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Article

Non-Modifiable Risk Factors (Age and Sex), Stroke Types, and Outcomes in Rivers State, Nigeria: A Retrospective Hospital-Based Study

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Abstract: This study used structural equation modelling (SEM) to evaluate the direct effect of sex and age on stroke types and outcomes in Tertiary Health Facilities in Rives State, Nigeria. The study was a cross-sectional retrospective hospital-based research that utilized specific stroke patients' information between 2015-2019. The study obtained the sex and age, stroke type (ischemic/hemorrhagic), and outcomes (No disability/disability/death) from the records. The retrieved data was Microsoft Excel (2016), then analyzed using SPSS (version 21, Amos) and STATGRAPHICS centurion (Stat Point Tech., Inc.). From the result, out of the recorded 1916 stroke patients, 1229 (64.1%) were female, while 687 (35.9%) were males. The older adults (>55 years) had more recorded cases (n=1289) than young adults (ages 18–35 years; n=77) and middle-aged adults (ages 36–55 years, n=550). The SEM results showed that age was significantly associated with stroke type (P<0.001) and outcomes (P=0.038), while sex was significantly associated with stroke outcomes (P<0.001). The likelihood of death was 1.3× higher in hemorrhagic stroke than ischemic stroke. In conclusion, age and sex had direct effects on stroke type, while age had a direct effect on stroke outcome. Hemorrhagic stroke was more likely to cause death than ischemic stroke in the studied population.

Keywords: *Age; Sex; Stroke Types; Outcomes; SEM; Tertiary Hospitals; Rivers State.*

1. Introduction

The subject of stroke can be traced back to 460 - 370 preceding the Common Era and was first referred to as 'Apoplexy' by Hippocrates due to the physical symptoms of spasms and loss of motion [1], [2]. Although the nomenclature by Hippocrates suggests physical changes that occur in stroke patients, but not necessarily cerebral function disturbances associated with stroke [3]. It was only until the last half of the seventeenth century, that Jakob Wepfer and Thomas Willis highlighted blood supply disruption in the brains of people diagnosed with Apoplexy, thus, providing the most important advances in the

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understanding of stroke [3]–[5]. Apoplexy was further described as blocked carotid or vertebral artery in some cases, and bleeding into the brain in others [3], [6]. However, in 1689 the word 'Stroke' was introduced into medicine by William Cole [7], [8].

Stroke which is defined as focal neurological deficit of a vascular origin [9]–[11] is the second-leading single cause of death in the world and the third leading cause of premature morbidity and mortality as measured by disability adjusted life years (DALY) according to WHO [11]–[14], closely behind ischemic heart disease [11], [14]–[19]. Surprisingly, the proportion appears underestimated [20], [21] and the consequence on patients and their families is often unexplainable, and sometimes referred to as tragic [22], [23] because of the enormous psychological, social, and financial burden [6], [24].

The burden of stroke is likely to increase in low-and middle-income countries because of the ongoing epidemiological transition [25], [26]; however, the people of African descent are suggested to be the most predisposed to stroke at a younger age, with the worst outcomes [27], [28]. Evidence from community-based study suggest that the age-standardized annual stroke incidence in Africa was up to 316 per 100,000 [29]. In Sub-Saharan Africa (SSA), a good number of hospitals register a high incidence of stroke death, with more than 30% of patients dying within the first month of onset [17], [30]–[32]. From a community-based survey, the estimated prevalence of stroke was about 300 cases per 100,000 population in SSA; affecting mainly young people [13], [24], [29]. Incidentally, epidemiological information on stroke in SSA remains a challenge because available data are often fragmented arising from inadequacies in registries, facilities, poor access to care, and lack of specialists [36]. In Nigeria, the prevalence ranges from 0.58 to 13.31 per 1,000 persons [25], [26], [33]–[35]. The annual mortality rate increased with age from 0.70/1,000 to 15.19/1,000 per year in the eighth decade [34].

On the basis of imaging findings stroke is divided into two [37]; ischemic and hemorrhagic stroke [6], [8], [12], [37]–[40]. Ischemic stroke arises from blocked artery, which could be because of an embolus or thrombosis that interrupts the flow of oxygen to the brain, while hemorrhagic stroke is simply due to a blowout or breakage of a blood vessel in the brain which can either be intracerebral or subarachnoid [3], [21], [41]–[43]. According to Avan *et al*., the global number of those diagnosed with ischemic stroke doubled between 1990 and 2017 [44]. In 2013 alone, 10.3 million new stroke cases were reported with 67% ischemic stroke [45]. Of the 6.5million stroke deaths, 51% were caused by ischemic stroke. Additionally, out of the 25.7 million stroke survivors, 71% had ischemic stroke [45]. On the other hand, Katan and Luft found that hemorrhagic stroke was responsible for more death and disability-adjusted life-years lost (DALYs) worldwide [46].

