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(RESEARCH ARTICLE)

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Effects of temperature variation on stroke in Cotonou (Benin, West Africa)

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Abstract

Climate variations, particularly temperature fluctuations, have a major impact on public health, especially regarding strokes. This study focuses on the effect of temperature changes on strokes in the municipality of Cotonou, Benin. The main objective is to analyze the impact of temperature variations on stroke incidence in Cotonou, particularly heat waves and sudden drops in temperature.

The data used include minimum and maximum temperatures collected by Benin Meteorological Service from 1994 to 2025, as well as health data on strokes recorded between October 2023 and June 2025 at the Cotonou University Neurology Clinic. The analysis of the results relies on statistical methods, including Pearson's correlation coefficient, which were used to examine the relationship between temperature and strokes.

The results show a strong correlation between extreme temperature variations and an increase in stroke cases. Minimum and maximum temperatures showed a correlation of r = 0.75 and r =0.65, respectively, with stroke cases. In particular, June 2024 and February 2025, when maximum temperatures reached 33.25°C and 33°C, coincided with peaks of 21 strokes recorded per month, reinforcing the importance of climatic factors in the occurrence of these public health events.

Keywords: Climate Change; Temperature; Stroke; Cotonou; Public Health

1. Introduction

Stroke is a major cause of morbidity and mortality worldwide, and its incidence is increasing, particularly in developing countries. In Benin, strokes are affecting a growing number of people, with serious consequences for patients and their families. These public health events are often associated with individual factors such as hypertension, diabetes, or a family history of stroke [1]. However, environmental factors, such as temperature variations, are increasingly recognized as influencing stroke incidence [2, 3].

The city of Cotonou, characterized by a subtropical climate and a dense population, is particularly vulnerable to the effects of climate change, especially extreme temperature variations. These climatic conditions can be a trigger for strokes, notably through dehydration or increased blood pressure [4].

The research question posed in this study is: How do temperature variations influence the occurrence of strokes in the municipality of Cotonou, Benin? The hypothesis of this study is that increases in maximum and minimum temperatures, particularly heat waves, exacerbate the incidence of strokes in this region. The objective of this research is to determine the specific impact of these temperature variations and to propose recommendations for public health policies in Benin.

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2. Materials and Methods

2.1. Presentation of the study environment

The city of Cotonou, the economic capital of Benin, is located on the country's coastal plain, with geographic coordinates of 6°21' North latitude and 2°26' East longitude. It is bordered by the Atlantic Ocean to the south, Lake Nokoué to the north, and municipalities such as Sèmè-Kpodji to the east and Abomey-Calavi to the west. Cotonou covers an area of 79 km2 and comprises 13 districts, some of which are more exposed to environmental risks than others.

