **Résultats.** L'âge moyen était de  $66 \pm 14$  ans et 135 (53,6%) étaient des hommes. L'incidence des AVC était de 75,8% pendant la saison des pluies et quelle que soit la saison, les AVC ischémiques étaient plus représentés. Il n'y avait pas de différence significative par rapport à l'incidence médiane des cas d'AVC pendant les saisons humides et sèches  $p = 0,5$ . Nous n'avons pas non plus trouvé d'association significative entre les variations saisonnières équatoriales et les accidents vasculaires cérébraux ( $p = 0,86$ ). Entre l'AVC et les précipitations moyennes mensuelles ( $p = 0,62$ ), les températures quotidiennes moyennes mensuelles ( $p = 0,12$ ), les températures maximales moyennes mensuelles ( $p = 0,06$ ) et la moyenne mensuelle des températures minimales ( $p = 0,60$ ). **Conclusion.** Il n'y a pas d'association significative entre les variations saisonnières en région équatoriale et les AVC à l'hôpital régional de Bafoussam. Le climat de type équatorial peut ne pas influencer la survenue d'un AVC.

## INTRODUCTION

Many diseases are linked to climatic fluctuations, whether it is malnutrition related to food shortages during harvest time, respiratory infections occurring during cold weather, or cardiovascular events [1]. Some authors reported that the global burden of Stroke is increasing globally [2]. The risk factors for stroke are well known and have not changed, which is why it is thought that seasonal variations may play an important role in its occurrence. Surveys have reported conflicting evidence. Some studies have shown a higher frequency of stroke in the coldest months and abrupt temperature changes in the days preceding the event, both rising and falling, have been proven to impact the risk of a cerebral vascular accident [3–5]. In a meta-analysis, Oberg et al. found clear evidence of a seasonal pattern for strokes in general and ischemic strokes in particular [6]. Wang et al. reported a significant trend toward higher stroke attack rates in winter in the Hunter Region in Australia [7]. These findings show the influence of the climate in the occurrence of stroke but most of these studies were not carried under the equatorial climate.

Cameroon is a country in sub-Saharan Africa that enjoys three types of climates: humid tropical, dry tropical, and equatorial. The latter is a tropical climate generally found between 10- and 15-degrees latitude from the equator and receives at least 60 millimeters of rainfall every month of the year. It has two distinct seasons: a long rainy season of 9 months (March to November) and a short dry season of 3 months (December to February). The daily minimum temperature varies mostly between 12°C and 20°C and the daily maximum temperature lies in the interval between 25°C and 38°C throughout the year [8]. Stroke is already a common condition in Cameroon, responsible for an increase in morbidity and mortality. It was responsible for 54% of the mortality rate at the General hospital of Douala in 2008 [9]. We, therefore, carried out this study to evaluate the influence of seasonal variation in the occurrence of stroke in the regional hospital of Bafoussam. Understanding the relationship between seasonal variations and stroke occurrence in this equatorial climate zone could lead to the timely implementation of preventive strategies and favorable allocation of resources for stroke management.

## METHODOLOGY

### Study design and setting

We conducted a retrospective cross-sectional study in the internal medicine unit of the Bafoussam regional hospital. Records were collected from January 2016 to January 2018 (3 years). Bafoussam is a city in western Cameroon where we have an equatorial climate. It has about 847,517 inhabitants.

### Participants

We included all patients admitted to the internal medicine unit of the regional hospital of Bafoussam, who were confirmed of strokes by brain scan. Their records also had to contain the data required to complete the form. Patients who did not undergo a CT scan and those with incomplete records were excluded.

### Data collection

We used a data extracting form to report sociodemographic data (age, gender), cardiovascular risk factors, type, date, and season of stroke occurrence. Meteorological data was provided by the meteorological station of the Bafoussam airport and consisted of the monthly mean precipitation (MMP), maximum temperatures (MMMTmax), minimum temperatures (MMMTmin), daily temperatures (DT). These were also the monthly data of precipitation throughout 2016–2018.

