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Original Research

Validation of Siriraj Stroke Scoring System in the Clinical Differentiation of Stroke Sub-types in a resource-limited Setting

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Abstract

Background: Stroke remains one of the major non-communicable public health disease conditions with resultant high morbidity and mortality. Neuroimaging in the form of Computed Tomography (CT) or Magnetic Resonance Imaging (MRI) is adjudged to be the most reliable and efficient method of accurately diagnosing stroke and ruling out differentials. However, in view of cost implication and non-availability, a clinical scoring system known as the Siriraj Stroke Score (SSS) was developed to clinically differentiate stroke types, especially in resource-limited settings. This study sought to validate and determine the role of Siriraj stroke score in the clinical evaluation of patients presenting with acute stroke.

Methodology: This is a descriptive prospective study that was conducted over a one-year period. The study populations were adult patients presenting with acute stroke in a tertiary health facility in North-Western Nigeria. Clinical details with neuroimaging in the form of a CT scan were obtained. Data obtained was analyzed using Stata 15.

Result: Fifty-four percent (54%) of patients enrolled were males and ischaemic stroke is the commonest stroke subtype present in 69% of patients studied. Altered levels of consciousness, headache and vomiting are important discriminatory variables of the scoring system. The sensitivity, specificity, Positive Predictive Value (PPV), Negative Predictive Value (NPV) and accuracy of Siriraj Stroke Score for haemorrhagic stroke is 92%, 72%, 62%, 95% and 62% respectively.

Conclusion: Siriraj Stroke Score with sensitivity greater than 90% is reliable in differentiating the stroke sub-types; the patients in the 'grey zone' will however require neuroimaging.

Keywords: *Siriraj stroke scoring system; Validation; Resource-limited setting; Diagnosis.*

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Introduction:

Stroke is a medical emergency that requires an urgent approach to the diagnosis.[1] It remains one of the leading causes of morbidity and mortality worldwide. There is a significant rise in the stroke burden particularly in the developing world. For instance, in 2013, stroke was the third leading cause of death after ischaemic heart disease and cancer.[1–3] But now stroke is the second most common cause of death after ischaemic heart disease.[4,5] The rise in stroke burden can be partly explained by the paradigm shift from communicable diseases to non-communicable diseases. This health transition will ultimately lead to an increase in the absolute number of people who die or remain disabled from stroke.[1,4,6,7] Some of the factors responsible for the health transition include; changes in lifestyle, eating habits (from a traditional healthy diet made up of high-fiber grains, fruits and vegetables) to a more westernized diet (rich in saturated fats), obesity, diabetes mellitus, hypertension, smoking and alcohol consumption which will lead to increase in prevalence of stroke. Ageing of the population is also a very important risk factor.[4,8]

The diagnosis of stroke requires neuroimaging in the form of a Computed Tomographic scan (CT scan) of the brain or Magnetic Resonance Imaging (MRI). However, in resource-limited settings, neuroimaging is not just expensive but is also relatively scarce. In an attempt to circumvent these challenges and ease the difficulty in differentiating ischaemic from haemorrhagic stroke, scoring systems such as Siriraj stroke score were developed.[9]

Siriraj stroke score has been validated and has been in use throughout Thailand since 1986. It has been found to be user-friendly and easy to administer at the patient's bedside.[10] After validation of Siriraj stroke score in 1986 in Thailand with the resultant high positive predictive value of 90.3%, studies in other populations found different sensitivity and specificity such as in West infirmary, Glasgow, North-Eastern and South-Eastern Nigeria.[10–12]

This study therefore sought to validate and determine the role of Siriraj stroke score in the clinical evaluation of patients presenting with acute stroke at the Usmanu Danfodiyo University Teaching Hospital Sokoto state, Northwestern Nigeria.