Furthermore, data obtained from the INTERSTROKE study involving 22 countries indicates that in African countries [47], the gap between those diagnosed with ischemic and hemorrhagic stroke were about 66% and 34%, respectively [29], [47], [48]. In Nigeria and Ghana, the percentage of individuals confirmed to have ischemic stroke was 68% and hemorrhagic stroke 32% whereas in high income countries the percentage was significantly higher for ischemic stroke (91%) and lower for hemorrhagic stroke (9%) [6], [31]. Additionally, when the two subtypes of hemorrhagic strokes were compared, the incidence of intracerebral hemorrhage was higher than subarachnoid hemorrhage [49]. Intracerebral stroke accounts for 80% of hemorrhagic stroke [6]. Studies that compared the incidence of TIA with the types of stroke suggested that the incidence of TIA was lower than ischemic stroke but higher than hemorrhagic stroke [47], [49].

There are two types of risk factors associated with stroke: modifiable and non-modifiable [13], [50]–[52]. The modifiable risk factors are often adjustable and associated with the individual’s lifestyle which includes high cholesterol, smoking, lack of physical activity, and poor diet, alcohol consumption, stress, obesity, diabetes, heart disease, and hypertension [6], [7], [56], [13], [47], [50]–[55]. On the other hand, the non-modifiable risk factors are usually beyond the individual's control and include gender, age, genetics and ethnicity [51]–[53], [57]. According to reports from the INTERSTROKE study, around 90% of the global stroke burden is brought about by ten modifiable risk factors [6], [58], [59]. A recent systematic review showed that among the modifiable risk factors, hypertension

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and diabetes were identified as the main danger components of stroke [60]–[62]. For non-modifiable factors, the relationship between stroke and age, sex, and ethnicity remain non-linearly correlated [53], [57], while genetic predisposition has a significant correlation with stroke [53], [63], [64].

Although there is a lot of the hospital-based study confirming a high prevalence of stroke in Nigeria [65]; however, there is still epidemiological gaps in stroke characteristics and its distribution in Nigerian populations and subpopulations, specifically among South-South populations. On this background, this study employed SEM to evaluate the role of age and sex as non-modifiable risk factors for stroke types and outcomes in Rivers State; relying on the evidence from retrospective hospital data.

2. Materials and Methods

2.1 Study Design

This was a five-year (Jan 2015-Dec 2019) hospital-based retrospective, analytical study conducted at the Rivers State University Teaching Hospital (RSUTH) and University of Port Harcourt Teaching Hospital (UPTH), the two tertiary health facilities in Rivers State, Nigeria. The study was carried out from 15th May 2019 to 31st February 2020. The study was conducted in line with the ethical declaration of Helsinki [66]. During the research, the ensured that anonymity and confidentiality was upheld to the highest standard.

2.2 Study Framework

The conceptual model for this study was developed on the background of theoretical constructs and empirical evidence of sex and age as factors for stroke cases and outcomes [11], [15], [72]–[76], [41], [59], [61], [67]–[71]. Studies have shown that stroke types (ischemic/hemorrhagic) are associated with stroke outcomes (no-disability/disability/death) [6], [7], [45], [69], [76], [77] and it can be influenced by non-modifiable risk factors such as age and sex [6], [13], [53], [70], [78].