### Operational terms

Seasons were classified according to the meteorological station of the Bafoussam airport as a long rainy season of 9 months from March to November, and a short dry season of 3 months from December to February.

### Statistical analysis

All collected data were analyzed using the software SPSS 23. Quantitative variables were expressed in terms of means and standard deviation (SD), while qualitative variables were expressed as counts and proportions. Means were compared using the student's test and frequencies using the chi-square test. We compared the frequencies with the chi-square test, the student t-test was used for comparisons of the means of the quantitative variables. A p-value of less than 0.05 was taken as statistically significant. For the selection of the variables, we used the stepwise ascending and descending selection algorithm.

### Ethical considerations

Ethics clearance was obtained from the Institutional Review Board of the “Université des Montagnes”, Bagangte in Cameroon (Authorization No. 2019/097 / UdM / PR / CIE) followed by the obtaining of research authorizations from the directorate of the Bafoussam regional hospital.

## RESULTS

### Characteristics of the sample

Overall, 252 patients (53.6% males) were included in the study, the mean age of participants was  $65.9 \pm 13.79$  years with extremes of 19 and 99 years. The subgroup of 55-75 years was most represented. We reported the median incidence of stroke per month in both the dry and wet seasons. The median incidence per month was 8 [4; 9] for the long-wet season and 6 [4; 8] for the short dry season, with no significant difference between the two  $p=0.5$ . The cerebrovascular risk factors found in our population were high blood pressure (45.9%), alcoholism (21.7%), diabetes (13.1%), smoking (13.1%), and dyslipidaemia (6.1%). Ischemic stroke was predominant (74.6%). When analysing the curve (**Figure 1**), it appears that the monthly incidence of stroke is higher in the wet season than in the dry season; it also appears that the incidence of stroke increases over time, with the highest numbers being found in August.

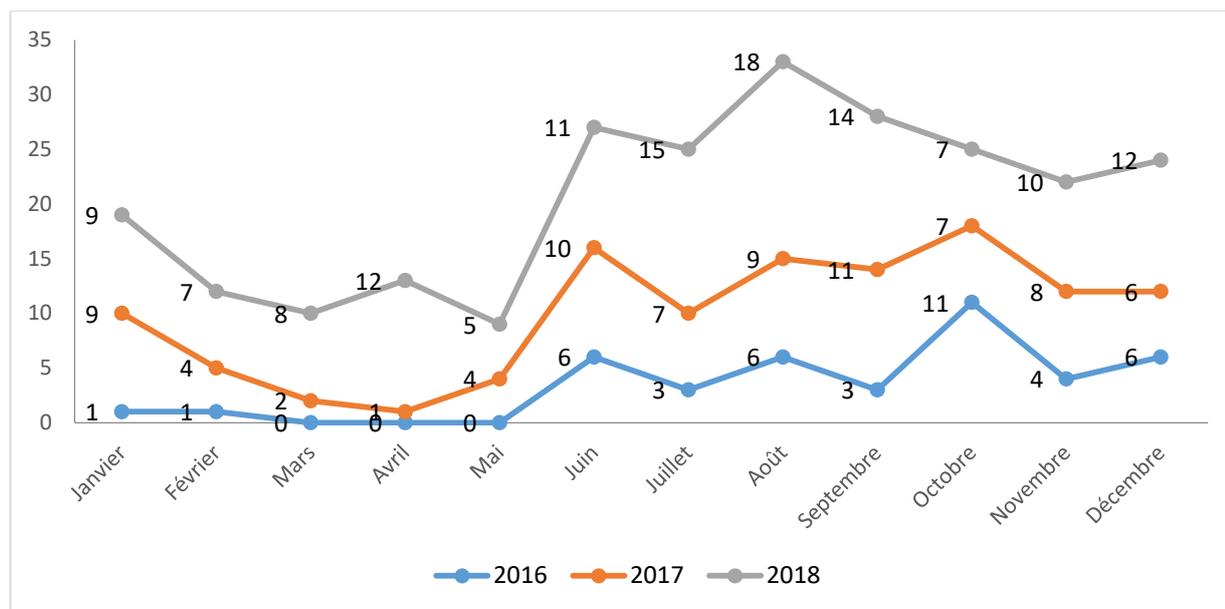


Figure 1: Stroke incidence by month.

