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Determinants of some risk factors affecting stroke patients' survival

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Abstract

This study aimed to identify the primary risk factors affecting the survival of stroke patients receiving follow-up care using the University of Ilorin Teaching Hospital as a case study. We analyzed data from 390 patients, 120 of whom were female, and 270 males, between 2021 and 2022. Shockingly, 27.5% of the female patients and 57.7% of the male patients passed away during the study. Of the 225 patients with high blood pressure, 72% experienced the event. A total of 162 individuals with cardiac disease suffered mortality, while 33 of the 85 patients with diabetes mellitus passed away. Hemorrhagic and ischemic strokes were prevalent, resulting in 45 and 102 deaths, respectively, while 96 out of the 204 patients with baseline complications succumbed. The Cox regression analysis identified hypertension, gender, and baseline complication as the most significant factors affecting mortality rates. Univariate analysis revealed that stroke type, drug type, and patient age were significant, but not at the multivariate stage. Although gender, baseline complication, and hypertension were insignificant, the results revealed no statistically significant difference in survival probability among groups categorized by diabetes mellitus, cardiac disease, stroke type, or drug type.

Keywords: Stroke patients; Risk factors; Survival rate; Follow-up care; Teaching Hospital; Mortality; Cox regression analysis

1. Introduction

The dire and hazardous malady of stroke afflicts countless individuals across the globe.[14] It stands tall as the second most prevalent cause of mortality for those exceeding 60 years of age. Forecasts propose that its incidence and death toll will soar in the future.[15] In 2005, an estimated 16 million people experienced new stroke cases, while 62 million survivors persisted worldwide. Additionally, this ailment represents 9.7% of the world's entire fatalities.[16] Nevertheless, if appropriate and extensive measures are not implemented through communal health initiatives, it is anticipated that 23 million new stroke cases and 7.8 million deaths resulting from it will manifest by 2030. Consequently, it is vital to acknowledge and address this dilemma with utmost sincerity to thwart and regulate stroke efficiently.[1]

The outcomes of a comprehensive investigation executed in the South Western region of Saudi Arabia divulged a conspicuous correlation between various elements and in-patient mortality rates among individuals who suffered from a stroke.[17] The said factors comprise a smoking habit before the stroke, a history of high blood pressure before the stroke, disordered consciousness following the stroke, poor physical mobility following the stroke, and the onset of pulmonary embolism.[18, 27] These revelations emphasize the criticality of addressing these jeopardy factors to curtail the death rate of stroke victims within hospital premises. The outcome of this analysis could potentially serve as a precious resource for healthcare experts in their endeavors to prevent and regulate deaths associated with stroke.[2]

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The escalating incidence of stroke in Africa is a mounting concern, predominantly attributed to the surging pervasiveness of hypertension and the inadequate cognizance and regulation regarding this matter.[19] Presently, African countries are confronting an epidemiological transformation, which is an outcome of the altering demography and lifestyle elements. This shift is increasing the prevalence of stroke and necessitating the need for communities to prioritize the edification and regulation of hypertension and other risk factors related to stroke.[20] By confronting these issues and endorsing improved health customs and practices, African nations can anticipate ameliorating the effect of stroke and lessening its impact on their populace. [3] As of late, the prevalence of non-transmissible ailments has seen a marked upsurge, wherein cardiovascular jeopardy factors have had a major role to play. With this surge in NCDs, the incidence of stroke has seen an upward trend as well, being one of the primary outcomes of these cardiovascular risk factors. The situation has been particularly concerning in the African continent, where the incidence of stroke seems to be growing at an alarming pace.[21] The situation is further heightened by the fact that there are limited resources to deal with this mounting health crisis.[22] As such, there is an imminent need for more comprehensive research and treatment options to mitigate the deleterious effects of these conditions.[4]