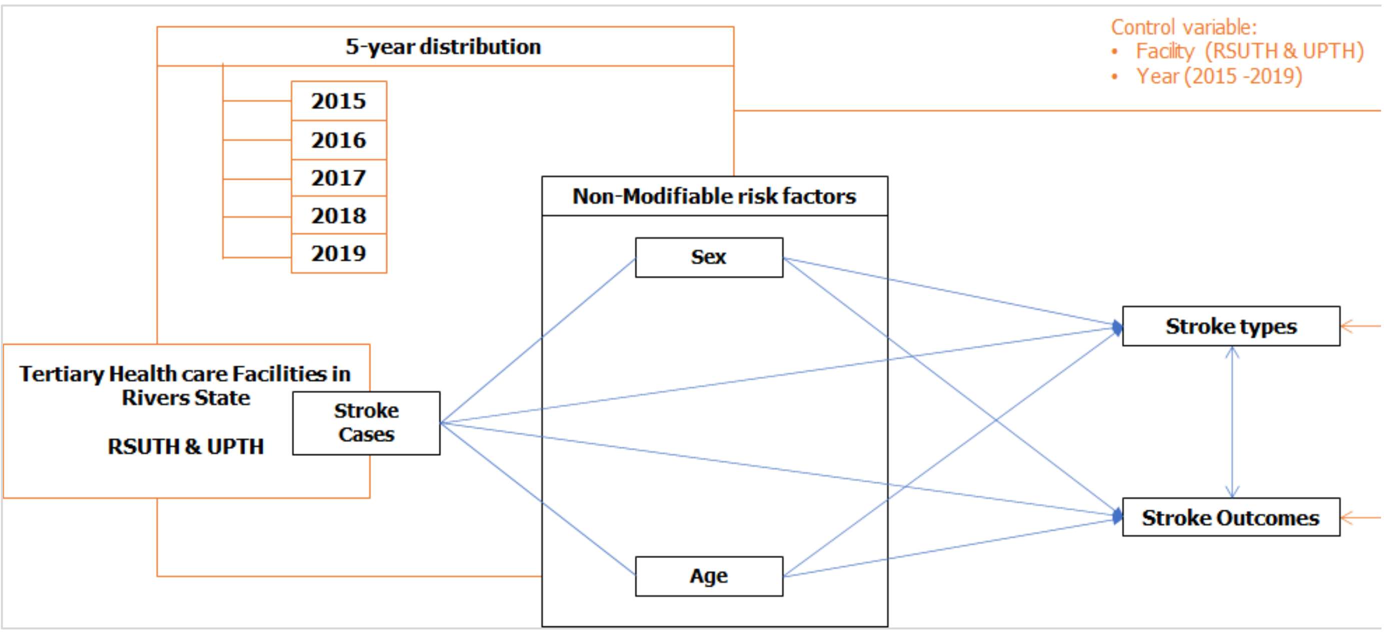

Figure 1: Construct model for assessing the stroke cases and structure in tertiary health facilities in Rivers State

The study conceptualized that the common non-modifiable factors (age and sex) have direct effect on stroke types and outcomes. The construct is based on the hypothesis that stroke types and outcomes will differ (1) between the sex and (2) among age categories in the studied population, and (3) there is a significant association between stroke types and outcomes. The study controlled for facility (RUSTH and UPTH) and the years (2015-2019) the data were collected (Figure 1).

2.3 Data Collection

Stroke data were retrieved from the archives (2015 to 2019) of RSUTH and UPTH. The collected data were categorized into three age groups; young adults (ages 18–35 years; n=77), middle-aged adults (ages 36–55 years, n=550), and older adults (aged older than 55 years, n=1289); sex into male (687) and female (1229). The stroke cases were categorized based on types (ischemic or hemorrhagic) and outcomes (no disability, disability, or death).

2.4 Data Management and Analysis

The obtained data was managed in Microsoft Excel 2016 and transferred to STATGRAPHICS centurion CVI version 16 (Stat Point Tech., Inc.) and Statistical Package for the Social Sciences (SPSS) version 23 (IBM, Amos, USA) for analysis. SPSS descriptive statistics; median (percentile) for continuous variables and frequencies (percentages) for categorical variables were used to describe the data distributions. Pearson's Chi-square (Yates correction) analysis evaluated the association of sex, age, and stroke type and outcome after hospitalization.

SPSS–Amos structural equation modelling (SEM) using direct path analysis evaluate the relationship between sex & age, and the stroke type and outcomes. The study controlled for facility and years from which the data were retrieved. To justify for the non-normal distribution of the model variables, we used the maximum likelihood with robust standard errors (MLR) as the estimator. The study considered fit indices to assess the fit of the models: (i) The goodness of fit index (GFI) under generalized least squares (GLS) [79] and (ii) Bentler's comparative fit index (CFI) [80]. Values between 0.90 and 1.0 on Bentler's CFI and value ≥ 0.95 on the GFI suggests the model provides a good fit to the data [81]. The study also determined the standardized and unstandardized direct effects of the predictor variables on the response variables. Multinomial logistics regression analysis was used to determine the relative difference in the predictor variables in the SEM model. The confidence level for all analysis was set at 95% and p-value less than 0.05 were considered significant.

3. Results

3.1. Presentation of Results

The descriptive characteristics of the study demography is presented in Table 1. The graphical representation 5-year (2015-2019) distribution of stroke cases stratified by sex, age group, type, outcome after hospitalization is presented in Figure 2.

Table 2 represents an association between study demographics and stroke types, while Table 3 represents the association between the study demographics and hospitalization outcome. Using SEM, the result of the analysis is presented in Figure 3. Multinomial logistics regression analysis in Table 4 & 5 evaluated the difference in the effects of the significant terms in the SEM.

3.2. Interpretation of Results

From the result in Table 1, both facilities had more female cases of stroke (RSUTH - 718; 79.7% and UPTH - 511; 50.3%) compared to males (RSUTH; 183 [20.3%] and UPTH; 504 [49.7%]). The age grouping indicated that the older adults (>55years) predominated the stroke cases (1289; 67%) with 647 (71.8%) in RSUTH and 642 (63.3%) in UPTH. The middle-aged adult also had some recognizable cases (550; 28.7%) in RSUTH (221; 24.5%) and UPTH (329; 32.4%).