The baseline characteristics of studied population are presented in Table 1.

Variables	Frequencies	Percentages (%)
<b>Age (years)</b>		
18-35	10	4
35-55	44	17.5
55-75	142	56.3
≥75	56	22.2
<b>Gender</b>		
Male	135	53.6
Female	117	46.4
<b>Cardiovascular risk factors</b>		
Hypertension	116	45.9
Alcoholism	55	21.7
Diabetes	33	13.1
Smoking	33	13.1
Dyslipidemia	16	6.2

**Meteorological data and seasons**

In Bafoussam, there is an equatorial monsoon climate with two distinct seasons: a long rainy season from March to November and a short dry season from December to February. During the period of our study, the following characteristics were found: The average monthly mean daily temperature was 20.82°C ± 0.95°C with extremes of 16.70 and 23.50°C. The average monthly mean daily temperature was 20.82°C ± 0.95°C with extremes of 16.70 and 23.50°C. The mean monthly rainfall was 145.80 C ±112.54 with extremes of 2.80 and 354.30 °C. The average monthly mean rainfall was 145.80 C ±112.54 with extremes of 2.80 and 354.30 °C. The mean monthly mean maximum temperature was 27.98°C ± 1.85°C with extremes of means at 24.10 and 32.20°C. The mean monthly mean minimum temperature was 15.66°C ± 1.80°C with extremes of means at 12.10 and 32.20°C. The mean monthly mean minimum

temperature was 15.66°C ± 1.80°C with extremes of means at 12.10 and 32.20°C.

**Association between seasonal variation, meteorological parameters, and stroke**

Stroke incidence was highest during the rainy season (76%) particularly in August (figure 1), and irrespectively of the season, ischemic stroke was predominant (Table 2). We did not find any significant association (p-value > 0.05) between meteorological parameters and the different types of stroke, also there was not any significant association between seasonal variations and stroke (Table 2).

Table 2: Association between seasonal variation, meteorological parameters, and stroke

Variables	Type of stroke		p-value
	Ischemic (n=188)	Hemorrhagic (n=66)	
<b>Season, n (%)</b>			
Dry	45 (73.8)	16 (26.2)	
Rainy	143 (74.9)	48 (25.1)	0.864
<b>DT, mean (SD)</b>	20.87±0.94	20.69±0.98	0.202
<b>MMP, mean(SD)</b>	142.28±109.91	156.14±120.24	0.396
<b>MMMTmax, mean (SD)</b>	27.99±1.90	27.96±1.71	0.893
<b>MMMTmin, mean (SD)</b>	15.71±1.89	15.50±1.53	0.412
<i>MMP: Monthly mean precipitation; MMTJ: Monthly mean of daily temperature; MMT min: monthly mean of minimum daily temperature; MMT max: monthly mean of maximum daily temperature; MMTTJ: mean of MMTJ; MMTT min: mean of MMT min; MMTT max: mean of MMT max.</i>			

**DISCUSSION**

In this study, we examined monthly and seasonal variations in stroke occurrence and its subtypes in 252 stroke patients registered at the Bafoussam Regional Hospital (Cameroon) between 2016 and 2018. To our

knowledge, this is one of the few studies on monthly and seasonal stroke trends conducted to date in a sub-Saharan African region with an equatorial climate.

