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A systematic review of the epidemiology and the public health implications of stroke in Sub-Saharan Africa

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ABSTRACT

Background: With approximately 11 million strokes occurring annually worldwide, and over 6.5 million deaths annually, stroke has made its place as one of the major killers in the world. Although developing countries make up more than 4/5 of the global stroke burden, well-grounded information on stroke epidemiology remains lacking there.

Aims: This systematic review study aimed to provide a synthesis of studies on the incidence and prevalence of stroke among adults in sub-Saharan Africa (SSA), subsequently deduce the associated risk factors and public health implications (mortality rates and economic costs) of the disease on the population of this region.

Methods: A systematic review of studies carried out in the region and published on PUBMED. Eligibility criteria were established using the PEO (Population/Patient, Exposure, Outcome) format. Research articles investigating either (or all) of the following: ischemic or haemorrhagic stroke, incidence, prevalence, and risk factors of stroke in adults ($\geq$ 18 years old), in at least one region of SSA were included. Exclusion criteria comprised studies involving populations younger than 18 years old, research conducted outside the designated research region, and articles inaccessible in full text. The PRISMA guidelines were used for the search strategy.

Results: Fifty-two studies were included review. Among them, over 11 studies investigated the prevalence of the disease. Some older studies within the continent (Nigeria, 2011) showed a prevalence of 1.3 per 100 while more recent studies (Zambia, 2021) showed a prevalence of 4.3 per 1000. The highest prevalence noted in this region was in Madagascar (2017) with 48.17 per 100, while the lowest was recorded in (Zimbabwe, 2017) with 0.61 per 100. The study in Tanzania showed a crude incidence of 94·5 per 100 000 (76·0–115·0) while the study in Ghana in 2018 showed an incidence of 14.19 events per 1000 person-years [10.77–18.38]. The identified risk factors included hypertension, diabetes, smoking, alcohol consumption, physical inactivity, poor diets (more salt, less vegetables), dyslipidaemia, HIV/AIDS co-infection, heart disease (cardiomyopathies, cardiac arrhythmias), obesity, previous stroke and/or family history of stroke. Over 21 studies investigated the mortality rates due to stroke in SSA, with most of the studies being in West Africa. These studies revealed mortality rates as high as 43.3% in Ghana, and as low as 10.9% in Cameroon. Few studies reported on the economic costs of stroke in the region; two in Benin, two in Nigeria and one in Tanzania.

Conclusion: The increasing incidence/prevalence, lifestyle factors and interactions with other diseases, including major communicable diseases, stroke is becoming a pressing public health problem for SSA. Reducing the incidence of stroke in Africa will surely lower mortality, morbidity, disability, and the neurological as well as cognitive aftereffects of stroke, as is clear from the experience of higher-income nations. We recommend a collective intervention involving the governments of nations, international organizations, civil society, and the private sector for greater impact and sustainable outcomes reducing the epidemiology and implications of stroke in SSA.

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Background

Based on a publication by the Centre for Disease Control[1], a stroke can be defined as an interruption in brain circulation, either by a block or burst. This implies that stroke can be divided into two sub-groups depending on its cause: ischemic stroke, which is one in which blood circulation is interrupted by the presence of a clot in a vessel; and haemorrhagic stroke, in which, blood circulation in the brain is interrupted by a ruptured vessel that causes bleeding in the brain. While research shows ischemic strokes are typically more frequent, accounting for around 80% of cases, this proportion can vary depending on the population studied[2].

Globally, approximately 11 million strokes occur annually[3]. Aside being recognised as a silent killer accounting for 6.5 million deaths annually[4], stroke is also a principal cause of impairment[5]. There were approximately 143 million Disability-Adjusted Life Years (DALYs) due to stroke[6]. DALYs can be defined as the amount of healthy life years lost because of early death and disability. It was adopted by the World Health Organisation (WHO) to assess the burden of a disease[7].

Several observational studies have grouped risk factors of stroke into non-modifiable and modifiable risk factors[8]. Non-modifiable risk factors include age (> 55)[9], sex (female)[10], race (black)[11] and genetics[12]. The modifiable risk factors include smoking, dyslipidaemia, hypertension, alcohol intake, diabetes, obesity, heart disease etc, with the first three being the most common according to research[13].

In the same light, some studies have highlighted that risk factors vary with sex, age, and geographic location amongst others. For example, Rexrode et al., report that some female specific risk factors are linked to their reproductive nature[14]. Lifetime oestrogen exposure, menopausal hormonal therapy, oral contraceptive pills, and increased parity have all been associated with an increased risk of stroke amongst women. In male, the traditional risk factors come in place. The major risk factors for stroke in young people include recreational drug-abuse, sickle-cell anaemia and congenital heart diseases[15–17]. Geographically, Moya-Moya is the predominant risk factor in China[18], while diseases like chagas disease, sickle-cell disease, HIV, rheumatic heart disease, neurocysticercosis and lately, the Corona Virus Disease 2019 (COVID 2019) are the more predominant risk factors in Africa, India and South America[19–22]. This shows the complexity of the disease and why its prevalence remains high.

Recently, the burden of stroke is becoming higher in low-income countries, with almost five million stroke-related deaths and about 92 million DALYs, compared to about 2 million deaths and 22 million DALYs in high-income countries[4,23].

Although developing countries make up more than four-fifths of the global stroke burden, well-grounded information on stroke epidemiology, especially its prevalence/ incidence, remains lacking in these areas[24]. Given that there are no systematic reviews on the epidemiology of stroke throughout the continent of Sub-Saharan Africa (SSA), this research provides an in-depth analysis of studies which investigated the epidemiology of stroke in adults in SSA across different countries and settings (hospitals, communities, and populations).

Therefore, the aims of the current study are to provide a synthesis of studies conducted on the incidence and prevalence of stroke among adults in SSA and ascertain the risk-factors and public health implications (mortality rates and economic costs) associated with it.

Methods

We searched for published articles that investigated either (or all) of the following: ischemic or haemorrhagic stroke, the incidence, the prevalence, and risk factors of stroke in adults (≥ 18 years old), in at least one region of sub-Saharan Africa (SSA): This study was performed and reported following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses checklist for systematic reviews of intervention. A protocol for this systematic review was prospectively registered on the International Prospective Register of Systematic Reviews (PROSPERO) and can be found at https://www.crd.york.ac.uk/PROSPERO/ CRD42023442857.

Data sources and search strategy

The main site for research was PUBMED. There were no time restrictions, but only articles in English and French were included as these are the most common used languages for research in this region. Firstly, a scoping review was done in two databases (PUBMED/MEDLINE) to identify the number of existing literature relevant to the review question. It was from this scoping review that the key terms were derived for the systematic review. Subsequently, a comprehensive search in this database was carried out to identify studies reporting the prevalence of stroke, its associated risk factors and comorbidities, and its public health implications (mortality rates and economic cost) in SSA.

In PUBMED/MEDLINE, the Medical Subject Headings (MeSH) was used to identify articles. This is because in this database, articles may have standardised search words associated with them that refer to the same or related ideas[25]. The Boolean search strategy was equally used to refine the search.

Finally, to find additional research that might be qualified for the evaluation, the bibliography of all pertinent studies and publications were manually searched.

Inclusion and exclusion criteria

The eligibility criteria were defined using the PEO (Patient/Population, Exposure and Outcome) format. To be included in this study, research articles must have investigated any or all of the following: ischemic or haemorrhagic stroke, the incidence, prevalence, and risk factors of stroke in adults (≥18 years old), in at least one region of SSA: spanning Western region such as Nigeria and Ghana, eastern region such as Uganda and Kenya, South Africa and Central Africa (Central African Republic). in addition, articles should have examined the public health implications of stroke (including mortality rates and the economic burden of stroke) in the specified region. Only articles published in French or English were included. However, all articles from inception were included without placing any time limits. The exclusion criteria included: studies involving populations <18 years old, studies conducted outside the research region, articles for which full texts were not accessible.