As per the report of the World Health Organization (WHO), stroke is the second most frequent cause of mortality in Nigeria, contributing to about 15% of the overall deaths in the country. [5] In Nigeria, the incidence of stroke is mounting at an alarming pace, predominantly among the geriatric populace.[23] According to numerous studies, hypertension is identified as the leading risk factor for strokes, with an incidence rate of nearly 40% in the region. Other noteworthy risk factors encompass smoking, diabetes, and elevated cholesterol levels. [6]

Although stroke is widespread in Nigeria, the country is grappling with multiple hurdles in its management and prevention. [24, 26] Among these challenges are restricted entry to healthcare services, an insufficiency of awareness regarding the disease and its associated risk factors, and limited resources dedicated to the control and prevention of stroke. [7, 25] Despite all these, the quandary of stroke in Nigeria can be assuaged by investing in a stroke education and awareness campaign, making healthcare services more accessible, and channeling more resources into research and development to manage and prevent the disease.[8]

1.1. Checking for Significant Differences in Survival between Groups

To evaluate the survival encounters of varying groups, it is essential to identify any significant distinctions between them. This evaluation can be conducted using statistical analyses, including the Peto test, Flemington-Harrington test, Tarone-ware test, Wilcoxon test, or the log-rank test. Amongst these, the log-rank test is commonly utilized, measuring the divergence between survival curves and determining whether the variance is statistically significant. A substantial difference between the survival curves as deduced by the log-rank test indicates that the survival experiences of the distinct groups are not similar.

H_o: *Survival times between groups are the same*

H_1: *Survival times between groups are different*

2. Methodology

2.1. Study Area

This study was conducted at the University of Ilorin Teaching Hospital, Ilorin, Kwara State, Nigeria.

2.2. Study Design and Population

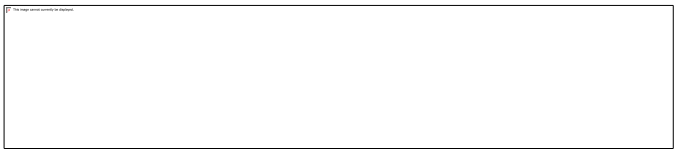
Retrospective data was compiled from a pool of 390 patients afflicted with the debilitating stroke disease for a span of 24 months.

2.3. Variable in the Study

The dependent (outcome) variable in this study was the time variable length of stay measured (in days) from the start date of stroke treatment until the date of the patient's death or censor. The following are covariate variables in the study: gender, age, hypertension, cardiac disease, diabetes mellitus, stroke type, baseline complication, and drug type.

2.4. Method of Data Analysis

In the realm of statistical data analysis, survival analysis encompasses a series of techniques to evaluate data concerning time to an event of interest.[29] The first step in the analysis of survival data is to showcase numerical or graphical synopses of survival times within a specific cluster. In summarizing survival data, the two primary functions employed are the survivor function and the hazard function.[9] The Kaplan-Meier estimator is a statistical technique that is parameter-free and employed to calculate the survival function based on lifetime data.[28, 30] The estimator computes the survivorship function or the survival probability of an individual as thus:



Where t_j, j = 1, 2,...,n is the total set of failure times recorded (with t^+ the maximum failure time), d_j is the number of failures at time t_j, and r_j is the number of individuals at risk at time t_j.

One of the most popular types of regression models used in survival analysis is the Cox proportional hazard model.[10] The authors proposed a semiparametric model for the hazard function that allows the addition of covariates while keeping the baseline hazards unspecified, and only positive values with this parameterization of the Cox hazard function are given by:

$$h_i(t) = h_0(t)\exp(\alpha + \beta_1 x_{i1} + \beta_2 x_{i2} + \ldots.. + \beta_k x_{ik})$$

Where the term $h_0(t)$ is called the baseline hazard function, $x = (x_1, x_2, x_3 \ldots x_p)'$ is the values of the vector of explanatory variables; and $\beta' = (\beta_1, \beta_2, \ldots \beta_p)$ is a vector of regression coefficients. The main assumption of the Cox proportional hazard model is proportional hazards which means that the hazard function of one individual is proportional to the hazard function of the other individual; i.e., the hazard ratio is constant over time.