Table 1. Descriptive characteristics of observed study variables.

Variables	Facility	Total (%)

	RSUTH (%)	UPTH (%)	
Year			
2015	205 (22.8)	211 (20.8)	416 (21.7)
2016	159 (17.6)	155 (15.3)	314 (16.4)
2017	122 (13.5)	191 (18.8)	313 (16.3)
2018	172 (19.1)	226 (22.3)	398 (20.8)
2019	243 (27.0)	232 (22.9)	475 (24.8)
Sex			
Male	183 (20.3)	504 (49.7)	687 (35.9)
Female	718 (79.7)	511 (50.3)	1229 (64.1)
Age group			
= or < 35 years	33 (3.7)	44 (4.3)	77 (4.0)
36 to 55 years	221 (24.5)	329 (32.4)	550 (28.7)
= or > 56 years	647 (71.8)	642 (63.3)	1289 (67.3)
Stroke type			
Hemorrhagic	207 (23.0)	214 (21.1)	421 (22.0)
Ischemic	694 (77.0)	801 (78.9)	1495 (78.0)
Outcome			
No Disability	468 (51.9)	167 (16.5)	635 (33.1)
Disability	175 (19.4)	554 (54.6)	729 (38.0)
Death	258 (28.6)	294 (29.0)	552 (28.8)

From Figure 2, (A) the increase in stroke cases for males continued to rise from 2016 to 2018 which was steady to 2019, while there was a reduction in the cases between 2016 and 2017, then a steady rise through 2019. (B) There was a similar distribution pattern for middle-aged and older adults from 2015 through 2019, while younger adults had a sharp fall in the incidence of stroke from 2015 through 2017, with an increase which steadied out through 2019. (C) There was a steady rise in the cases of ischemic stroke from 2016 to 2019, after an initial decrease in 2015, while hemorrhagic stroke cases fluctuated across the years; with the lowest record in 2017.

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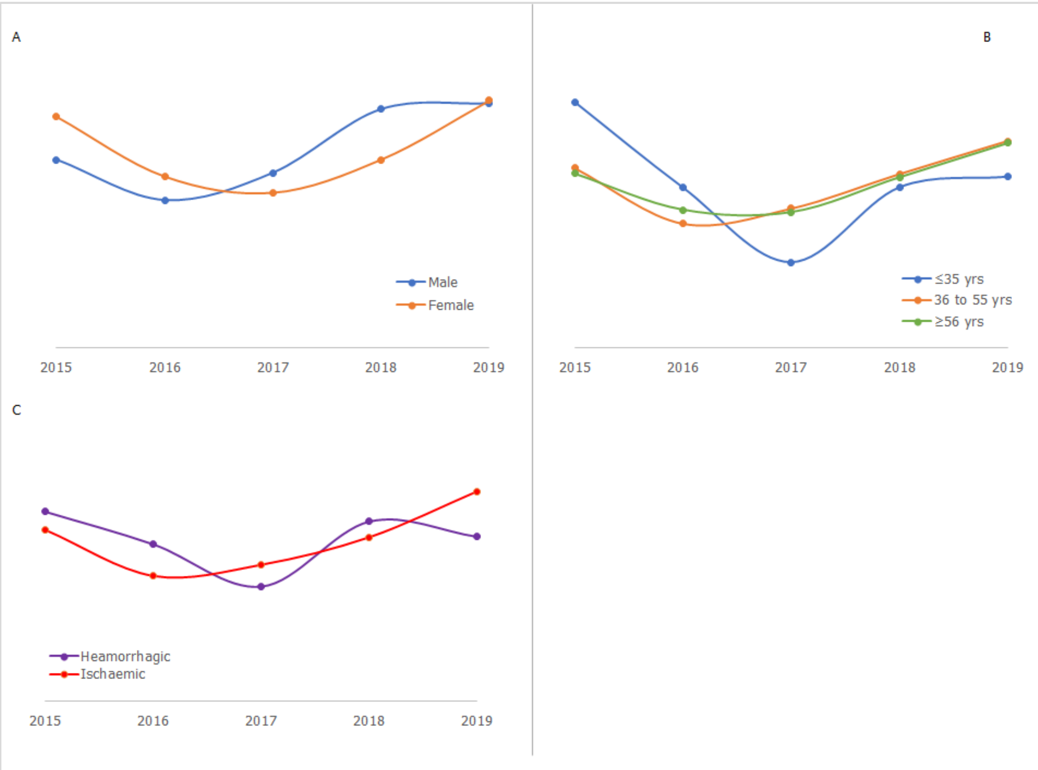

Figure 2. 5-year (2015-2019) distribution of stroke cases stratified by **(A)** sex **(B)** age group **(C)** stroke types

Table 2 and 3 show the test of association between the study variables. In Table 2, there was significant association between the stroke type and sex (χ^2=4.075; P=0.039), age group (χ^2=35.621; P<0.001), and stroke type (χ^2=10.158; P=0.0002). There was no association between the health facility and type of stroke (P>0.05). The results in Table 3 indicates a significant association between hospitalization outcome and facility (χ^2=336.473; P<0.001), sex (χ^2=242.862; P<0.001), age group (χ^2=16.742; P=0.0022), and stroke type (χ^2=17.052; P=0.0002).