Study selection and assessment of methodological quality

Articles were searched and independently reviewed by the authors. PUBMED yielded 1740 studies upon initial search, plus an additional three studies gotten from the reference lists of some articles, giving a total of 1743 articles. After adding automatic PUBMED filters of “Free full text”, “humans” “adults 18+” “English & French” and “male/female”, the eligible studies were reduced to 179. Thereafter, each study’s key concepts were individually culled and documented using RAYYAN AI[26] and assembled into a data extraction as per the PRISMA guidelines (Fig. 1).

The AI generated a descriptive summary of the studies, with abstracts comprising headings, dates, authors, titles, types of study, objectives of the study and key findings. The next step involved reading the abstracts of the remaining 179 articles and manually selecting eligible papers. This resulted in screening out 109 papers. The remaining 70 papers were assessed for eligibility, of which 52 were finally included in the study.

Data extraction and synthesis

Each article was independently appraised using the Critical Appraisal Skills Programme (CASP) tool, which assigned each article a quality grade of either poor, intermediate or good[27]. The data extraction

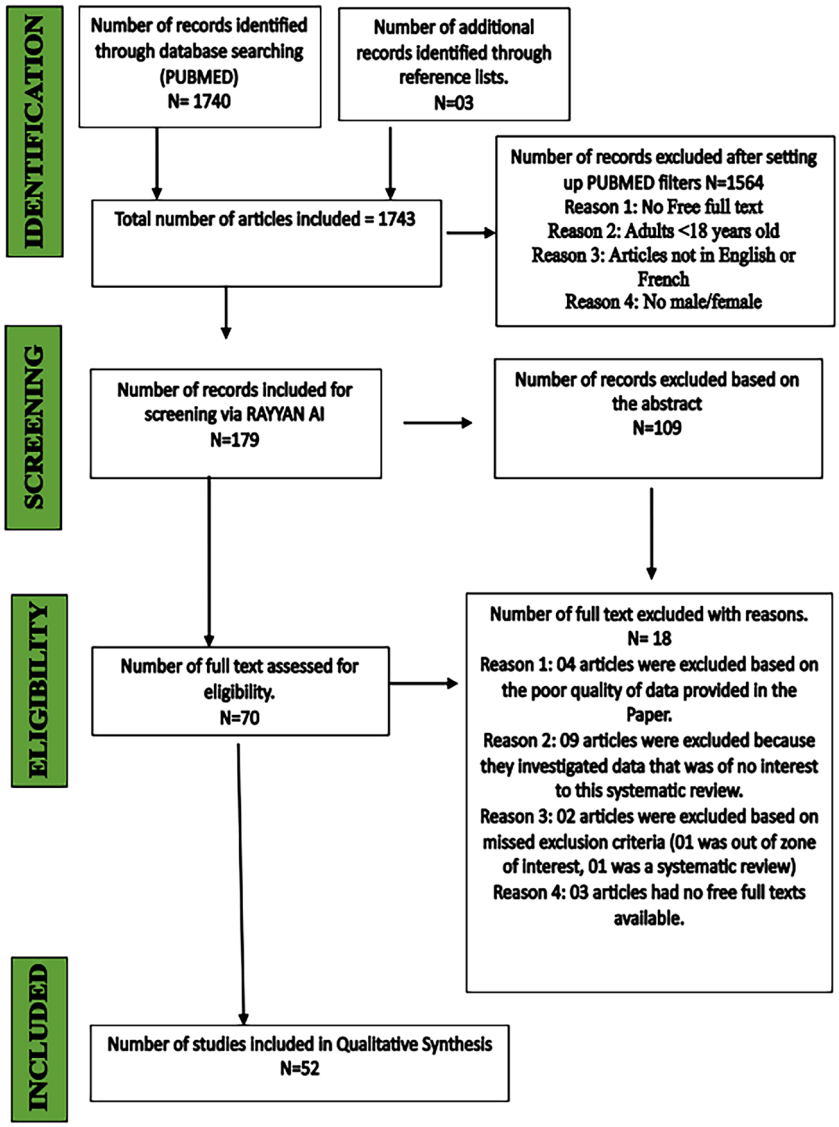

Fig. 1. Prisma flow diagram.

tool was an excel sheet which retrieved data such as the name of authors, date, title of the study, type of study, research aims and objectives, and key findings (Fig. 2). Two reviewers independently extracted the data and determined if the study was eligible. Discrepancies were resolved by consensus or, where necessary, with the help of a third reviewer.

Study data were extracted by three reviewers into a template. The findings of each study epidemiology (incidence, prevalence, risk factors, mortality rates, and economic costs) of stroke in SSA were summarised by one reviewer, and subsequently discussed and modified by the research team as necessary, to generate an overall conclusion of the systematic review.

Results

This systematic review included 52 studies that met the inclusion criteria. Although there were some differences in the research questions, quality, design, and sample size, it was possible to pinpoint recurrent features among the 52 studies. Overall, the studies were conducted in a range of regions in SSA (17 countries). This result provides a synthesis of data organised based on the research aims under five subheadings. Accompanying tables are shown in the appendix section each showing the authors, year of publication, study region, design, sample size, and key findings.

The prevalence and incidence of stroke in Sub-Saharan Africa

a. The prevalence of stroke in SSA

The prevalence of stroke in SSA varied from one region to another. Over 11 studies have been carried out in the region, with the aim of deducing the prevalence of the disease. An earlier study conducted in Nigeria showed a prevalence of 1.3 per 100[28] while later studies showed a prevalence of 4.3 per 1000 in Zambia[29]. The highest prevalence of stroke in SSA was noted in Madagascar with 48.17 per 100[30] while the lowest, 0.61 per 100 was recorded in Zimbabwe[31] (Table 1).

b. The Incidence of Stroke in Sub-Saharan Africa

Three studies investigated the incidence of stroke in SSA. The study in Tanzania showed a crude incidence of 94·5 per 100 000 persons (76·0–115·0)[32] while the study in Ghana showed an incidence of 14.19 events per 1000 person-years [10.77 – 18.38][33]. The study in Cameroon reported an incidence of 0.3 per 100-person years[34] (Table 2).

Fig. 2. Data extraction tool authors date of publication title & geographic location type of study aims & objectives demographic data.

Risk factors of stroke in Sub-Saharan Africa

32 studies investigated the risk factors of stroke in the given region. The risk factors highlighted included hypertension, diabetes, smoking, alcohol consumption, physical inactivity, poor diets (more salt, less vegetables), dyslipidaemia, HIV/AIDS co-infection, heart disease (cardiomyopathies, cardiac arrhythmias), obesity, previous stroke and/or family history of stroke. Some peculiarities from the studies were the reports on a female specific risk factor (use of oral contraceptives) in two studies, one each in Kenya[35] and Nigeria[28]. Also, a study in Ghana and Nigeria[36], reports low income (<$1000) as a risk factor. Some other non-modifiable risk factors that were highlighted in the studies were age and gender. While some studies showed a higher prevalence of stroke in men, others showed a predominance in women and with an age range of 18-114. In Kenya, Kaduka et al., in 2018, reported the use of recreational drugs (cocaine) as a risk factor[35] (Table 3).

The mortality rates due to stroke in Sub-Saharan Africa

Over 21 studies investigated the mortality rates due to stroke in SSA, with most of the studies being in west Africa. These studies revealed that mortality rates were as high as 43.4% in Ghana[37], and as low as 10.9% in Cameroon[38]. Some studies reported 30-day mortality rates only, while others reported in multiples of 7. A study in Kenya reported as far as 9 months mortality rates[39]. Studies in Nigeria[28], Ghana[40], Zambia[29], Tanzania[41], and Ethiopia[42,43] reported a higher mortality rate in patients who suffered haemorrhagic strokes while the study in Congo showed a higher mortality rate in patients with ischaemic strokes[44]. Studies in Uganda, Cameroon and Malawi showed no particularities in that regard. Also, studies in Nigeria[28], Ethiopia[45] and Ghana[37] reported a male predominance in mortality rates with 29.2%, 53.3% & 53.5% respectively. Aspiration pneumonitis was reported as one of the major causes of death in Ghana[40] and in Zimbabwe[31] (Table 4).