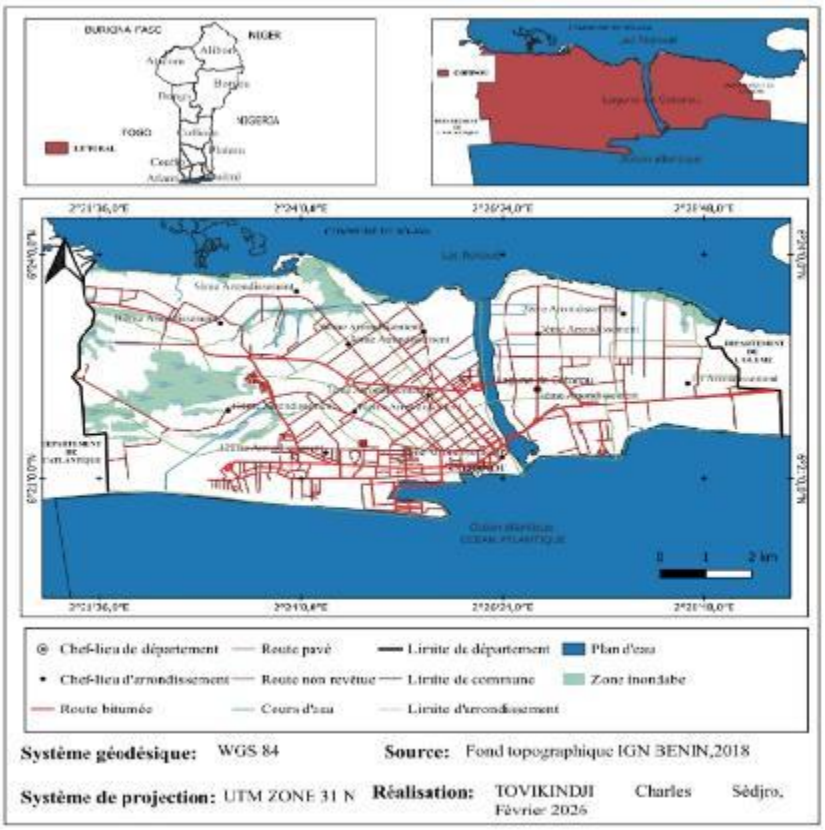


Figure 1 Geographical location of the Commune of Cotonou

The city is characterized by a coastal plain marked by marshes and low-lying areas. Cotonou has a humid tropical climate, with an average annual temperature of 27.3°C [5]. The hottest months, from February to April, see maximum temperatures ranging between 30°C and 31°C, while nights remain relatively cool with temperatures around 24°C. The annual temperature range is approximately 8°C. These temperature variations are particularly pronounced during the long dry season and the rainy season, directly impacting living conditions and public health.

Demographically, Cotonou has a population of 679,012 inhabitants according to the 2013 census, with a declining population growth rate. The population is predominantly made up of young, active adults, which represents a vulnerability factor for the incidence of strokes, particularly among people with pre-existing conditions.

2.2. Data used

For this study, several types of data were collected. These include climate data and health data. The climate data relating to minimum and maximum temperatures over the period from 1994 to 2025 were extracted from the Météo Bénin database, notably from the synoptic station of Cotonou Airport.

As for health data, it is focused on stroke statistics. They were obtained from the CNHU-HKM University Neurology Clinic, covering the period from October 1, 2023 to June 30, 2025.

2.3. Data processing and results analysis methods

Climate data was processed by calculating the monthly averages of minimum and maximum temperatures for each year of the period 1994-2025. This analysis made it possible to visualize temperature trends and highlight periods of extreme heat or intense cold.

The analysis of the relationship between temperature variations and stroke incidence was performed using Pearson's correlation coefficient. This method allows us to assess the degree of dependence between variables (temperature and number of stroke cases). The Pearson formula used is as follows:

$r = Cov(X, Y) / (\sigma X * \sigma Y)$

Where:

- r is the Pearson correlation coefficient.
- Cov(X, Y) is the covariance between the two variables.
- σX and σY are the standard deviations of the variables X and Y respectively.

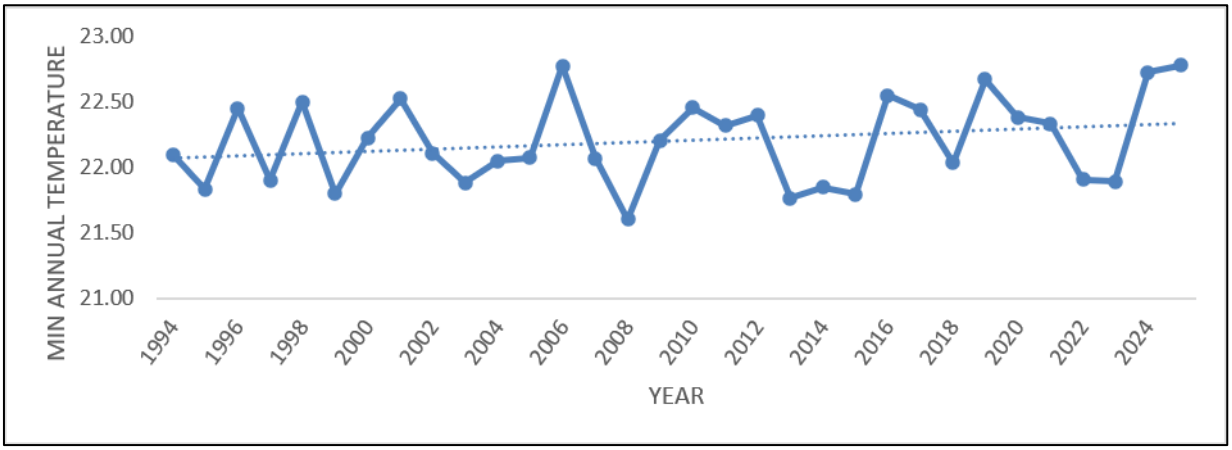
This coefficient, which varies between -1 and +1, has been interpreted according to the

following grid:

- If $|r| = 1$, then there is a total dependence between the two characteristics studied;
- If $|r| = 0$, then the two characteristics being studied are independent;
- If $|r| < 1$, the dependence is said to be partial;
- If $0.6 < |r| < 1$, then the two characteristics studied evolve in the same way and the evolution of one influences the other. In this case, the two characteristics are strongly correlated;
- If $0.3 < |r| < 0.6$, the two characteristics evolve in approximately the same way. In this case, they are moderately correlated;
- If $0 < |r| < 0.3$, the two characteristics are independent. Therefore, there is no correlation between the two characteristics studied.