### **Influence of Seasons and Meteorological Parameters on the Incidence of stroke.**

We found that there is no significant association between seasonal variation, meteorological parameters, and incidence of strokes in the Bafoussam regional hospital ( $p=0.864$ ). These results are like those reported by Bahonar and al. who in a Hospital-based retrospective study which was conducted by Isfahan Cardiovascular Research Center with 24186 cases, showed that there are no seasonal variations that influence the occurrence of stroke. However, several authors have found results opposed to ours. This is the case of Azevedo et al. in Portugal, Anderson et al. in New Zealand, who found a higher incidence of stroke in winter than in summer [10,11]. Yang Wang and al. analysed 3803 stroke events that were registered in residents of the Hunter Region and found that there is an increase in stroke attack rates and case-fatality rate from summer to winter [7]. Seasonal variation in stroke has also been reported in Japan, the United States, Canada, and the United Kingdom [12–14]. Several studies have been carried out to explain this, some of which have revealed that during cold periods there is an increase in plasma viscosity, fibrinogen, and factor VII activity, all of which leads to an increase in blood hypercoagulability [15]. As you can see, these explanatory mechanisms cannot be the same in regions with an equatorial climate, because of the great disparity of temperatures. Therefore, it seems advisable to carry out further studies to evaluate the possible biological modifications in healthy subjects living in equatorial zones.

### **Influence of Seasons and Meteorological Parameters on the type of stroke.**

Even if ischemic stroke (74.6%) was predominant irrespectively of the season We found no significant association ( $p\text{-value} > 0.05$ ) between meteorological parameters and different types of stroke. Although this may seem odd, many authors found a significant association between meteorological, seasonal variations, and stroke occurrence, particularly ischemic stroke [17–21]. Oberg and al. used a longitudinal study design involving 72,779 veterans hospitalized for a stroke and found clear evidence of a seasonal pattern for stroke in general and ischemic stroke in particular [6]. Yun-Chul Hong suggested that stroke occurrence rises with decreasing temperature and that even a moderate decrease in temperature can increase the risk of ischemic stroke [21]. Some authors also found that changes in air pressure over the last 24 hours increased the incidence of ischemic stroke [3]. It, therefore, appears that in the northern hemispheric regions sensitive people must take measures to protect themselves from the cold, especially in winter, to avoid the occurrence of an ischemic stroke, but in the areas with an equatorial climate, the weather has no influence on the occurrence of a stroke. Therefore, it is not necessary to act at this level but rather

to put the resources available to act effectively on modifiable cerebrovascular risk factors.

This study has encountered some difficulties. First, not all stroke patients undergo a CT scan in our context, which has resulted in a considerable number of records not analysed. Besides, we did not take into consideration all meteorological parameters such as atmospheric pressure, wind speed, and others. Although seasonal variation in blood pressure was not observed in our study, this retrospective analysis did not allow us to assess the biological characteristics of our patients that may have influenced the occurrence of stroke. Further studies with serial assessment of risk factors should be conducted to better understand the reasons for seasonal differences in stroke incidence.

### **CONCLUSION**

There is no significant association between seasonal variation, meteorological parameters and stroke thus the equatorial type climate may not influence stroke. Acting on modifiable risk factors remains the key to preventing stroke.

### **DECLARATION**

#### **Acknowledgement**

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#### **Authors contribution**

CNNG and APM conceived and designed the study and supervised data collection.

RSD collected data.

JRN, DBE and RSD analyzed data and drafted the manuscript.

CNNG and APM substantively revised the manuscript.

All authors read and approved the final manuscript.

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#### **Availability of data and materials**

The datasets used for this study are available from the corresponding author on reasonable request.

#### **Ethical approval and consent to participate.**

The study was approved by the Institutional Ethical Review Board of “Université des Montagnes” (Cameroon).

#### **Consent for publication**

Not applicable.

#### **Conflict of interest**

The authors declare that they have no conflict of interests.

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