Table 2. Stroke types and study demographics.

Variables	Stroke type			Chi-square test	
	Hemorrhagic	**Ischemic**	***df***	***X*²-value (Yt)**	**P-value**
Sex					
Female	252 (20.5)	977 (79.5)	1	4.075	0.044
Male	169 (24.6)	518 (75.4)			
Age group					
= or < 35 years	26 (33.8)	51 (66.2)	1	35.621	<0.001
36 to 55 years	162 (29.5)	388 (70.5)			
= or > 56 year	233 (18.1)	1056 (81.9)			

***Note:** X^2=Chi-square; Yt=Yates correction; df= degree of freedom.*

Table 3. Stroke types and study demographics.

Variables	Hospitalization outcome			Chi-square test		
	No Disability (%)	**Disability (%)**	**Death (%)**	***df***	***X*²-value (Yt)**	**P-value**
Sex						
Female	539 (28.1)	324 (16.9)	366 (19.1)	2	242.862	<0.001
Male	96 (5.0)	405 (21.1)	186 (9.7)			

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Age group						
= or < 35 years	21 (1.1)	41 (2.14)	15 (0.78)			
36 to 55 years	187 (9.8)	227 (11.9)	136 (7.1)	4	16.742	0.002
= or > 56 years	427 (22.3)	461 (24.1)	401 (20.9)			
Stroke type						
Hemorrhagic	151 (35.9)	125 (29.7)	145 (34.4)	2	17.052	0.0002
Ischemic	484 (32.4)	604 (40.4)	407 (27.2)			

Note: *X²=Chi-square; Yt=Yates correction; df= degree of freedom.*

The study used SEM in evaluating the strength of the relationship between the variables after controlling for multicollinearity and non-normally distributed data. The GFI and the Bentler's CFI for the model fitness were 0.982 and 0.739, respectively. The small value for CFI is associated with the large sample size (n=1916) which according to Cochran indicates a disagreement between the theory and data ($\chi^2_{[df=4]}$= 107.043, P<0.001); of which such departure is almost certainly detectable in data with large samples [82], [83].

The reconstructed path diagram with the standardized regression coefficients is depicted in Figure 3. The results showed that age was significantly associated with stroke type (P<0.001) and outcomes (P=0.038), while sex was significantly associated with stroke outcomes (P<0.001). There was no relationship between the stroke type and outcome (P=0.428). The standardized (z-statistic) and unstandardized direct effects are shown in the Appendix (Fig. A1 and Table A1).

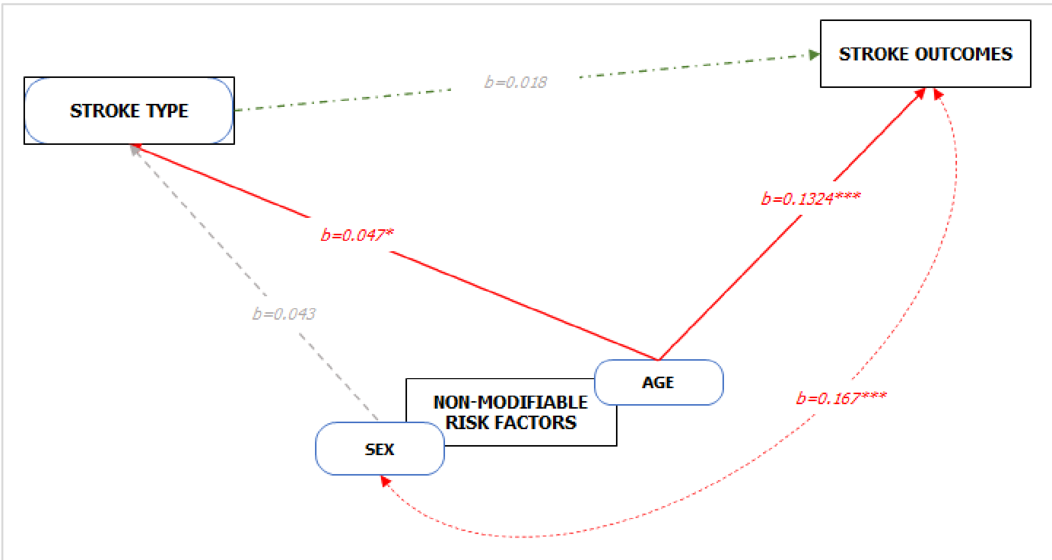

Figure 3. Standardized Pathways (z-statistic) for the relationship between sex, age, stroke types, and outcomes *(1) red indicates significant path with *P<0.05, ***P<0.001 (2) [See Appendix; Fig. A1 for the unedited SPSS-Amos output].*