The economic costs stroke in Sub-Saharan Africa

Only a few studies were found that reported on the economic costs of stroke in the region. Specifically, two studies were identified in Benin, two studies in Nigeria and one study in Tanzania. In Benin, one study reported the cost of stroke to range from 38,500F to 1,099,700F, with an average of 316,810.3F[46], while another study reported the costs of stroke to range from $144.9 to $9393.9; with an average of $1030[47]. In Nigeria, a study reported hospital investigations to be the most responsible for the general high costs of stroke[48], while another study reported that radiological investigations were highest (median: $85.45/₦39,050) and closely followed by laboratory investigations (median: $25.82/₦11,800)[49]. The study in Tanzania was a pilot study using new methods. It reported that the mean cost per case was TZS 256, 338 (USD 220)[50] (Table 5).

Discussion

This systematic review pulled epidemiological data from 52 studies in over 17 countries in SSA including five countries in West Africa (Benin, Ivory Coast, Burkina Faso, Ghana, and Nigeria), one country in Central Africa (Cameroon), 10 countries in East Africa (Kenya, Uganda, Ethiopia, Tanzania, Madagascar, Malawi, DRC, Zambia, and Zimbabwe) and one country in Southern Africa (South Africa). This means that there are still over 30 countries in this region lacking adequate data necessary for decision-making regarding the evolution of the burden of stroke.

Indeed, recent studies have shown that Africa is facing a double burden of disease; with both communicable and non-communicable diseases being on a rise in the continent[51]. While communicable diseases have always been a problem for Africa[52], the last two decades have highlighted a rise in the burden of NCDs with cardiovascular diseases (including stroke) being the most prominent[53].

Concerning the prevalence of stroke in the region, earlier studies showed that stroke was not quite a problem for Africans. For example, Osuntokun et al., in 1987, reported a crude prevalence of 58/100.000 in

Table 1
The prevalence of stroke in Sub-Saharan Africa.

AUTHOR	COUNTRY	STUDY TYPE	POPULATION	PREVALENCE (95% CI)
Dsalu et al.,[1]	Nigeria	Retrospective Descriptive study	N=101, F (52.5%), M (47.5%) Age Range[30-80] Age Mean/SD (68±12)	1.3 per 100 Ischemic stroke = 64.4% Haemorrhagic stroke = 36.4%
Agyeman et al.,[2]	Ghana	Retrospective Descriptive study	N=1050, F (48.9%), M (51.1%) Age Mean (63.7%)	9.1 per 100
Enwereji et al.,[3]	Nigeria	First stage: Door-to-door survey using the WHO protocol for determining neurological diseases. Second Stage: Case-control study	N=20, Cases[10]: F (40%), M (60%) Age Range[47-86] Age Mean/SD (60.7 ±11.4) Controls[10]: F (40%), M (60%) Age Range[45-84] Age Mean/SD (60.4 ±11.9)	1.63 per 1000 (0.78–3.00) Male: 1.99 per 1000 (0.73–4.33) Female: 1.28 per 1000 (0.35–3.28)
Sanya et al.,[4]	Nigeria	A descriptive cross-sectional study using a modified version of the World Health Organization (WHO) protocol for Epidemiological Neurological Disorders.	N=18, F (41.2%), M (58.8%) Age Mean/SD (58.2± 11.5)	1.31 per 1000 Male: 1.54 per 1000 Female: 1.08 per 1000
N'goran et al.,[5]	Ivory Coast	Retrospective cross-sectional design	N=176, F (56%), M (44%) Age Range[32-86] Age Mean[60]	4 per 100
Kaseke et al.,[6]	Zimbabwe	Retrospective cross-sectional design	N=417	0.61 per 100 Ischemic stroke = 46% Haemorrhagic stroke = 54%
Rasaholiarison et al.,[7]	Madagascar	Retrospective cross-sectional design	N=157, F (38.55%), M (61.44%) Age Mean (59.09)	48.17 per 100
Fekadu et al.,[8]	Ethiopia	A prospective Cohort study	N=116, F (37.1%), M (62.9%) Age Range[23-96] Age Mean/SD (55.1 + 14.0)	16.5 per 100 Ischemic stroke = 49.2 per cent Haemorrhagic stroke = 50.8 per cent
Ominde et al.,[9]	Kenya	Prospective cross-sectional design	N=227, F (62%), M (38%) Age Range[32–96] Age Mean/SD (68.8 ±6.8)	7.09 per 100 Ischemic stroke = 67.6% Haemorrhagic stroke = 32.6%
Sanuade et al.,[10]	Ghana	A cross-sectional study that retrieved data from the World Health Organization (WHO) survey on Global Ageing and Adult Health (SAGE)	N=4279, F (52.3%), M (47.7%) Age Range[50-114] Age Median[62]	2.6 per 100 Male: 2.4 per 100 Female: 2.8 per 100
Tshilanda et al.,[11]	DR Congo	Retrospective cross-sectional design	N=114, F (36%), M (64%) Age Range[30-80] Age Mean/SD (61.8 ± 2.4)	4.2 per 100
Nutakki et al.,[12]	Zambia	Retrospective cohort study	N=324, F (62%), M (38%) Mean/SD (60±18)	4.3 per 1000 Ischemic stroke = 58% Haemorrhagic stroke = 28% Unknown type= 14%

a community-based study in Nigeria[54] while Tekle-Haimanot et al., in 1990, report a prevalence of 15/100.000 in Ethiopia[55]. While some authors argue that these low prevalent values may be as a result of high fatality rates[56], other authors believe this is as a result of an increase in risk factors[57]. This systematic review aligns with other more recent studies in Nigeria[58] and Uganda[59] to show the high prevalence of stroke in SSA. In west Africa, Enwereji et al., in 2014, report a prevalence of 1.63 per 1000 inhabitants[60], N'goran et al., in 2015, report a prevalence of 4 per 100 in Ivory coast[61]. In East Africa, Ominde et al., in 2019, report a prevalence of 7.09 per 100[62] while Kaseke et al., in 2017, report a prevalence of 0.61 per 100[31]. Despite variations in population sizes and methodologies among these studies, they all confirm the high prevalence of the disease in the regions.

Regarding the incidence of stroke in SSA, the current systematic review found three notable studies. One study examining two regions of Tanzania (Hai and Dar-Es Salaam) showed a crude incidence of 94.5 per 100.000 (with a range of 76.0 – 115.0) and 107.9 per 100.000 (with a range of 88.1 – 129.8) respectively[32]. The second study conducted in Ghana showed an incidence rate of 14.19 events per 1000 person-years (with a range of 10.77 – 18.38)[33]. The third study, which was conducted in Cameroon showed an incidence rate of 0.3 per 100 person-years[34]. These values demonstrate an increasing incidence rate of stroke in Africa when compared to earlier studies. For example, in Zimbabwe, an earlier study showed a crude incidence rate of 30.7 per 100.000 (with a range of 27.1 - 34.4)[63], while in Nigeria, another study reported an incidence rate of 26 per 100.000[64]. With this observed increase, it is suspected that

Table 2
The incidence of stroke in Sub-Saharan Africa.