Methodology:

The reason, benefit, method and implication of the research were explained to the patient or next of kin (if the patient was not capable of making a voluntary and informed decision) after whom he/she signed a written informed consent. The patient’s fingerprint was used as a substitute if he/she was unable to sign. The detail of each clinical variable was used to calculate the Siriraj Stroke Score. Any history that was not obtained from the patient was obtained from a reliable informant. The eligible participants were recruited consecutively using an interviewer-administered structured questionnaire containing information on the patient’s age, gender, ethnicity, occupational status, religion and anthropometric measurements (weight and height). The height of patients unable to stand was measured by taking the whole-body length of the patient in a supine position using a rigid tape measure, while their weight was estimated using Lorenz’s formula; Women: $110.924 + (\text{height} \times 0.4053) + (\text{Weight Circumference} \times 0.325) + (\text{Hip Circumference} \times 0.836)$ Men: $137.432 + (\text{height} \times 0.60035) + (\text{Weight Circumference} \times 0.785) + (\text{Hip Circumference} \times 0.392)$

Blood pressure was measured on presentation with the patient sitting upright, feet flat on the floor and the arm supported at the level of the heart. Caffeinated drinks, smoking and exercise were avoided. An appropriate-sized cuff was used after the patient had rested for at least five minutes. The systolic pressure was taken as the first sound while diastolic blood pressure was taken immediately the sounds disappeared viz, Korotkoff phase I and V.

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Diabetes mellitus was considered in previously known diabetic patients, patients on anti-diabetic medications and those who fulfil the WHO criteria for the definition of diabetes mellitus. Repeat testing was required in asymptomatic patients with a single abnormal result of either fasting or random blood glucose unless a patient presents with unequivocal hyperglycaemia with classical symptoms.

Intermittent claudication was considered in patients with exercise-induced calf pain that is relieved by rest and presumably of atherosclerotic origin. Angina was considered a sudden onset of chest, jaw, shoulder and arm pain that is aggravated by physical and emotional stress and relieved by rest or nitroglycerine.[13]

Angina was considered a sudden onset of chest, jaw, shoulder and arm pain that is aggravated by physical and emotional stress and relieved by rest or nitroglycerine.[13]

Atrial fibrillation (AF) was diagnosed by assessing the rhythm of the patient's pulse and confirmed using electrocardiography (ECG).

A cardiothoracic ratio of more than 0.5 on chest X-ray was considered cardiomegaly.

A thorough cardiovascular examination was done to assess for murmurs and clinical features of heart failure, which include leg swelling, orthopnoea, third heart sound, distended neck veins, bibasal crepitation etc.

Details of the parameters discussed were used to test the Siriraj stroke score. The score uses five variables to distinguish supratentorial haemorrhage and infarction. The overall score was calculated using the formula [(2.5 x consciousness level) + (2 x headache) + (2 x vomiting) + (0.1 x diastolic blood pressure) – (3 x atheroma markers)] – 12.

Score greater than +1 = haemorrhagic; Score less than -1 = infarction and score between +1 and -1 =uncertain.

A patient presenting with full consciousness gets a score of zero, an unconscious or comatose patient scores two while any state of consciousness between coma and full consciousness (e.g. confused or drowsy) is scored one. The presence of a headache within two hours of the onset of stroke is scored as one while its absence is awarded zero point. Vomiting is scored as one or zero for presence or absence respectively. The presence of atheroma markers is scored as one irrespective of the number of parameters present in the patient. For example, a patient who is diabetic and has a history of both intermittent claudication and angina pectoris gets the same score of one as a non-diabetic patient with only a history of intermittent claudication. The ideal diastolic pressure that was used was the diastolic blood pressure taken at the onset of the stroke or immediately at the presentation.

Table 1: The siriraj stroke score

VARIABLE	PRESENTATION	SCORE
level of consciousness	Alert	0
	drowsy, stupor	1
	Coma	2
headache	No	0
	Yes	1

Vomiting	No	0
	Yes	1
atheroma markers (DM, angina, intermittent claudication)	No	0
	Yes	1
Constant		-12

Brain CT Scan reported by a radiologist was used to confirm the diagnosis and to differentiate the types of strokes. Patients that meet the criteria for the definition of stroke clinically with a non-enhancing intraparenchymal hypodense area on brain CT scan were diagnosed as cerebral infarction while hyperdense lesions (HU= 50 to < 100) were diagnosed as acute haemorrhage. The scan was done within the first two weeks to avoid missing haematomas as resolution starts after 14 days. Patients with normal CT scans after 24 hours with obvious focal neurologic deficits were considered infarction.