The multinomial logistics regression analyses were presented in Table 4 & 5. The Goodness-of-Fit analysis indicated that the models fit the data for Stroke Types (χ^2= 4.524, P=0.104) and outcomes (χ^2= 10.393, P=0.733). The parameter estimates (model coefficients) in Table 4 indicates that age group was significantly associated with stroke type. That is, older adults (≥55years) were 1.9 times and 2.3 times more likely to have ischemic stroke than middle-aged adults (36 to 55 years) and younger adults (≤35 years), respectively.

Table 4. Logistic regression model for stroke types and, sex and age.

Parameter Estimates	B	S.E	Wald	df	P-value	OR [95% C.I]
Intercept	-1.584	0.084	356.6	1	<0.001	

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Male	0.206	0.115	3.228	1	0.072	1.229 [0.981 - 1.539]
≤35 years	0.853	0.252	11.45	1	0.001	2.346 [1.432 - 3.845]
36 to 55 years	0.623	0.119	27.55	1	<0.001	1.864 [1.477 - 2.352]

***Note:* (1)** *Reference variables [Response; Ischaemic stroke, Predictor; Sex=Female, Age group=≥55years].* **(2)** *Goodness-of-Fit [χ^2= 4.524, P=0.104], B – unstandardized regression weight, S.E – standard error of B, df – Degree of freedom, OR – Odd ratio, C.I – Confidence Interval* **(3)** *Values in red indicate statistical significance*

The parameter estimates (model coefficients) in Table 5 indicates that sex, age group, and stroke types were significantly associated with stroke outcome following hospitalization (P<0.05). When comparing the outcome for females and males following hospitalization from stroke, males were almost 3 times more likely to die than have no disability compared to females. On the other hand, females were more 2.6 time more likely to die than have disability compared to males. Older adults (≥55years) were 1.4 times and 1.2 times more likely to die than have no disability compared to middle-aged adults (36 to 55 years) and younger adults (≤35 years), respectively. When comparing death and disability outcomes, the likelihood that older adults (≥55years) will die than have disability following hospital admission for stroke were 1.5 times and 3.1 times compared to middle-aged adults (36 to 55 years) and younger adults (≤35 years), respectively. Hemorrhagic stroke was 2 times more likely to cause death than disability when compared to ischemic stroke.

Table 4. Logistic regression model for stroke types and, sex and age.

Parameter Estimates	B	S.E	Wald	df	P-value	OR [95% C.I]
No Disability						
Intercept	0.317	0.082	15.13	1	<0.001	
Male	-1.063	0.144	54.63	1	<0.001	0.345 [0.261 - 0.458]
≤35 years	0.217	0.348	0.389	1	0.533	1.243 [0.628 - 2.460]
36 to 55 years	0.338	0.136	6.175	1	0.013	1.402 [1.074 - 1.830]
Haemorrhagic	-0.098	0.139	0.499	1	0.48	0.907 [0.691 - 1.190]
Disability						
Intercept	-0.142	0.088	2.582	1	0.108	
Male	0.951	0.119	63.42	1	<0.001	2.589 [2.049 - 3.273]
≤35 years	1.122	0.317	12.55	1	<0.001	3.071 [1.651 - 5.714]
36 to 55 years	0.39	0.133	8.569	1	0.003	1.476 [1.137 - 1.916]
Haemorrhagic stroke	-0.735	0.145	25.82	1	<0.001	0.479 [0.361 - 0.637]

***Note:* (1)** *Reference variables [Response; Ischaemic stroke, Predictor; Sex=Female, Age group=≥55years, Stroke type=Ischaemic].* **(2)** *Goodness-of-Fit [χ^2= 10.393, P=0.733], B – unstandardized regression weight, S.E – standard error of B, df – Degree of freedom, OR – Odd ratio, C.I – Confidence Interval* **(3)** *Values in red indicate statistical significance*

4. Discussion

Disruption of blood supply to the brain tissue leads to stroke [3], [39], [84], with two major types; ischemic stroke which results from interrupted blood supply to the brain (ischemic stroke) and haemorrhagic stroke caused by bleeding into or around the brain due to a ruptured artery [3], [13], [58], [78], [85]. Nevertheless, there is often a small-scale stroke attack before the occurrence of ischaemic or haemorrhagic stroke, and it is referred to as transient ischemic attack (TIA) [35], [56], [72], [74], [86], [87].