AUTHOR	COUNTRY	STUDY TYPE	POPULATION	INCIDENCE (95% CI)
Walker et al.,[13]	Tanzania (2 sites: Hai (Site 1) and Dar-es-Salaam (Site 2))	A Tanzanian Stroke Incidence Project (TSIP) Survey	N= 636 Site 1 (453): M (52.3%), F (47.7%) Site 2 (183): M (54.6%), F (45.4%)	Site 1: Crude incidence = 94·5 per 100 000 (76·0–115·0) Age-standardized = 108·6 per 100 000 (95% CI 89·0–130·9) Site 2: Crude Incidence = 107·9 per 100 000 (88·1–129·8) Age-standardized = 315·9 per 100 000 (281·6–352·3)
Mapoure et al.,[14]	Cameroon	Retrospective Cohort Design	N=407, F (62.4%), M (37.6%) Age Mean/SD (40.1 ± 9.9)	0.3 per 100 person years
Fred S. Sarfo et al.,[15]	Ghana	Prospective Cohort Study	N=54, F (63%), M (37%) Age Mean/SD (61.4 ± 10.6)	14.19 events per 1000 person-years [10.77–18.38]

further discoveries could be made if there were more studies conducted in other countries within Sub-Saharan Africa (SSA). This underscores the need for additional research to provide updated insights into the incidence of stroke in SSA.

For the non-modifiable risk factors, age has always been one of the most prominent. This is evidenced in the study of Yousufuddin and Young in 2019, which stated that age is the most robust risk factor of stroke, with the risk doubling every 10 years after the age of 55[65]. This is further supported by Roy-O'Reilly and McCullough in 2018, who reported that being older than 50 years is the most significant risk factor of stroke[66]. The current study aligns with this finding, as it confirmed results showing several mean ages around 50 years. The increasing prevalence of stroke in the region has also been acknowledged through projections from the United Nations (UN), which anticipate a progressively older population in the region, potentially tripling by 2050[67]. This is certainly a warning for actions to mitigate future additional burden of stroke in the region.

Over half of the studies included showed a higher prevalence of stroke in women than men. Reeves et al., in 2008, highlighted that the higher prevalence in women may be due to their higher life expectancy[10], while Rexrode et al., in 2022, noted several sex-specific associated risk factors including pregnancy, sexual hormones, and use of oral contraceptives[14].

Family history, genetics, Transient Ischaemic Accidents (TIAs) or previous stroke have also been highlighted as risk factors of stroke in at least one of the studies included. In Nigeria, Sanya et al., in 2015[68] report that 41.2% of all patients with a stroke, had a TIA. In Ethiopia, Fekadu et al., in 2019,[69] report family history to be present in 33.6% of all stroke patients while sickle-cell disease is identified as a risk factor in Uganda[70]. These findings are similar to worldwide studies published[8,71].

As for the modifiable risk factors, hypertension emerges as the most common risk factor associated with stroke as evidenced by over 30 studies worldwide, recording a frequency of 64% in all stroke patients[72,73]. Similar results were deduced from the current study, as most studies identified hypertension as the most common risk factor. Frequencies as high as 90% were recorded in a SIREN study in Nigeria and Ghana[74]. Several surveys in Africa have shown that this high prevalence is because of low awareness about hypertension and its management (Blood pressure (BP) control etc). For example, a study showed that <20% were aware of the diagnosis and only about 1% had their BPs controlled[75]. This poses a serious challenge in the overall burden of disease.

Diabetes is another major risk factor of stroke. Dal Canto et al. in 2019, claims that incidence rates of strokes are 2.5 times higher in diabetic patients[76]. Currently in SSA, 10.4 million people have diabetes and values are expected to rise to about 18 million by 2025[77]. This systematic review reports diabetes prevalence in stroke patients to be as high as 58.8% in Congo[44] and 30% in Uganda[78]. These reports are similar to reports in India[79] and in the United States (US)[80].

Dyslipidaemia emerged as an important risk factor of stroke in SSA. Although regional differences in the prevalence of dyslipidaemia, particularly cholesterol, have been observed across Africa, Noubiap et al., in 2018, report a prevalence of 23.6% among adults in Africa[81]. So, it came as no surprise that it was the one of the major risk factors highlighted in the studies of this systematic review. With prevalence values in stroke patients as high 855 in Nigeria[82], 71% in Congo[44] and 61% in Ghana and Nigeria[74], these studies showed similarities with other research such as study in India[83] and in China[84] who reported prevalence values as 80% and 62% respectively.

Several other modifiable risk factors were discussed in the studies included in the systematic review. Apart from those listed earlier, Kaddumukasa et al., in 2017 and Tribelhorn, Motara and Lewis in 2021, amongst others, highlighted HIV coinfection as a risk factor[78,85]. This agrees with other studies that report HIV as a risk factor of stroke through various mechanisms including vasculopathies, opportunistic diseases, cardiac embolism etc[86]. Heart disease also appeared as a risk factor from most studies, including atrial fibrillation, valvopathies, cardiomyopathies etc. Studies show that over 1/3 of all stroke patients are diagnosed with heart disease[87]. Obesity and other unhealthy habits such as alcohol intake, tobacco use, physical inactivity and bad diets were also highlighted in different studies throughout this systematic review. Studies show that the relative risk of stroke in smokers in 1.9 times higher than in non-smokers[88] and 1.69 times higher in people who consume alcohol than in those who don't[89]. And with an increasing prevalence of substance abuse in SSA, as highlighted by Delobelle in 2019[90], the incidence of stroke will continue to increase.

The main public health implications of stroke include disability rates, mortality rates and economic costs of managing the disease. Infectious diseases such as COVID19, malaria, HIV, tuberculosis (TB) have drawn the world's attention, and hence are the priority with regards to funding from national governments and international organisations. Hence, stroke is slightly neglected, but posing real public health issues to the nations of SSA.

Concerning the mortality rates, twenty studies included in this systematic review reported data on the mortality rates of stroke in the region. Mortality rates were calculated in monthly intervals in some studies and in intervals of 3 or 6 in others (30-day, 90-day, 3 months, 6 months, 9 months, and 12 months) depending on the studies. Generally, higher mortality rates were recorded within more time after the stroke episode. For example, Heikinheimo et al.,[91] from Malawi, report that mortality rates at 6 weeks, 6 months, and 1-year were 37/134 (27.6%), 52/134 (38.8%), and 59/131 (45.0%) respectively and Fred S. Sarfo et al.,[92] in Ghana report mortality rates at 12, 24, and 36 months to be 9.3%, 11.5% and 14.1% respectively using estimates from Kaplan-Meier curves. These results are similar to a study in India that showed that mortality increased with time after the episode[93]. However, a study in Ghana contradicted these findings by reporting a higher mortality rate (62.1%) within the first seven days[37]. Infection was the most frequent complication and cause of death reported and this aligns with other studies that report initial stroke, further stroke and infection as the most common causes of death after a stroke in Africa[94]. Sarfo et al., in 2022,

Table 3
The risk factors of stroke in Sub-Saharan Africa.