3. Result

3.1. Descriptive Summaries

A comprehensive analysis of 390 patients who had experienced a stroke between the years 2021 and 2022 was conducted. This study revealed that the male populace outweighed the female with a staggering 270 males compared to 120 females. The study revealed that 33 females, representing 27.5% of the population experienced fatality, while 156 males, accounting for 57.7% of the entire population, shared a similar fate. Additionally, 225 patients were diagnosed with high blood pressure, and out of this lot, 162 individuals (72%) experienced the event. Further, out of the 162 patients diagnosed with cardiac disease, 67 (41.4%) of them died. On the other hand, 85 patients were diagnosed with diabetes mellitus, out of which 33 (38.8%) had died while the remaining 52 (61.2%) were censored. Notably, 120 of the patients experienced a hemorrhagic stroke, while the remaining 270 experienced ischemic stroke, leading to 45 and 102 fatalities, respectively. Lastly, the study revealed that 204 of the patients had a baseline complication, of which 96 individuals did not survive. (Table 1).

Table 1 Baseline covariate characteristics with their time-to-death status.

Variables	Categories	Frequency	Death (%)	Censored (%)
Gender	Male	270 (69.2%)	156 (57.7%)	114 (42.2%)
	Female	120 (30.8%)	33 (27.5%)	87 (72.5%)
Blood pressure	Yes	225 (57.7%)	162 (72.13%)	63 (28%)
	No	165 (47.3%)	52 (27.87%)	113 (45.4%)
Cardiac disease	Yes	162 (41.5%)	67 (41.4%)	95 (58.6%)
	No	228 (58.5%)	92 (40.4%)	136 (59.6%)

Diabetes mellitus	Yes	85 (21.8%)	33 (38.8%)	52 (61.2%)
	No	305 (78.2%)	62 (20.3%)	243 (79.7%)
	Hemorrhagic	120 (30.8%)	45 (37.5%)	75 (62.5%)
Stroke type	Ischemic	270 (69.2%)	102 (37.8%)	168 (62.2%)
Baseline complication	Yes	204 (52.3%)	96 (47.1%)	108 (52.9%)
	No	156 (47.7%)	71 (45.5%)	85 (54.5%)

3.2. The Kaplan-Meier Estimate

The general evaluation of the Kaplan-Meier survivor function indicated that a considerable number of fatalities were recorded in the initial stages of anti-stroke medication, as evidenced by the graph. Furthermore, the same diagram demonstrated a decline in the number of deaths over a course of the follow-up duration. (Figure 1) below.

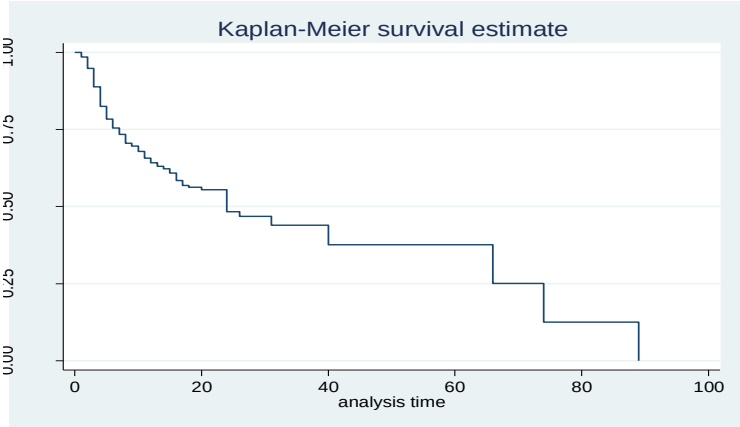


Figure 1 Overall Stroke infected patients KM descriptive plot

The Kaplan-Meier estimates demonstrate that females have a higher chance of survival compared to their male counterparts. The survival curves for female patients exceed those of males, indicating that women have better odds of survival. (Figure 2) below.