Sample Size

The minimum required sample size for this study was calculated using the formula for sample size determination for the prevalence study.[14]

$$n = \frac{Z^2 p(1-p)}{d^2}$$

Where;

n = Minimum sample size

Z= Standard deviation (constant of 1.96 corresponding to 95% confidence interval)

p= = proportion in the target population estimated to have a particular characteristic or disease.

d= degree of accuracy desired (set at 0.05 corresponding to 95% confidence interval)

The proportion of 21.3% will be used based on a previous study.[15]

n= 257

However, since the average number of acute stroke patients managed annually is approximately 100, which is less than 10,000, a finite correction will be done using the formula below.[14]

nf = n/ [1 + (n-1)/N]

Where;

nf = finite corrected sample

n = calculated sample size

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N = Total population

nf = 257/ [1 + (257- 1)/100]

nf = 72

Adjusting for a non-response rate of 10% for a sample size of 72 = 7.2

72 + 7.2

A sample size of 80 patients was therefore recruited for the study.

Data collated was entered into a computer to generate a computerized database using Microsoft Excel and then subsequently analysed using Stata version 15 (StataCorp. 2015. *Stata Statistical Software: Release 14*. College Station, TX: StataCorp LP). This study being a predictive study with dichotomous variables, the validity here was analysed using the sensitivity, specificity, positive predictive value, negative predictive value and accuracy using the '*diagti'* command in Stata the '*diagti'* command displays various summary statistics for a diagnostic test. Results were presented in a 2X2 table and summarized as percentages of the sensitivity, specificity, positive predictive values, and negative predictive values, with their respective 95% confidence intervals (95% CI).

Univariate analysis of descriptive statistics, using Chi-square or Fishers Exact test was used to compare categorical variables. A student t-test (to compare 2) or one-way ANOVA (to compare 3) was done, for continuous variables, if normally distributed (or the non-parametric equivalent Mann-Whitney U test/Kruskal-Wallis if not normally distributed was also done). The results were presented in the form of tables, graphs and figures as appropriate.

Ethical approval: Ethical approval was obtained from the Research and Ethics Committee of the Usmanu Danfodiyo University Teaching Hospital Sokoto. Informed written consent was obtained from the patient or relative if the patient was unconscious before enrolment into the study.

Result:

One hundred patients with stroke who fulfilled the inclusion criteria for the study were recruited. Their SSS and ASS were calculated, and they had a brain CT scan done. The age varied from 25-80 years with a median age of 58years as shown in Table 2 and Figure 1. Table 2 also shows that the age group 46-65 years accounted for the highest percentage (54%) of patients in the study population.

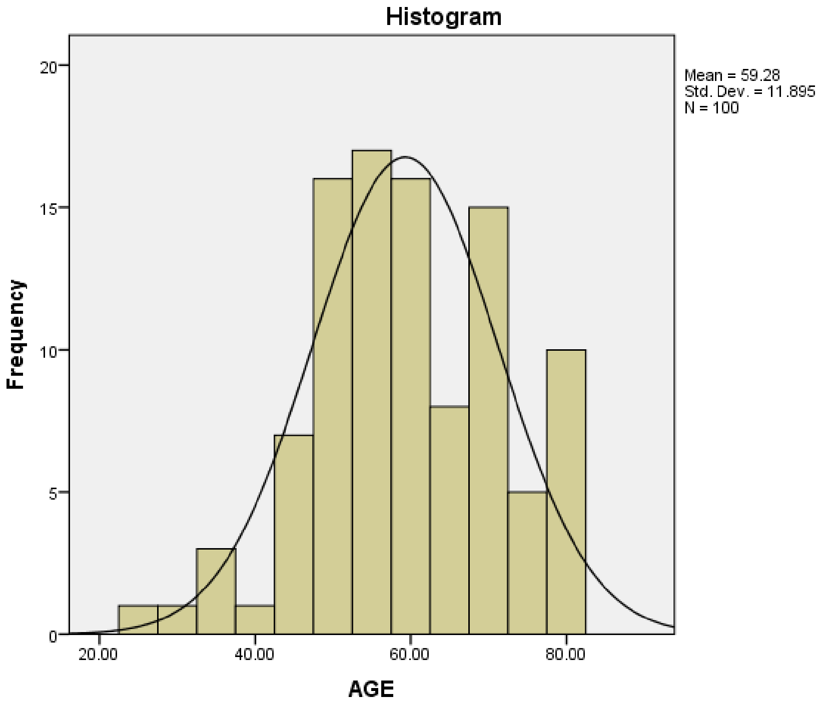

Figure 1: Age Distribution of patients

The sociodemographic, risk factors and clinical variables of the study subjects are as shown in Table 2. Males accounted for fifty-four of the one hundred study subjects. Sixty-seven of the study population were married, sixteen were widowed, ten were divorced and the remaining were single[7]. Seventy-five percent of the patients studied were Hausa-Fulani, six percent Igbo and six percent Yoruba while other minor ethnicities accounted for the remaining thirteen percent. Eighty-five percent of the recruited patients practice Islam as a form of religion, while the remaining (15%) were Christians. Twenty-five percent had primary education, 36% had secondary education, 30% had tertiary education and 9% had only Arabic education.