AUTHOR	COUNTRY	STUDY TYPE	POPULATION	RISK FACTORS
Thorogood et al.,[16]	South Africa	Prospective cross-sectional design	N=402, F (76%) M (24%)	1. Smoking 2. Alcohol Consumption 3. Physical Inactivity - Moderately active (male = 68.4 (58.1, 77.6), female =74.9 (69.7, 79.7 - Low active (male= 20.0 (12.5, 29.5), female=18.2 (14.1, 23.0) - Sedentary (male = 11.6 (5.92, 19.8), female = 6.84 (4.28, 10.3)
Karaye et al.,[17]	Nigeria	Prospective cross-sectional design	N=81, F (49.1%), M (51.9%) Age Range[17-85] Age Mean/SD (55.83±16.15)	1. Hypertension: 79% 2. Heart Disease: 65.4% 3. Diabetes + Chronic Renal
O. O. Desalu et al.,[1]	Nigeria	Retrospective case-control design	N=101, F (52.5%) M (47.5%) Range[30-80] Mean/SD (68±12)	1. Systemic hypertension: 85.2% 2. Diabetes: 23.8% 3. Tobacco smoking: 22.8% 4. Previous Transient Ischemic Attack (TIA): 18.8% 5. Previous stroke: 14.9% 6. Alcohol: 11.9% 7. Cardiomyopathy: 10.9% 8. Cardiac arrythmias: 8.9% 9. Obesity: 5.9% 10. Dyslipidaemia: 3.0% 11. Carotid artery stenosis: 1.0% 12. Oral contraceptive pills: 1.0% NB: Seventy storke patients (69.3%) had two or more risk factors for stroke while 31 (30.7%) had one risk factors for stroke
Walker et al.,[18]	Tanzania	Prospective case-control design	N=598, Cases (200):F (46.5%), M (53.5%) Controls (398):F (46.2%) M (53.8%)	1. HIV status 2. Hypertension 3. Smoking status 4. Previous cardiac event 5. A high ratio of total to HDL cholesterol level. NB: In Hai, additional risk factors of diabetes and low HDL cholesterol were also significant. Diabetes was associated with increased risk in Dar-es-Salaam, albeit not significantly.
Donkor et al.,[19]	Ghana	Prospective cross-sectional design	N=102, Cases (156): F (37.8%), M (62.2%) Controls (156): F (37.8%) M (62.2%) Cases Age Mean/SD (58.0±11.4) Control Age Mean/SD (57.6 ±12.0)	1. Hypertension: 89% 2. Diabetes: 29% 3. Alcohol consumption: 28% 4. High cholesterol: 25% 5. Heart disease: 7%
Sarfo et al.,[20]	Ghana	Prospective case-control design	N=265, F (56.6%), M (43.4%) Age Mean/SD 64.6 ± 14.54	1. Systemic hypertension: 85% 2. Physical Inactivity: 73% 3. Obesity: 58% 4. Hypercholesterolemia: 47% 5. Diabetes Mellitus: 38% 6. Alcohol consumption: 19% 7. Precious Stroke: 14% 8. Smoking: 8% 9. Atrial fibrillation: 4% 10. TIA: 2% 11. Other Cardiovascular Diseases (CVDs): 3%
N'goran et al.,[5]	Ivory Coast	Retrospective cross-sectional design	N=176, F (56%) M (44%) Range[32-86] Mean[60]	1. Hypertension: 84.6% 2. Diabetes: 11.4% 3. Smoking: 2.2%
Sanya et al.,[4]	Nigeria	Prospective cross-sectional survey design	N=18, F (41.2%) M (58.8%) Mean/SD (58.2± 11.5)	1. Hypertension: 82.4% 2. TIA: 41.2% 3. Smoking: 17.6% 4. Diabetes: 11.8% 5. Recurrent Stroke: 11.8%
Owolabi et al.,[21]	Nigeria	Prospective case-control design	N=85, F (43.5%), M (56.5%) Age Range[38-80] Age Mean/SD (56.1 ± 10.1)	1. Diabetes: 25.9% 2. Cardiovascular risk factors: 74.1% (hypertension, hypercholesterolemia, and smoking)
Olamoyegun et al.,[22]	Nigeria	A retrospective descriptive study	N=106, F (32.5%) M (67.5%) Age Mean/SD (Haemorrhagic)=56.21 ± 12.38 Age Mean/SD (Ischaemic) =64.08 ± 10.87	1. Diabetes 2. Hypertension 3. Angina pectoris 4. Intermittent claudication
Kaseke et al.,[6]	Zimbabwe	Retrospective cross-sectional design	N=417	1. Hypertension: 58.4% 2. HIV/AIDS: 14% 3. Diabetes: 18% 4. Heart disease: 6% 5. Aspiration Pneumonia: 9%

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Table 3 (*continued*)

AUTHOR	COUNTRY	STUDY TYPE	POPULATION	RISK FACTORS
Kaddumukasa et al.,[23]	Uganda	Prospective cross-sectional design	N=440, F (65.5%), M (34.5%) Age Median[54] Age Range[42-62]	1. Hypertension = 66% 2. Previous stroke = 38% 3. Diabetes mellitus = 30% 4. Obesity = 26% 5. HIV/AIDS = 8.1 NB: Only 17.2% with hypertension engaged in physical exercise.
Sarfo et al.,[24]	Ghana	Prospective case-control design	N=1080, Cases (540): F (45.7%), M (54.3%) Controls (540): F (61.3%) M (39.7%) Cases Mean/SD (60.8 ± 15.5) Control Mean/SD (60.0 ± 15.5)	1. Hypertension: Cases (91.6%), Controls (58%) (p<0.0001), 2. Dyslipidaemia: Cases (80.4%), Controls (70.6%) (p=0.0002), 3. Diabetes Mellitus: Cases (38.1%), Controls (6.1%) (p<0.0001), 4. Cardiac Disease: Cases (3.5%), controls (0.6%) (p=0.0006). 5. HIV: Cases (2.2%), Controls (2.8%) (p=0.70) NB: Both current use of alcohol and cigarette smoking were significantly higher among cases than controls.
Owolabi et al.,[25]	Ghana & Nigeria	Prospective case-control design	N=4236, Cases (2118): F (44%), M (56%) Controls (2118): F (44%) M (56%) Cases: Age Mean/SD (59±13.8) Controls: Age Mean/SD (57.8±13.7)	1. Hypertension: Cases (95%) & Control (58%) 2. Dyslipidaemia: Cases (38%) & Controls (13%) 3. Diabetes: Cases (12%) & Controls (5%) 4. Cardiac Disease: Cases (3%) & Controls (1%) NB: According to Population Attributable Risk (PAR), the top 11 potentially modifiable risk factors for stroke included hypertension, dyslipidaemia, regular meat consumption, a high waist-to-hip ratio, diabetes, low consumption of green leafy vegetables, stress, added salt at the table, cardiac disease, inactivity, and current cigarette use. These risk factors were listed in decreasing order of importance.
Kaduka et al.,[26]	Kenya	Prospective cohort design	N=691, F (57.6%) M (42.4%) Range[45-73] Median[60]	1. Hypertension [77.3% (males: 75.7%; females: 78.5%)] 2. Cigarette smoking [16.1% (males: 26.6%; females: 8.3%) 3. Diabetes [14.9% (males: 15.7%; females: 14.4%)], 4. Hypercholesterolaemia [2.8% (males: 4.1%; females: 1.8%) p < 0.05]. 5. Previous migraine [32.8% (males: 28.3%; females: 36.0%) p < 0.05] 6. HIV infection [8% (males: 7.2%; females: 8.6%)] 7. Use of oral contraceptives [3.9% (females: 6.8%)] 8. Cocaine use [0.7% (males: 0.7%; females: 0.8%)]
Fred Stephen Sarfo et al.,[27]	Ghana & Nigeria	Prospective case-control design	N=1080, Cases (540): F (45.7%), M (54.3%) Controls (540): F (61.3%) M (39.7%) Cases Mean/SD (60.8 ± 15.5) Control Mean/SD (60.0 ± 15.5)	Odds Ratio (OR) (95% CI) 1. Hypertension: 10.34(6.91,15.45) 2. Dyslipidaemia 5.16(3.78,7.03) 3. Diabetes mellitus 3.44(2.60,4.56) 4. Low green vegetable consumption 1.89(1.45,2.46) 5. Red meat consumption 1.89(1.45,2.46) 6. Cardiac disease 1.88(1.22,2.90) 7. Monthly income of $1001.72 (1.24,2.39) 8. Psychosocial stress 1.62(1.18,2.21)
Fred S. Sarfo et al.,[15]	Ghana	Prospective cohort design	N=54, F (63%) M (37%) Mean/SD (61.4 ± 10.6)	1. Male gender 2. Increasing age 3. Receiving care at a secondary level health facility 4. Unemployment 5. Previous cigarette smoking 6. Physical inactivity.
Fred Stephen Sarfo et al.,[28]	Nigeria & Ghana	Prospective case-control design	N=4236, Cases (2118): F (40.6%), M (59.4%) Controls (2118): F (40.6%) M (59.4%) >50: Cases Age Mean/SD: (64.79 ± 10.00) Controls Age Mean/SD: (63.48 ± 10.08) <50: Cases Mean/SD: (40.95 ± 6.58) Controls Mean/SD: (40.12 ± 6.53)	OR (95% CI) – Cases/Controls 1. Hypertension: (30.84, 11.37 – 83.61; 88.7%, 82.5–94.8%) 2. Dyslipidaemia: (2.75, 1.34–5.61; 48.2%, 30.6–65.9%) 3. Diabetes mellitus: (5.80, 2.05–16.36; 22.6%, 18.7–26.5%) 4. Low green vegetable consumption: 2.31 (1.02–5.22; 18.2%, −6.8–43.2) 5. Stress:(2.26, 1.04–4.93; 14.5%, 4.9–24.1%) 6. Cardiac disease:(8.03, 1.91–33.82; 8.4%, 5.8–11.1%).
Ominde et al.,[9]	Kenya	Prospective case control design	N=227, F (62%), M (38%) Age Range[32–96] Age Mean/SD (68.8±6.8)	1. Hypertension: 74% 2. Alcohol Abuse: 63% 3. Smoking: 48% 4. Diabetes: 32% 5. Diabetes + Hypertension: 28% 6. Atrial Fibrillation: 20%
Akpalu et al.[29]	Ghana & Nigeria	Prospective case-control design	N=4236, Cases (2118): F (44%) M (56%) Controls (2118): F (44%) M (56%) Males: Mean/SD (58.09±13.16) Females: Mean/SD (60.15±14.53)	OR (95% CI) 1. Hypertension: F= [29.95 (12.49–71.77) M=16.10 (9.19–28.19)] 2. Dyslipidaemia: F= [2.08 (1.42–3.06) M=1.83 (1.29–2.59)] 3. Diabetes mellitus: F= [3.18 (2.11–4.78) M= 2.19 (1.53–3.15)], 4. Stress: F= [2.34 (1.48–3.67), M= 1.61 (1.07–2.43)] 5. Low consumption of green leafy vegetables: F= [2.92 (1.89–4.50), M= 2.00 (1.33–3.00] 6. Cardiac disease: F= [1.82(1.00–3.27), M= 1.75(0.97–3.170]