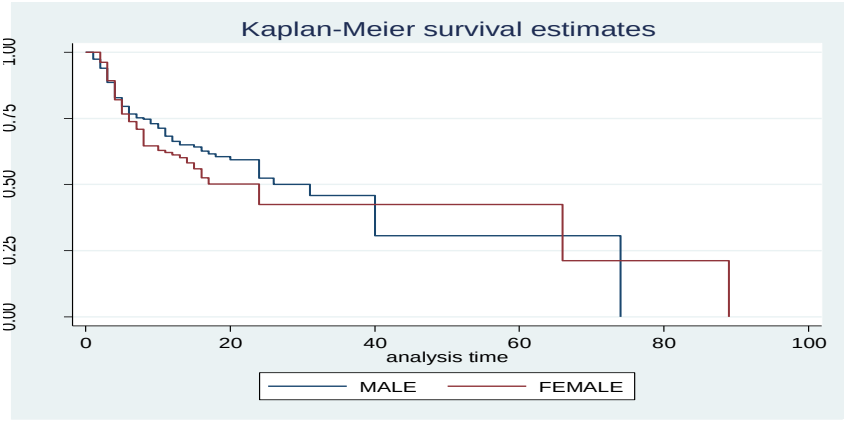


Figure 2 Survival curve based on the gender of Stroke patients

As shown by the survival curves of the Kaplan-Meier estimates, patients diagnosed with hemorrhagic stroke have a notably higher survival rate than those diagnosed with ischemic stroke. This suggests that patients with ischemic stroke stand a greater chance of survival than their hemorrhagic counterparts. (Figure 3).

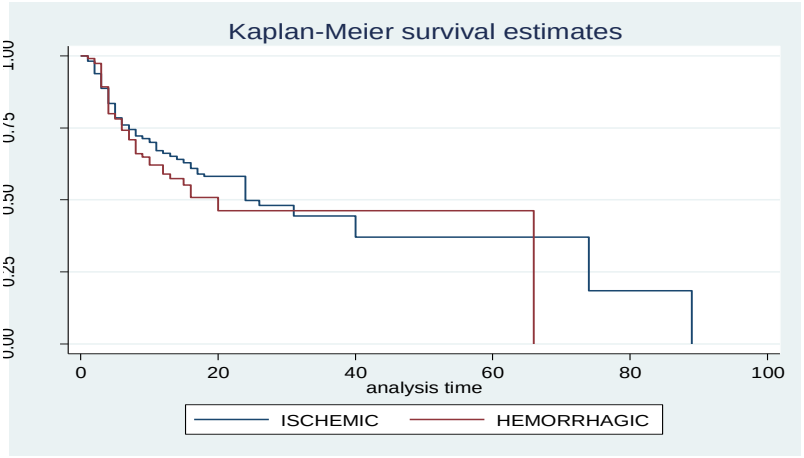


Figure 3 Survival curve based on the diagnosis of stroke type

3.3. Log-Rank Tests of Each Covariate

The log-rank test indicates that statistically there is a significant difference in survival experience among groups of gender, age, high blood pressure (hypertension), and baseline complication. On the other hand, there are statistically no significant differences in survival/death experience among groups of the categorical covariates cardiac disease, diabetes mellitus, stroke type, and drug type. (Table 2)

Table 2 Results of the Log-Rank Test and Peto Test for the Categorical Variables of Stroke Patients**.**

		Log Rank		**Peto**		
	Covariates	df	χ^2	p-value	χ^2	p-value
	Gender	1	12.536	0.0002	14.62	0.0031
	Age group	1	3.44	0.0000	4.35	0.0002
	Diabetes Mellitus	1	7.96	0.0048	3.89	0.0881
	Type of Stroke	1	15.58	0.0353	15.31	0.0361
	Baseline Complication	1	12.34	0.0004	12.74	0.0007
A	Cardiac Disease	1	9.80	0.065	8.97	0.0617
	Blood Pressure	1	5.44	0.0001	4.96	0.000
	Drug Type	5	2.23	0.876	3.45	0.638