Of the one hundred subjects studied, eighty-five percent (85%) had hypertension while 17% had diabetes mellitus with body mass index ranging from 17-51 kg/m^2. Only forty percent (40%) of the patients were found to have normal BMI. Four percent were underweighted; twenty-five percent were overweight while obese patient accounted for thirty-one percent of the population studied.

Family history of stroke was present 4% of the patients, while 3% had a history of atrial fibrillation, twenty patients (20%) had a prior history of transient ischaemic attack, 5% smoked cigarettes and 6% drank alcoholic beverages.

Twenty-five patients (25%) had a positive history of headache while 19% had a history of vomiting, Forty-three of the hundred patients studied were fully conscious at presentation; thirty-one were drowsy while twenty-six were unconscious. Out of the twenty patients with a history of TIA, fifteen (75%) of them developed ischaemic stroke while the remaining five (25%) had haemorrhagic stroke. CT confirmed ischaemic stroke accounted for sixty-nine percent of the population studied while haemorrhagic stroke accounted for thirty-one percent.

Table 2: Patient Characteristics, Risk factors and Clinical features

CHARACTERISTICS	INFARCT	HAEMORRHAGE	TOTAL (N=100)	P-VALUE
AGE				0.005
18-45 years	5 (7%)	6 (19%)	11	
46-64 years	33 (48%)	21 (68%)	54	
65-80 years	31 (45%)	4 (13%)	35	
GENDER				
Male	37	17	54	0.9
Female	32	14	46	
HYPERTENSION	54 (78%)	28 (90%)	82	0.15
DM	16 (23%)	1 (3%)	17	0.01
AF	3 (4.3%)	0 (0%)	3	0.55
TIA	15 (22%)	5 (16%)	20	0.51
SMOKING	4 (5.8)	1 (3%)	5	1.00
ALCOHOL CONSUMPTION	4 (6%)	2 (7%)	6	1.00
OBESITY	21 (30%)	10	31	0.86
DIASTOLIC BLOOD PRESSURE				0.32
Less than 110mmHg	45 (65%)	17 (55%)	62	
110mmHg and above	24 (35%)	14 (45%)	38	
LEVEL OF CONSCIOUSNESS				<0.001
Alert	39 (57%)	4 (13%)	43	
Drowsy	16 (23%)	15 (48%)	31	
Unconscious	14 (20%)	12 (39%)	26	
HEADACHE	9(13%)	16 (52%)	25	<0.001
VOMITING	8(12%)	11(35%)	19	0.005

The diastolic blood pressure of the patients enrolled at the presentation ranged between 60- 149mmHg, while the diastolic blood pressure after twenty-four hours ranged between 60-139 mmHg as summarised in Table 3.

Table 3: Diastolic blood pressure of patients at presentation and 24 hours after admission

	N=100 BP AT PRESENTATION	N=100 BP AFTER 24 HOURS OF ADMISSION
<80mmHg	12%	11%
80-89mmHg	14%	25%
90-99mmHg	12%	24%
>100mmhg	62%	38%
Total	100	100.

Cardiovascular risk factors (heart failure, myocardial infarction and cardiomyopathy) were found in nine percent of the patients. None however had a history of angina pectoris or cardiac murmur on physical examinations.

Based on age group and gender, the frequency of both ischemic and haemorrhagic stroke was more common among the age group 50-59 years; 33.3% had ischemic stroke and 29.0% haemorrhagic stroke respectively. There was no case of haemorrhagic stroke in the age group 20-29years and 80-89 years. Thirty-seven (53.6%) males and thirty-two (46.4) females had an ischemic stroke, while 17 (54.8%) males and 14 (45.2%) females had haemorrhagic stroke.