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Table 3 (*continued*)

AUTHOR	COUNTRY	STUDY TYPE	POPULATION	RISK FACTORS
Fekadu et al.[30]	Ethiopia	Prospective cohort design	N=116, F (37.1%) M (62.9%) Age Range[23-96] Age Mean/SD (55.1 + 14.0)	1. Hypertension: 75.9% 2. Family history: 33.6% 3. Alcohol intake: 22.4% 4. Smoking:17.2%
Sanuade et al.,[10]	Ghana	Prospective cross-sectional survey design	N=4279, F (52.3%) M (47.7%) Range[50-114] Median[62]	1. Smoking: 74.2% (Current=12.5%, previous smokers= 13.3%) 2. Alcohol consumption: occasionally=28.5%, Regularly=30.1% 3. Physical Activity: partially=5.2%, fully=8.3% 4. Obesity: 28.6% 5. Hypertension: 57.8% 6. Diabetes: 4.2%
Mekonen et al.,[31]	Ethiopia	Prospective case control design	N=445, F (51.5%), M (48.5%) Cases: Age Mean/SD (56.3 ±13.53) Controls: Age Mean/SD (51.9 ±12.67)	1. Alcohol Consumption: Cases=36% & Controls=13.8% 2. Salty diets: Cases = 24.7% & Controls = 7.9% 3. Non-adherent to medication: Cases=66.3% & Controls=29.8% 4. Exercise: Cases=70.8% & Controls = 68.8% 5. Overweight: Cases=14.6%) & Controls = 16.9% 6. Family History of stroke: Cases=5.6% & Controls=7%
Tshilanda et al.,[11]	Congo	Retrospective cross-sectional design	N=114, F (36%), M (64%) Age Range[30-80] Age Mean/SD (61.8 ± 2.4)	1. Hypertension: 76.3% 2. Dyslipidaemia: 71.1% 3. Diabetes mellitus: 58.8% 4. Heart rhythm disorders:10.5% 5. Valvopathy: 7.0% 6. Ischemic heart disease: 11.4% 7. Dyslipidaemia: 71.1% 8. Chronic alcoholism: 28.1% 9. Active smoking: 6.1% 10. Previous stroke episode: 9.6%
Gadisa et al.,[32]	Ethiopia	Retrospective descriptive cross-sectional design	N=111, F (50.5%) M (49.5%) Mean/SD (63.4±12.18)	1. Hypertension 39 (35.1%) and 9 (8.1%) 2. Atrial fibrillation 15 (13.5%) and 7 (6.3%) 3. heart disease (6.3%) 4. Previous stroke/TIS (5.4%) 5. Tuberculosis (0.9%)
Sarfo et al.,[33]	Nigeria & Ghana	Prospective case-control design	N=854, F (36.9%) M (63.1%) Mean = 54.7	OR (95% CI) 1. Hypertension: 66.63 (20.78-213.72) 2. Dyslipidaemia: 2.95 (1.84-4.74) 3. Meat consumption: 1.55 (1.01-2.38) 4. Family history of CVD: 2.22 (1.41-3.50) 5. Nonconsumption of green vegetables: 3.61 (2.07-6.31) 6. Diabetes mellitus: 2.11 (1.29-3.46); stress, 1.68 (1.03-2.77) 7. Tobacco use: 14.27 (2.09-97.47)
Tribelhorn et al.,[34]	South Africa	Retrospective cross-sectional design	N=160, F (54%) M (46%) Age Range[28-90] Age Mean/SD (57.7±14.9)	1. Hypertension: IS = 61%, HS=52% 2. Diabetes: IS=20%, HS=6% 3. Previous Cardiovascular Accident: 11%, 4. HIV: 12%, 5. Smoking: 8% 6. CVD: 6%
Nutakki et al.,[12]	Zambia	Retrospective cohort design	N=324, F (62%), M (38%) Age Mean/SD (60±18)	1. Hypertension: 80% 2. Diabetes: 16% 3. Hyperlipidaemia: 14% 4. Heart Disease: 34% 5. Atrial Fibrillation: 9% 6. Previous Stroke: 22% 7. HIV/AIDS: 18%
Tribelhorn et al.,[34]	South Africa	A retrospective descriptive study	N=160, F (54%) M (46%) Age Range[28-90] Age Mean/SD (57.7 ± 14.9)	1. Hypertension (58%) 2. Diabetes (14%) 3. Previous stroke (11%) 4. HIV (12%) 5. Smoking (8%) 6. Heart disease (6%)
Dabilgou et al.,[35]	Burkina Faso	Prospective cross-sectional design	N=44, F (27.3%), M (72.7%) Age Range[36-86] Age Mean/SD (66.5 ± 11.49)	1. Hypertension: 81.8% (n=36) 2. Chronic alcohol consumption: 45.5 % (n=20) 3. Overweight: 40.9% (n=18).
Kuate et al.,[36]	Cameroon	Retrospective cohort design	N=43, F (69.8%), M (30.2%) Age Mean/SD (52.1 ± 12.9)	Framingham cardiovascular risk (67.4%, n = 29) before admission
Namaganda et al.,[37]	Uganda	Prospective case-control design	N=102, Cases[51]: F (56.9%), M (43.1%) Controls[51]: F (52.9%) M (47.1%) Cases Age Mean/SD (36.8±7.4) Control Age Mean/SD (36.8±6.9)	1. HIV infection, OR 3.57 (95% CI 1.16–10.96) 2. Elevated waist to hip ratio, OR 11.59 (95% CI 1.98–68.24) 3. Sickle cell disease, OR 4.68 (95% CI 1.11–19.70). NB: This study found a protective effect of oral contraceptive use for stroke OR 0.27 95% CI 0.08–0.87.

also suggests that these high mortality rates may be due to poor infrastructure and management guidelines in the local health centres[95]. This can be supported by studies in more developed countries which report relatively lower mortality rates[96].