3.4 Multivariate Analysis of Cox PH Regression Model: The elimination of non-significant covariates in the multivariate analysis was achieved through the adoption of a stepwise elimination method, which resulted in the exclusion of cardiac disease and diabetes mellitus. In assessing the significance of each variable, the P-value for each parameter was determined, and any variable with a P-value less than 0.05 was deemed important and subsequently incorporated into the final model. Consequently, gender, blood pressure, baseline complication, and stroke type were identified as the crucial variables that have a significant impact on the survival of stroke patients. (Table 3).

Table 3 Multivariate Cox PH analysis of the stroke data set from the UITH.

Covariates	Category	Coef (β)	Haz. ratio	Std. Err. (β)	Wald	P -value
Age	≤ 40 years	0.0051853	1.0051988	0.0052631	0.985	0.325
Gender	Female					0.002
	Male	-0.7226692	0.4854547	0.1937196	-3.730	
Blood pressure	No					
	Yes	0.6713666	1.9569097	0.2145444	3.129	0.002
Baseline complication	No					
	Yes	0.5218596	1.6851584	0.2236382	2.333	0.020
	Hemorrhagic			.		
Stroke type	Ischemic	-0.2105377	0.8101485	0.2094069	-1.005	0.0315

3.4. Diagnosis of the Model

In the likelihood ratio and significance of the final Cox PH model from the likelihood ratio test, it can be seen that the PH model is significant since *P*-value is less than 5%. (Table 4)

Table 4 The likelihood ratio and significance of the PH model

Covariate	Coef (β)	HR	se (β)	Wald	P value
Gender (Male)	-0.452	0.231	0.167	-3.66	0.002
BP (Yes)	0.454	1.765	0.218	3.15	0.002
Baseline (Yes)	0.556	1.981	0.222	3.12	0.002

4. Discussion

The findings of this study provide valuable insights into the determinants of survival among stroke patients in Nigeria, particularly at the University of Ilorin Teaching Hospital. The analysis revealed several significant risk factors affecting patient outcomes, with hypertension, gender, and baseline complications emerging as the most crucial variables impacting stroke survival.

High blood pressure was identified as a major risk factor, with 72% of hypertensive patients experiencing mortality. This aligns with recent global trends, as highlighted by the World Stroke Organization's 2022 fact sheet, which emphasizes hypertension as a leading modifiable risk factor for stroke.[16] The high prevalence and mortality rate associated with hypertension in this study highlights the critical need for improved hypertension management and prevention strategies in Nigeria.

Gender differences in stroke outcomes were notable, with male patients showing a higher mortality rate (57.7%) compared to females (27.5%). This gender disparity in stroke outcomes has been observed in other studies, including a 2021 systematic review by Carcel et al., which found that women generally have poorer functional outcomes and higher disability rates post-stroke.[31] However, our findings contradict this trend in terms of mortality.

The significance of baseline complications in determining stroke outcomes aligns with recent literature emphasizing the importance of comprehensive stroke care. A 2020 study by Akinyemi et al. highlighted the complex link between pre-existing conditions and stroke outcomes in sub-Saharan Africa.[32] Our findings reinforce the need for thorough assessment and management of comorbidities in stroke patients.

Interestingly, our study found no statistically significant difference in survival probability among groups classified by cardiac disease, diabetes mellitus, stroke type, and drug type. This contrasts with some recent studies, such as a 2019

meta-analysis by Esenwa et al., which identified diabetes as an independent risk factor for poor outcomes in ischemic stroke.[33] This discrepancy may be due to regional differences in risk factor profiles or healthcare delivery systems, highlighting the importance of context-specific research in stroke epidemiology.