3. Results and Discussion

3.1. Temperature evolution in the municipality of Cotonou (1994-2025)

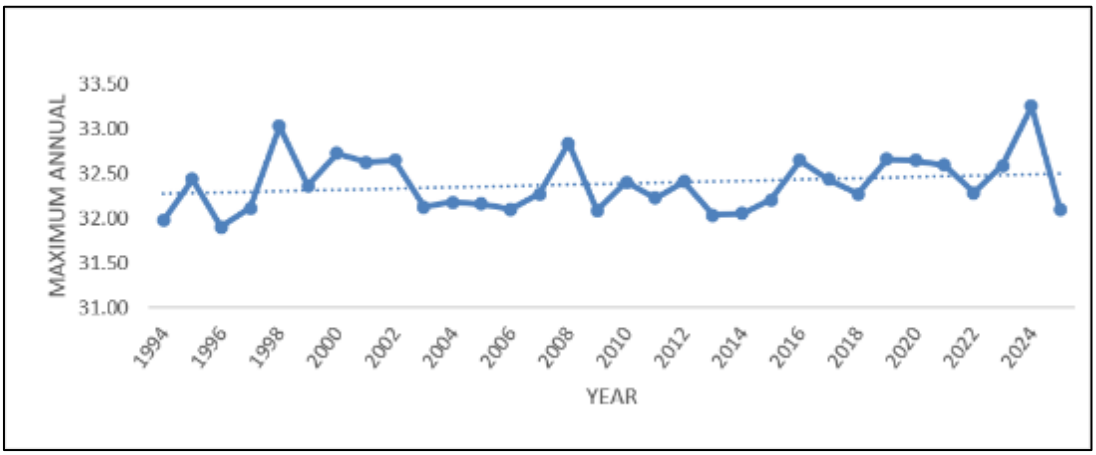


Source: Benin Meteorological Data, 2025

Figure 2 Inter-annual evolution of minimum temperature

The evolution of minimum and maximum temperatures in Cotonou from 1994 to 2025 showed significant fluctuations, with overall warming trends. Data from Météo Bénin revealed a gradual increase in both minimum and maximum temperatures over the years.

Observation of the inter-annual minimum temperatures shows they range between 21.60°C and 22.78°C, representing an interannual range of 1.18°C. The lowest value was observed in 2008 at 21.60°C, while the highest values were recorded in 2006 and 2025 at 22.78°C. The difference between the coldest and warmest years thus reaches 1.18°C, indicating a warming trend in nighttime and early evening temperatures, which is particularly important for health as it reduces opportunities for physiological recovery. The increasing trend means that, over three decades, the daily base temperature is rising, increasing the likelihood of prolonged heat waves and cumulative heat stress within the exposed population.

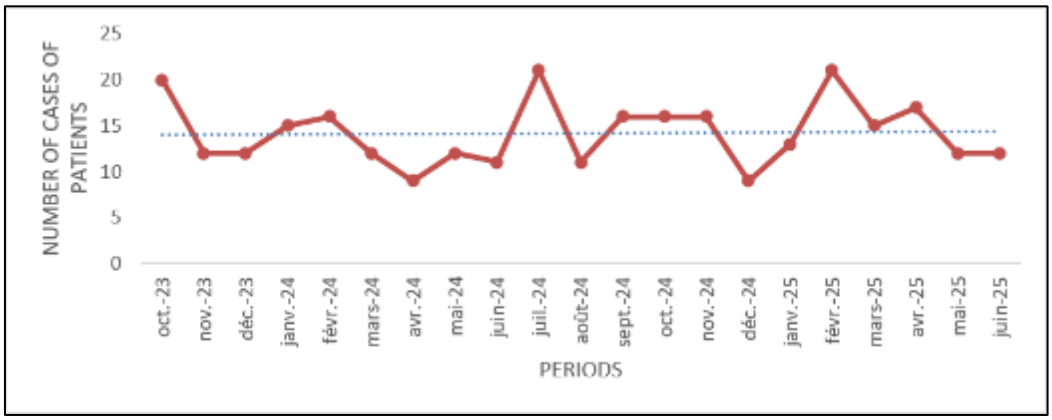


Source: Benin Meteorological Data, 2025

Figure 3 Inter-annual evolution of maximum temperature

An examination of maximum temperatures shows they fluctuate between 31.90°C and 33.25°C, with a notable peak in 2024 when the maximum temperature reached 33.25°C, the highest recorded during the period. This value is 1.35°C higher than the lowest recorded in 2008, which was 31.90°C. These temperature fluctuations demonstrate significant variability in maximum temperatures from year to year, with notable increases in recent years. In 2024, the hottest year ever recorded globally, maximum temperatures significantly contributed to extreme weather events. The trend towards rising maximum temperatures in this region coincides with the occurrence of more frequent heat waves, a factor known to increase the risk of strokes.