In this study, ischaemic stroke (78.0%) was the most common type of stroke at the health facilities each year from 2015 to 2019. The case-distribution for ischaemic was 76.2%, 73.9%, 80.8%, 76.4%, and 81.9%, while haemorrhagic stroke was 23.8%, 26.1%, 19.2%, 23.6%, and %18.1 for the years 2015, 2016, 2017, 2018, and 2019 respectively. TIA was not captured in the records of the hospital. Surprisingly, only a few studies found TIA within the records of Nigerian hospitals [35], [88]. The distribution of stroke cases suggests a rise in hospitalisation from ischaemic stroke and a high incidence of hemorrhagic within the study environs. Studies have reported varying finding about the most common stroke type [6], [13], [21], [26], [29], [33], [63]. According to the Global Burden of Disease Study 2016, Asia and Sub-Sharan Africa had the least reduction in stroke cases across the globe [89]. Evidence from Stroke Investigative Research and Educational Network (SIREN) study undertaken in Nigeria and Ghana suggests that those confirmed with ischemic stroke was 68% higher than haemorrhagic stroke cases [90]; whereas, in high-income countries ischemic stroke contribute to 91% of stroke cases while the remaining 9% are haemorrhagic stroke [6].

There were more females (1229; 64.1%) with stroke compared to males (687; 35.9%) in this study. Studies in the United States found that women experience approximately 55,000 more strokes each year [91], [92], which has been linked to higher life expectancy, hormonal changes, use of contraceptives, and variable risk factors in women [93]–[96]. On the premise of non-modifiable risk factors; age and sex associated with stroke [21], [30], [99], [100], [35], [53], [54], [57], [63], [76], [97], [98], this study found that age group but not sex had direct effect on the stroke type. While the initial analysis found some association between sex and stroke type, the SEM after controlling for several factors, found no significant direct effect. Nevertheless, noteworthy was the distributional difference such that more males had haemorrhagic stroke (24.6%) compared to females with ischaemic stroke (79.5%). Specifically, for ischemic stroke, there are evidence from in-vivo and in-vitro studies demonstrating the role sex plays on the epidemiology, pathophysiology, and treatment efficacy of ischemic stroke [67], [69], [70], [101]. When comparing the hospitalisation outcome for females and males as a result of stroke, males were more likely to die than not have abnormality. The outcome “death” in males is not surprising as the record showed they had more of haemorrhagic stroke compared to females. Haemorrhagic stroke has been associated with more deaths compared to ischaemic stroke [13], [46], [73], [74], [102].

The findings of the study indicates that the outcome after an ischaemic stroke favoured males in comparison to females [69]–[71], and the reason was highlighted in a clinical trial study that found that minocycline, an anti-apoptotic agent, enhances treatment outcome following ischemic stroke in males, but not females [103]–[105]. For haemorrhagic stroke, there is little evidence about sex-associated risk factors. In this study, there was higher proportion of male (24.6%) with haemorrhagic stroke compared to females (20.5%). Conversely, a recent study found that the risk of subarachnoid haemorrhage is greater in women of average age than in men [68]. The possible reason is that the risk in women across their lifespan changes; as younger will most possibly be on oral contraceptives (OCP) and the loss of the protective effect from endogenous oestrogen in postmenopausal women, which puts them at a higher risk of thrombotic events [68].

In this study, age was distinctively linked to the stroke type and outcome. Similar to the suggestion by international stroke centre [106], over three-quarter of the stroke cases in this study were among the older adults (>56years). The global summary data showed that the prevalence of stroke in older adults is more than three times in middle aged and younger adults [41]. This study notes that studies have avoided analysing age as a standalone dependent variable for the development of stroke [41], [87], [107]; as biological function changes are significantly associated with age. However, age itself is an important, non-modifiable risk factor for ischemic stroke [70]. Younger adults had higher proportion haemorrhagic stroke (33.8%) compared to middle aged (29.5%) and older adults (18.1%). This finding has been recently explained as a factor closely linked to behaviour; as younger men are less likely to seek professional care for presumed “mild” symptoms [68]. The older adults (≥55years) were more likely to have ischaemic stroke than middle-aged adults (36 to 55 years) and younger adults (≤35 years) and older adults were more likely to die compared to middle-aged adults and younger adults following hospitalisation for stroke. Studies have shown that older adults are at risk of death following a stroke [6], [65], [77], [88], [94], [108], [109].

When our study compared stroke type and outcome, haemorrhagic stroke was 2 times more likely to cause death compared to ischaemic stroke. In a study by Avan *et al.*

they found that ischemic stroke doubled between 1990 to 2017. And as at 2013 alone, there were 10.3 million new stroke cases with 67% ischemic stroke and 51% of death being those arising from ischemia [44]. El-Hajj *et al*. found out that in the Middle East, 71% of 25.7 million stroke survivors had ischemic stroke and with higher disability adjusted life years (DALY) [45]. Katan and Luft found that haemorrhagic stroke was responsible for more death and DALY worldwide [46].