The high mortality rate observed in the early stages of anti-stroke medication administration is concerning and warrants further investigation. Recent advancements in acute stroke management, as discussed in a 2022 review by Powers et al.[34], emphasize the critical importance of rapid and effective early interventions. This findings suggest a potential gap in the implementation of these best practices in this study setting.

The survival advantage observed in hemorrhagic stroke patients compared to those with ischemic stroke is an intriguing finding that contradicts some established patterns in stroke outcomes. A 2018 study by Krishnamurthi et al.[35] reported generally poorer outcomes for hemorrhagic stroke globally. This unexpected result in this study population may reflect differences in local risk factors, treatment protocols, or even genetic factors specific to the Nigerian population, emphasizing the need for more focused research in this area. This study findings contribute significantly to the understanding of stroke epidemiology in Nigeria, a country where the burden of stroke is rapidly increasing, as noted by Adeloye et al.[36] in their 2019 systematic review. By identifying key risk factors and survival patterns, this study provides valuable information for healthcare providers and policymakers to improve stroke prevention and management strategies.

5. Conclusions

The objective of the study was to identify significant risk factors that affect the survival of stroke patients who have been under follow-up at the University of Ilorin Teaching Hospital, Ilorin. For determining the risk factors for the survival time of stroke patients, a total of 390 stroke patients whose data were treated were analyzed from the years 2021 – 2022. it was found that 120 of these patients were female and 270 were male. Out of the female patients, 33 (27.5%), experienced death during the study. Similarly, 156(57.7%) male patients out of a total of 270 experienced death. Also, 225 patients had blood pressure. of these patients, 162 (72%) experienced the event. Also, out of 162 people who had cardiac disease of which 67 (41.4%) experienced death. It was also confirmed that of 85 people who had diabetes mellitus, 33(38.8%) were dead while 52(61.2%) were censored. 120 people have a hemorrhagic stroke while 270 people had an ischemic stroke, 45 people died of a hemorrhagic stroke and 102 people died of ischemic stroke. Finally, 204 people had a baseline complication of which 96 of them dead.

The Cox regression analysis showed that the major factors that affect the survival of stroke patients are hypertension, gender of the patients, and baseline complication which were strongly related to mortality, and based on the hospital outcome, the most common causes of death were

hypertension and baseline complication. However, some variables were significant at the univariate stage of analysis but not at the multivariate analysis stage. These were stroke type, drug type, and age of patients. Moreover, variables that were significant neither in univariate nor in multivariate analyses were gender, baseline complication, and hypertension. The result of this study also indicated that the survival probability of a patient is not statistically different among groups classified by cardiac disease, diabetes mellitus, stroke type, and drug type.

5.1. Recommendations

Based on the analysis of the data from this study, the following recommendations were made:

People should be made aware of the risk factors that can lead to stroke and the importance of being knowledgeable about the disease. This study identified hypertension, gender, and baseline complication as the major risk factors that significantly impact the survival of stroke patients. Therefore, it is crucial to prioritize management strategies that focus on reducing the incidence of these factors.

It is also recommended that the concerned health management authorities should implement measures to address hypertension and baseline complications to improve patient outcomes. This can include promoting healthy lifestyle practices and providing prompt medical attention to patients.

5.2. Limitation

One of the key limitations of this study is that it was conducted solely at the University of Ilorin Teaching Hospital in Ilorin, and as such, may not be generalizable to other hospitals or healthcare settings in different regions or countries. Another limitation is that the study only covers a two-year period, which may not be a sufficient timeframe to fully

capture the long-term effects of stroke and its risk factors. Also, the study only considers a limited set of risk factors, and other factors that may impact stroke survival, such as lifestyle, socioeconomic status, and access to healthcare, were not examined, which is a vital area for future research. These limitations should be taken into account in future studies to build on this research and expand the understanding of stroke patient outcomes.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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