3.2. Evolution of strokes in Cotonou



Source: CUN/SSMR data

Figure 4 Inter-monthly evolution of the number of stroke cases at the Cotonou University Hospital Center (CUN) between October 1, 2023, and June 30, 2025

Figure 4 shows the monthly evolution of the number of stroke cases at the University Neurology Clinic of Cotonou over the period studied, i.e. between October 2023 and June 2025.

This graph illustrates the monthly evolution of stroke incidence in the municipality of Cotonou, highlighting the months when peaks were observed. Incidence peaks are seen in June 2024 and February 2025, when the number of cases reached its maximum, with 21 strokes recorded in a single month—a significantly higher value compared to the monthly average of approximately 12 strokes. This incidence peak in June 2024 coincides with a period of extreme heat (maximum temperature of 33.25°C), which reinforces the hypothesis of a link between increased temperature and the higher incidence of strokes.

Conversely, April 2024 and December 2024, when temperatures were less extreme, recorded the lowest number of cases, with only 9 strokes per month. This data clearly illustrates the trend of increasing strokes associated with periods of intense heat, and this phenomenon is statistically significant. Analysis of this monthly trend highlights the direct impact of heat waves on cardiovascular health, underscoring the need to adapt prevention strategies during the warmer seasons.

3.3. Correlation between temperature and strokes in Cotonou

Table 1 presents the correlation coefficient between minimum and maximum temperatures and the number of stroke cases in Cotonou.

Table 1 Correlation coefficient between temperatures (minimum, maximum) and strokes

Climatic elements	Pathology: Stroke (CVA)
Minimum temperature	r = 0.75
Maximum temperature	r = 0.65

Source: Benin Meteorological Service, CUN/SSMR, 2025

The correlation coefficient for minimum temperature is r = 0.75, indicating a strong positive correlation between rising nighttime temperatures and stroke incidence. This means that rapid increases in minimum temperature are often followed by an increase in the number of stroke cases in the municipality. In contrast, for maximum temperature, the correlation coefficient is r =0.65, a moderate but still significant correlation. This result suggests that periods of intense

heat, characterized by high maximum temperatures, also have a direct impact on stroke incidence, although the relationship is slightly weaker compared to minimum temperatures.

These results confirm the hypothesis that temperature extremes influence stroke frequency, a phenomenon also observed in other regions experiencing heat waves, as shown in the work of Chen et al. [6]. The data in the table support the need to strengthen stroke prevention strategies during periods of extreme temperature.

4. Discussion of results

The results of this study highlighted a significant correlation between temperature variations and the incidence of strokes in the municipality of Cotonou. These results corroborate several previous studies that have found links between temperature extremes and the occurrence of strokes. For example, a study conducted in China by Chen et al. [6] demonstrated that extreme temperatures increase stroke-related mortality. Similarly, a study in Germany [7] revealed that temperature variations directly influence the risk of stroke, a phenomenon also observed in other regions of Africa [8].

The increase in minimum and maximum temperatures, particularly during heat waves, appears to play a direct role in the increased frequency of strokes, as observed in June 2024 and February 2025, when extreme temperatures coincided with spikes in stroke cases. These findings align with those observed by Zhou et al. [9], who documented a sharp increase in strokes associated with periods of intense heat in several East Asian cities.

The pathophysiological mechanisms underlying this relationship are well established: elevated body temperature can lead to dehydration and increased blood pressure, two major risk factors for stroke [4]. Furthermore, rapid temperature changes, especially sudden drops, can cause vascular contractions, contributing to the increased risk of ischemic stroke

[2]. These mechanisms are reinforced by the work of Gomes et al. [10], who also observed links between temperature variations and the occurrence of stroke in a tropical climate.

This study also highlights the need to adapt public health policies to these climatic realities. Awareness campaigns must be implemented to inform the public about the climate-related risks associated with strokes, particularly during periods of extreme heat. Prevention strategies could include measures such as promoting hydration, monitoring vulnerable individuals, and establishing mobile health centers during periods of intense heat [11].

Furthermore, it would be relevant to extend this study to other regions of Benin to better understand the impact of climate on public health in the country, especially taking into account climate change forecasts, as indicated by the WHO and IPCC projections on the future impacts of global warming [12, 13].