5. Conclusions

In the studied population, ischemic stroke was the most observed stroke type, but the proportion accounting for hemorrhagic stroke remained worryingly above the global average. Age has a significant influence on the type and outcome of stroke, while sex only influenced outcome – with males having better outcomes from ischemic stroke. The older adults dominated the stroke incidence and were more likely to die from a stroke irrespective of the type of stroke; however, younger adults had a more hemorrhagic stroke when compared to middle-aged and older adults. Hemorrhagic stroke was more likely to cause death than ischemic stroke.

Study Limitations: The study recognises that there are other non-modifiable risk factors which are associated with stroke type and outcomes. For this reason, the authors advocate for a robust and integrated hospital management information system (HMIS) for the African continent to enable holistic personal information documentation and history taking.

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Data Availability Statement: The data set for this study was deposited in Harvard Dataverse and it is available at https://dataverse.harvard.edu/dataset.xhtml?persistentId=doi:10.7910/DVN/JWRXQI.

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Appendix A

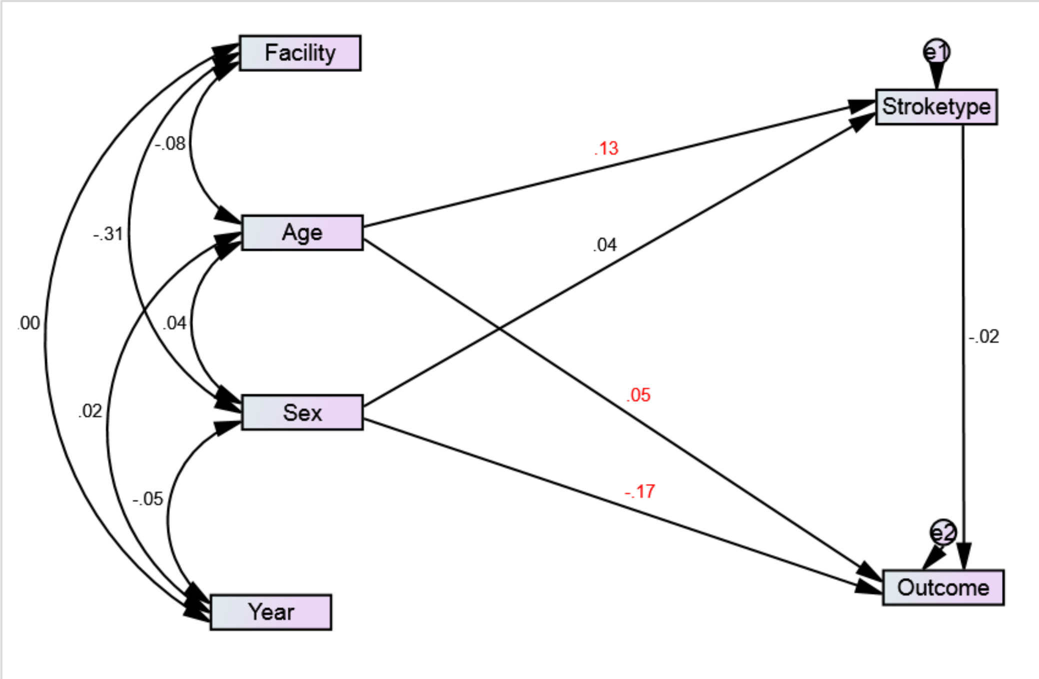

Figure A1: SPSS-Amos output for the SEM standardized pathways (z-statistic)
*Note: **1.** Red colours indicates low to moderate estimates; **2.** GFI=0.982, CFI=0.739; 3. Facility and year were statistically controlled.*

Table A1: Regression weight and standardized (z-statistics) estimates in the SEM analysis

Model Variable			**Estimate**	**S.E.**	**Z-Estimate**	**C.R.**	**P-value**
Stroke type	<---	Age group	0.098	0.017	0.132	5.836	<0.001
Stroke type	<---	Sex	0.037	0.02	0.043	1.884	0.06
Outcome	<---	Age group	0.066	0.032	0.047	2.07	0.038
Outcome	<---	Sex	-0.273	0.037	-0.167	-7.394	<0.001
Outcome	<---	Stroke type	-0.034	0.043	-0.018	-0.792	0.428

*Note: **1.** Z-standardised score; **2.** S.E-Standard error; C.R-critical ratio; P-probability; ***p<0.001; **3.** Sex, CD4 count on starting HAART, and Duration on HAART were statistically controlled.*

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