Stroke is recognised as a very expensive disease to treat especially considering the several tests required and the potential for various complications. For this systematic review, we identified five studies that reported the costs of stroke in the region. One study in Benin reported an

Table 4
The mortality rates of stroke in Sub-Saharan Africa.

AUTHOR	COUNTRY	STUDY TYPE	POPULATION	MORTALITY RATES
Desalu et al.,[1]	Nigeria	Retrospective case-control design	N=101, F (52.5%) M (47.5%) Range[30-80] Mean/SD (68 ±12)	30-day mortality rate (Types of patients): 1. Total death rate: 23.8%, M=29.2%, F=18.9% 2. Recurrent stroke (7, 43.8%), First ever stroke: 17 (20.0%). 3. Haemorrhagic stroke:12 (34.3%), Ischemic stroke: 12 (18.5%). 4. <2 risk factors: 7 (25.0%), ≥2 risk factor: 17 (24.3%)
Agyeman et al.,[2]	Ghana	Retrospective case-control design	N=1050, F (48.9%), M (51.1%) Age Mean (63.7%)	1. Overall death rate: 43.4% (F=46.5%, M=53.5) 2. < 24hrs: 13.2% 3. 7 days: 62.1% 4. 28 days: 43.2%
Heikinheimo et al.,[38]	Malawi	Prospective cohort design	N=147, F (47.7%), M (52.3%) Age Mean/SD (54.2 ± 16.9)	1. Overall, in-hospital mortality rate: 22.4% 2. 6 weeks: 27.6% 3. 6 months: 38.8% 4. 1 year: 45%
Sarfo et al.,[20]	Ghana	Prospective case-control design	N=265, F (56.6%), M (43.4%) Age Mean/SD 64.6 ± 14.54	1. Total death rate: 43.4% 2. Ischemic stroke: 17.5%, Haemorrhagic stroke: 70,2% NB: 35% of those who died had clinical evidence of aspiration pneumonitis.
Ekeh et al.,[39]	Nigeria	Prospective case-control design	N=120, F (38.3%), M (61.7%) Age Range[18-85] Age Mean/SD (55 ± 15.2)	1. Overall mortality: 2. 7 days mortality: 26.7% 3. 30 days mortality: 33.3%
Owolabi et al.,[21]	Nigeria	Prospective case-control design	N=85, F (43.5%), M (56.5%) Age Range[38-80] Age Mean/SD (56.1 ± 10.1)	30-day mortality rate = 30.6%.
Kaseke et al.,[6]	Zimbabwe	Retrospective cross-sectional design	N=417	1. Overall death rate: 25% (M=30.3%: 95% CI=22.9;37.6) and F= (22.0%: CI 95% CI=17.1; 26.9). NB: Eighteen (44.0%) patients with aspiration pneumonia died in hospital. Fifteen (23.8%) HIV positive patients died in-hospital.
Fred S. Sarfo et al.,[40]	Ghana & Nigeria	Prospective case-control design	N=607, F (50.3%), M (49.7%) Mean/SD (59.9 ± 13.9%)	1. Mortality rates at 12 months: 9.3% 2. Mortality rates at 12 months: 11.5% 3. Mortality rates at 12 months:14.1% using estimates from Kaplan-Meier curves.
Kaduka et al.,[41]	Kenya	Prospective cohort design	N=691, F (57.6%) M (42.4%) Age Range[45-73] Age Median[60]	SITE 1: KNH 10 days: 18%, 28 days: 8.4%, 3 months: 10.6%, 6 months: 5.4%, 9 months: 1.6% SITE 2: MTRH 10 days: 15.5%, 28 days: 10.3%, 3 months: 12%, 6 months: 8.2%, 9 months: 8.8%
Kaduka et al.[26]	Kenya	Prospective cohort design	N=719, F (56.7%), M (43.3%) Age Mean/SD (58.26± 18.7)	1. Overall: 21.6%, Incidence density = 507 deaths per 1,000 person-years of follow-up 2. 10 days: 18.4% 3. 28 days: 26.7%
Fekadu et al.,[8]	Ethiopia	Prospective cohort design	N=116, F (37.1%), M (62.9%) Age Range[23-96] Age Mean/SD (55.1 + 14.0)	1. Overall mortality rate: 23.6%, Ischemic stroke = 32.1% vs Haemorrhagic stroke = 32.1%
Agokeng Kemnang et al.,[42]	Cameroon	Descriptive cohort design	N=46, F (58.7%), M (41.3%) Age Range[42-88] Age Mean[62]	Overall mortality rate = 10.9%
Regenhardt et al.,[43]	Tanzania	Retrospective cohort design	N=149, F (48.3%), M (51.7%) Age Mean/SD (57.2 ± 14.6)	1. Ischemic stroke: Initially=19%, At 90 days= 49% 2. Haemorrhagic

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Table 4 (*continued*)

AUTHOR	COUNTRY	STUDY TYPE	POPULATION	MORTALITY RATES
				stroke: Initially=33%, At 90 days= 50%
Tshilanda et al.,[11]	Congo	Retrospective cross-sectional design	N=114, F (36%), M (64%) Age Range[30-80] Age Mean/SD (61.8 ± 2.4)	1. Ischemic stroke: 29.9% 2. Haemorrhagic stroke: 25.5%.
Namale et al.,[44]	Uganda	Prospective cohort design	N=141, F (66%), M (34%) Age Mean/SD (63.2±15.4)	1. Overall mortality: 31% 2. 30 days: 23% 3. 90 days: 47%
Gadisa et al.,[32]	Ethiopia	Retrospective descriptive cross-sectional design	N=111, F (50.5%), M (49.5%) Age Mean/SD (63.4±12.18)	1. Overall Mortality: 16.2% 2. Ischemic stroke: 13.5%, Haemorrhagic stroke: 30%
Nutakki et al.,[12]	Zambia	Retrospective cohort design	N=324, F (62%), M (38%) Age Mean/SD (60 ±18)	1. Total death rate: 24% (n=77) 2. Haemorrhagic stroke: 33%, Ischemic stroke: 18%, Unknown: 33%
Kuate et al.,[36]	Cameroon	Retrospective cohort design	N=43, F (69.8%), M (30.2%) Age Mean/SD (52.1 ± 12.9)	1. 7 days: 14% 2. 1 month: 34.9% 3. 1 year: 46.5% NB: Infection was the most frequent intra-hospital complication.
Tessua et al.,[45]	Tanzania	Prospective cohort design	N=130, F (63.8%), M (36.2%) Age Mean/SD (54 ± 16)	Mortality rate >45: 50% Mortality rate ≤ 45:28.6%
Ayehu et al.[46]	Ethiopia	Prospective cohort design	N=554, F (53.3%), M (46.7%) Age Mean/SD (61 ± 12.85)	1. Overall, the 28-days case fatality rate was 27.08% (150) 2. Haemorrhagic stroke: 60%, Ischaemic stroke: 40%. 3. In-hospital mortality: 80%, mortality after discharge: 20% 4. Male:53.3%, Female: 46.7%

average of approximately 704 ± 512 Euros, as the total direct cost per individual with stroke[46]. One study in Nigeria showed that the range of costs per individual was €279.16 - €935.57[49]. Another study conducted in Tanzania, reported a mean cost of $220 per individual[50]. Given that these countries dwell in poverty and have a minimum wage of <$100, these costs are felt heavily by the population. In addition, due to the lack of adequate national funding, stroke management may require individual patients and their families to pay a sizable amount of their income, which may not be feasible or affordable. This poses an economic burden on the population. Also, as stroke is one of the major causes of disability in the world, a high prevalence of the disease means less people can work impacting economic development, and in turn the health budget.