Ninety percent of the patients with haemorrhagic stroke were known hypertensive while seventy-four percent of the hypertensive patients had ischaemic stroke. Only one patient (3.2%) with diabetes mellitus had haemorrhagic stroke while 23.2% had an ischaemic stroke. The occurrence of headache, vomiting and altered consciousness was higher in patients with haemorrhagic stroke.

Following the administration of the SSS, 79% of the patients were classified as either ischaemic stroke (40%) or haemorrhagic stroke (39%) while 21 were classified as uncertain. Brain CT scans of these patients showed that 69 of them had ischaemic stroke while 31 had haemorrhagic stroke as shown in Table 4 below.

Table 4: Relationship between Siriraj stroke score and computed tomographic scan findings

		CT SCAN		Total
		INFARCT	HAEMORRHAGE	
SSS	INFARCTION	38 71.7%	2 7.7%	40 50.6%
	HAEMORRHAGE	15 28.3%	24 92.3%	39 49.4%
	Total	53 100.0%	26 100.0%	79 100.0%

The sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy of SSS for ischaemic stroke was 72%, 92%, 95%, 62% and 62% respectively and 92%, 72%, 62%, 95% and 62% respectively for haemorrhagic stroke.

Of the seventy-nine who were scored as either infarction or haemorrhage by the SSS, forty-seven were males and thirty-two females. The score diagnosed ischaemic stroke in 24 (44%), haemorrhagic stroke in 23 (43%) and 7(13%) uncertain results in males, while 16 (35%) females had ischaemic stroke, 16 (35%) haemorrhagic stroke and 14 (30%) fell within the uncertain range of the score. The sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and accuracy of SSS based on gender are shown in Table 5 below.

Table 5: Siriraj Stroke Score Stratification Based on Gender

	SENSITIVITY	SPECIFICITY	PPV	NPV	ACCURACY
MALE	88	73	91	65	79
FEMALE	100	70	100	56	69

PPV: positive predictive value, NPV: negative predictive value

Table 6: Siriraj Stroke Score Stratification based on Age group

	SENSITIVITY	SPECIFICITY	PPV	NPV	ACCURACY
YOUNG	100	33	100	71	75.0
MIDDLE AGE	94	65	94	67	78
ELDERLY	75	81	96	38	81

PPV: positive predictive value, NPV: negative predictive value

Discussion

This is a prospective study conducted over a one-year period in a resource-poor setting where neuroimaging is relatively scarce and expensive. In this type of setting, scoring systems like the Siriraj and Allen stroke score and other clinical features may be useful in differentiating the stroke subtypes which will enable timely intervention thereby saving lives and preventing complications. In view of this, it is essential that these scoring systems have a high sensitivity for haemorrhagic stroke.

The study showed a preponderance of males (54%) with a larger proportion of the patients having ischaemic stroke (69%). The ratio of haemorrhagic to ischaemic stroke detected in this study is similar to findings of other validation studies conducted in the southeastern and southwestern part of Nigeria by Chukwuoye et al and Kolapo et al respectively[11,12]. However, the 69% of ischaemic strokes found in this study is higher than what was obtained by Nyandaiti et al and Ogun et al in their validation study in the northeastern and Southwestern part of this country respectively while the 31% of haemorrhagic strokes in this study is lower than theirs.[3,10]

The findings of haemorrhagic to ischaemic stroke ratio in this study are also similar to that of other low to middle-income countries.[16] Both stroke subtypes are commoner in males in this study which is similar to what was obtained by Tomar et al.[17] Although, in a study by Chukwuoye et al, there was a preponderance of haemorrhagic stroke in females.[11] This study found more occurrences of both ischaemic and haemorrhagic stroke within the age group 50 to 59 years while others found both stroke subtypes to be commoner within the age group 60-69 years.[11] This may be due to the fact that the patient composition in that study is skewed towards that age group. In this study, haemorrhagic stroke is less common among young individuals which is in agreement with the study by Chukwuoye et al. [11]

The proportion of hypertension in patients with haemorrhagic stroke in this study is lower than what was obtained by Chukwuoye et al in his study while the proportion of diabetes mellitus in this study is higher than what was earlier reported.[11] Atheroma markers such as intermittent claudication and angina pectoris were not common findings in our study. This is similar to what was reported by Sign et al and Kolapo et al.[12,18] The low incidence of these atheroma markers may be due to the patient's difficulty in differentiating these symptoms from other causes of chest or leg pain that may appear similar or lack of awareness of these symptoms by informants.[12,18] Symptoms such as headache, vomiting and altered level of consciousness were commoner in patients with haemorrhagic stroke as was reported by other studies.[10,11,17]