5. Conclusion

A study of the impact of temperature variations on strokes in the municipality of Cotonou revealed significant results. Climatic and epidemiological data showed a strong correlation between periods of intense heat and an increase in stroke cases. These results confirm that extreme temperature variations, both sudden increases in minimum temperature and maximum variations, are important risk factors for public health, particularly for strokes.

This study highlights the importance of integrating climate risks into stroke prevention strategies in Cotonou. Awareness campaigns must be conducted to inform the population about the risks associated with extreme temperatures and the preventive measures to adopt. Furthermore, this research underscores the need to strengthen health infrastructure and adopt public policies adapted to the effects of climate change.

Finally, it is essential to extend this research to other regions of Benin and to further analyze the impacts of climate on public health, in order to better anticipate and manage the health risks related to climate change in the country.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

Statement of ethical approval

The collection and use of clinical data for this study were conducted in accordance with ethical standards and institutional guidelines.

Statement of informed consent

Patient data obtained from the CNHU-HKM University Neurology Clinic were fully anonymized and handled with strict confidentiality to protect patient privacy.

References

[1] Chen R, Ovbiagele B, Feng W. Diabetes and stroke: epidemiology, pathophysiology, pharmaceuticals, and outcomes. *Am J Med Sci* 2016;351(4):380–6. https://doi.org/10.1016/j.amjms.2016.01.011

[2] Lian H, Ruan Y, Liang R, Liu X, Fan Z. Short-Term Effect of Ambient Temperature and the Risk of Stroke: A Systematic Review and Meta-Analysis. *Int J Environ Res Public Health* 2015;12(8):9068-88. https://doi.org/10.3390/ijerph120809068

[3] Takumi I, Mishina M, Kominami S, Mizunari T, Kobayashi S, Teramoto A, et al. Ambient Temperature Change Increases in Stroke Onset: ~~Analyzes~~ Analyses Based on the Japanese Regional Metrological Measurements. *J Nippon Med Sch* 2015;82(6):281-6. https://doi.org/10.1272/jnms.82.281

[4] Larequi Y, He C, Breitner S, Zhang S, Huber V, Naumann M, et al. Nighttime heat exposure and stroke risk. *Mains Libres* 2024;41(3):214. https://doi.org/10.55498/MAINSLIBRES.2024.12.3.214

[5] ASECNA. Données climatologiques de la station synoptique de Cotonou Aéroport. Cotonou: Agence pour la Sécurité de la Navigation aérienne en Afrique et à Madagascar; 2010.

[6] Chen R, Wang C, Meng X, Chen H, Thach TQ, Wong CM, et al. Both low and high temperature may increase the risk of stroke mortality. *Neurology* 2013;81(12):1064-70. https://doi.org/10.1212/WNL.0b013e3182a4a43c

[7] Ghiani M, Mueller S, Wilke T. PCV150 Do weather changes affect the risk of stroke? An analysis using german claims data. *Value Health* 2019;22:S570. https://doi.org/10.1016/j.jval.2019.09.874

[8] Tchapebong JP. Climate Variations and Risk of Stroke in the City of Bamako [doctoral thesis]. Bamako: Faculty of Medicine and Odontostomatology; 2019. 160 p.

[9] Zhou L, He C, Kim H, Honda Y, Lee W, Hashizume M, et al. The burden of heat-related stroke mortality under climate change scenarios in 22 East Asian cities. *Environ Int* 2022;170:107602. https://doi.org/10.1016/j.envint.2022.107602

[10] Gomes J, Damasceno A, Carrilho C, Lobo V, Lopes V, Madede T, et al. Triggering of stroke by ambient temperature variation: A case-crossover study in Maputo, Mozambique. *Clin Neurol Neurosurg* 2015;129:72-7. https://doi.org/10.1016/j.clineuro.2014.12.002

[11] McCarthy J, Yang J, Clissold B, Young MJ, Fuller PJ, Phan T. Hypertension Management in Stroke Prevention: Time to Consider Primary Aldosteronism. *Stroke* 2021;52(5):e626–34. https://doi.org/10.1161/STROKEAHA.120.033990

[12] Sung FC, Huang LY, Huang YL, Wang YC. Population study on the risk of stroke associated with temperature variations. *ISEE Conf Abstr* 2011;2011(1). https://doi.org/10.1289/isee.2011.00336

[13] GBD 2019 Diseases and Injuries Collaborators. Global burden of 369 diseases and injuries in 204 countries and territories, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. *Lancet* 2020;396(10258):1135–59. https://doi.org/10.1016/S0140-6736(20)30925-9