Strengths and limitations

This study has several strengths and limitations. For the strengths, this study followed the guidelines for a systematic review including search strategy and multiple reviewers. All papers included were assessed with the CASP tool, to ascertain the quality of papers. Also, all studies included were peer-reviewed. The review used the database PUBMED which is known for its reliability and credibility, and which is maintained by the National Library of Medicine (NLM). The use of PUBMED guaranteed access to high quality papers and a focused scope of biomedical literature. It also guaranteed standardization and consistency, which encourages reproducibility and reliability of findings. This systematic review included studies in both French and English which are the two main publishing languages. Generalised and specialised key words were applied for the search, making sure that maximum data were retrieved. Time and date restrictions were equally avoided to prevent selection bias.

As for the limitations, with only one database used for the search, the amount of data available was quite limited, hence a high chance of excluding relevant literature. However, this review focused on the quality of data and not the quantity of data. Also, data was too diverse to yield a concrete summary estimate of the prevalence and incidence of stroke in the region.

The inclusion of only free full texts in this systematic review limits significantly the amount of data available. Although a significant limitation, it allows for transparency and reproducibility by allowing others access the same sources we accessed. The review becomes easily accessible to a wider audience that does not have access to subscription-based journals or databases (one of the most lauded by the proponents of Open Science). Some authors also argue this based on the obligation to reciprocity. In the context of science, reciprocity merely reflects that scientific results are the product of the research that has been funded from the public or taxpayers' money, and the results should be made available to those who paid for it in the first place[97].

Further directions

We therefore recommend that a meta-analysis exploring other databases be carried out to provide summarised figures for the data provided in this paper and using more advanced analytical software and approaches such as the GRADE (Grading of Recommendations, Assessment, Development and Evaluations) Approach.

Conclusion

The increasing incidence and prevalence of lifestyle factors and their connections to other diseases, especially major infectious diseases, are contributing to the emergence of stroke as a critical public health issue for SSA. Being one of the major causes of disability, stroke has a direct impact on the economy of this region, as human resources are being lost because of these disabilities. The data summarised in this systematic review, shows an increase in the incidence/prevalence and mortality rates of stroke in this region. Although, far lower than those reported in economically developed nations, they point to a potential 400% rise in the burden of stroke during the past twenty years at the very least. The systematic review also relates this high burden to the increase in the major modifiable and non-modifiable risk factors of the disease including age (as the population of Africa is growing older), gender (with more women having a higher prevalence due to increased life expectancy, pregnancy, hormones, contraception etc), hypertension and diabetes (due to poor awareness and lack of funding for the management of these diseases). Other risk factors were highlighted throughout this

Table 5
The economic costs of stroke in Sub-Saharan Africa.

AUTHOR	COUNTRY	STUDY TYPE	POPULATION	ECONOMIC COSTS
Birabi et al.,[47]	Nigeria	Retrospective cross-sectional design	N=29, F (34.5%), M (65.5%) Age Range[34-62] Age Mean/SD (49.66 ± 7.46)	1. Investigations = (N58,400: 00 ($370= €279.16) - N196,000: 00 ($1240= €935.57) for investigations (MRI, laboratory investigations and ECG). 2. Physiotherapy (12 weeks) = N32,000: 00 ($202= e€152.41) and N200,000: 00 ($1265= €954.43 N89,000:00 ($560= €422.51) and 3. Physiotherapy (36 weeks) = N560,000: 00 ($3540= €2670.89) 4. Medication (7-14 days) = N4,700: 00 ($30= €22.63) and N11,900: 00 ($75= €22.63)
Adoukonou et al.,[48]	Benin	Prospective cross-sectional design	N=78, F (33.3%), M (66.7%) Age Range[36-80] Age Mean/SD (57±10.9)	Total expenditure in direct cost =[38,500F - 1,099,700F] Mean: of 316,810.3F (±230, 774.8), (approximately 704 ± 512 Euros) Median being 262,565F. Reasons 1. Paraclinical explorations (34.3%), 2. Care and medication (28.4%) 3. Hospitalization costs (17.9%).
Gnonlonfoun et al.,[49]	Benin	Prospective cross-sectional design	N=122, F (29%), M (71%) Age Range[34-85] Age Mean/SD (56.4 ± 12.2)	Direct cost: $144.9 - $9393.9; average = $1030.1 ± $101.7. Age ≥ 50 cost = ($1277.4) Age < 50 ($857.4) p = 0.001. Male patients: $1157.5 Female: $831.8 Haemorrhagic: $1375 Ischemic: $1098
Kabadi et al.,[50]	Tanzania	New methods	N=16, F (31%), M (69%) Age Range[30-83] Age Mean/SD (57.7 ± 14.9)	1. Mean cost per case: TZS 256,338 (USD 220) Reasons: Diagnostic tests (blood, ECG, echocardiogram, chest X-ray, CT scans) Hospitalisation cost (registration, inpatient stay and drugs), Transport cost to designated hospitals. Physiotherapy Out-of-pocket payments to other points of care. Costs were more than four-fold higher in the urban district than in the rural district.
Omisore et al.,[51]	Nigeria	Retrospective cross-sectional design	N=170, F (48.2%), M (51.8%) Age Mean/SD (61.41±13.92)	1. Median total hospitalization cost (HC) per patient was $183.30 (₦83,770) 2. Median daily cost of $15.86 (₦7, 248) Reasons: 1. Radiological investigations ($85.45/₦39,050) 2. Laboratory investigations ($25.82/₦11,800) 3. Feeding ($24.07/₦11,000).

systematic review including Transient Ischaemic Accidents (TIAs), HIV/AIDS, dyslipidaemia, etc.

The burden of NCDs in Africa is just as important as that of communicable diseases but does not benefit from the same financial commitment by national governments and international organisations. The experience of higher-income countries shows that decreasing the prevalence of stroke in Africa will undoubtedly reduce mortality, morbidity, disability, and the neurological as well as cognitive aftereffects of stroke. Fortunately, significant advancements have been made in the fields of policymaking, research, education, care, priority-setting, and medicine related to stroke. Together with scientists and funders, patients, healthcare professionals, payers, policymakers, and the public will need to remain vigilant about the regional and continental burden of stroke, work assiduously to elucidate the specific causes of stroke in the area, and give top priority to the creation of localised preventive and therapeutic approaches.

Recommendations

As recommendations, we suggest that nations ensure that local stroke prevalence and incidence data are gathered, for example through the continuing Demographic and Health Surveys, to increase the accessibility of trustworthy information on current epidemiological trends. This can be done with the help of academic institutions. Also, models for evaluating the impact of diabetes on public health in relation to other significant diseases especially stroke, should be developed, with the guidance of intergovernmental organisations like the World Health Organisation (WHO) and the World Bank, to enable informed prioritisation of available health funding at the national level.

Academic institutions should gather information on mortality, morbidity, expenses, and accessibility to diagnosis and treatment of stroke for regions and nations. For greater impact and sustainable outcomes, it is important to incorporate the inputs of international organisations, civil society, and the private sector. This will encourage cooperation and pooling of resources to increase awareness of the links between stroke and the most common communicable diseases in SSA as well as inform the creation of integrated and complementary service delivery programmes and health policies.

Ethical Approval

For this study ethical approval is not required.

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Informed Consent

The patient's written informed consent was not made, as this was a systematic review study.

Data Sharing

All data related to this work are available in this research article.

CRediT authorship contribution statement

Gisele Abissegue: Writing – original draft, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Seidina Iliasu Yakubu:** Writing – review & editing. **Aiswarya Seema Ajay:** Writing – review & editing. **Faatihah Niyi-Odumosu:** Validation, Supervision, Project administration, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Dr. Faatihah Niyi-Odumosu reports article publishing charges was provided by University of the West of England. Dr. Faatihah Niyi-Odumosu reports a relationship with University of the West of England that includes: employment. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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