Elevated diastolic blood pressure occurred in 74% of the subjects studied. This agrees with earlier findings of elevated diastolic blood pressure in patients with stroke by Nyandaiti et al.[10] In this study, elevated diastolic blood pressure greater than 110mmHg was not significantly more common in Haemorrhagic stroke ($p > 0.05$). This is similar to what was reported by Kolapo et al[12] as against findings by Nyandaiti et al and Ogun et al in whose study DBP was a significant discriminatory variable.[3,10]
In this study, 87% of patients with haemorrhagic stroke had altered levels of consciousness (drowsiness and stupor/coma). Hence, alteration in the level of consciousness is significantly associated with haemorrhagic stroke ($P< 0.05$). The important discriminatory variables for the stroke scores in this study were level of consciousness, headache and vomiting which is similar to findings by Tomar et al and Chukwuoye et al[11,17]

In this study, the ability of SSS to diagnose haemorrhagic stroke is with a sensitivity of 92% which is similar to what was reported in two validation studies conducted in Nigeria by Nyandaiti et al in the Northeast and Chukwuoye et al in the Southeast with sensitivities over 90%.[10,11] This is also in agreement with what was reported in Thailand,[7] India,[17,19–210] China,[22] and Hong Kong[23], which had sensitivities of 80% and above.

In a similar comparative validation study conducted in Northeastern Nigeria, sensitivity was found to be 35% which is far lower than the 92% in this comparative study. This may be because about 15 of the 95 patients recruited for the study had normal CT scan findings and as such were excluded from the analysis. Soman et al whose sensitivity of 75% is lower than ours despite the similarities in methodology had a higher percentage of patients with haemorrhagic stroke than this study.[24] Celani et al in a multi-centre study in Italy with a larger sample size of 231 reported lower sensitivity for haemorrhagic stroke.[25] other studies with different methodologies from this study also got specificities lower than 75% in their validation studies.[26–31] When the patients that fell within the indeterminate range were added to the analysis as was done in other studies, the sensitivity for haemorrhagic stroke of 77% in this study was similar to that of Kolapo et al in their validation study in Southwestern Nigeria and Tomar et al in North-eastern India.[12,17] This result is however different from what was reported in another validation study conducted in Southwestern Nigeria by Ogun et al with a sensitivity of 50%.This could be due to it being multicentre with a larger sample size.[3] A prospective study conducted in South Africa with sensitivity for haemorrhagic stroke of 60% after including the indeterminate range is also low. This study however had more than twice our sample size and the composition of the study population was multi-racial.[32]

The specificity of 72% for haemorrhagic stroke in this study is similar to what was reported by Nyandaiti et al[10], Salawu et al,[33] Soman et al,[24] Panchal et al,[34] Zenebe et al,[29] Kochar et al,[20] Jamal et al[31] and Badam et al,[19]with specificities between 70% and 82%. This is contrary to the cross-sectional study with half our sample size with a specificity of 100% for haemorrhage.[35] other studies found sensitivity greater than 90%. Some of these studies however either had larger or smaller sample sizes than this study.[17,18,21,24,25,30,36] Meanwhile, when the patients within the uncertain range were added to the study, the specificity dropped to 55%, which is lower than other studies that adopted this method in their analysis[3,23,29,32]

The PPV and NPV of 62% and 95% in this study are similar to a comparative study conducted by Celani et al,[25] higher than 42% obtained by Salawu et al[33] but lower than the studies conducted by Abhishek et al[35] and Chukwuoye et al.[11] the overall diagnostic accuracy of this study (62%) is similar to the study by Ogun et al[3] but is lower than that of Nyandaiti et al, Chukwuoye et al, and Kolapo et al.[10–12]

Conclusion:

Siriraj Stroke Score with sensitivity greater than 90% is reliable in differentiating the stroke sub-types. Therefore, because resource-limited societies are still far away from having universal coverage with CT scans and MRI, it is essential to integrate the teaching of Siriraj Stroke Scoring systems that have high sensitivity to differentiate the stroke subtypes and enable prompt treatment. Nevertheless, Patients in the 'grey zone' will require neuroimaging.

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