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Journal of the American Heart Association

ORIGINAL RESEARCH

Determinants of First-Ever Stroke Severity in West Africans: Evidence From the SIREN Study

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BACKGROUND: Baseline stroke severity is probably partly responsible for poor stroke outcomes in sub-Saharan Africa. However, there is a paucity of information on determinants of stroke severity among indigenous Africans. We sought to identify the factors associated with stroke severity among West Africans in the SIREN (Stroke Investigative Research and Educational Networks) study.

METHODS AND RESULTS: Stroke was diagnosed clinically and confirmed with brain neuroimaging. Severe stroke was defined as a Stroke Levity Scale score of ≤5. A multivariate logistic regression model was constructed to identify factors associated with stroke severity at 95% CI and a nominal cutoff of 5% type 1 error. A total of 3660 stroke cases were included. Overall, 50.7%% had severe stroke, including 47.6% of all ischemic strokes and 56.1% of intracerebral hemorrhage. Factors independently associated with severe stroke were meat consumption (adjusted odds ratio [aOR], 1.97 [95% CI, 1.43–2.73]), low vegetable consumption (aOR, 2.45 [95% CI, 1.93–3.12]), and lesion volume, with an aOR of 1.67 (95% CI, 1.03–2.72) for lesion volume of 10 to 30 cm^3 and aOR of 3.88 (95% CI, 1.93–7.81) for lesion volume >30 cm^3. Severe ischemic stroke was independently associated with total anterior circulation infarction (aOR, 3.1 [95% CI, 1.5–6.9]), posterior circulation infarction (aOR, 2.2 [95% CI, 1.1–4.2]), and partial anterior circulation infarction (aOR, 2.0 [95% CI, 1.2–3.3]) compared with lacunar stroke. Increasing age (aOR, 2.6 [95% CI, 1.3–5.2]) and lesion volume >30 cm^3 (aOR, 6.2 [95% CI, 2.0–19.3]) were independently associated with severe intracerebral hemorrhage.

CONCLUSIONS: Severe stroke is common among indigenous West Africans, where modifiable dietary factors are independently associated with it. These factors could be targeted to reduce the burden of severe stroke.

Key Words: determinant ■ SIREN ■ stroke severity ■ West Africa

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Stroke has a huge burden in Africa, with an annual incidence rate of 316 per 100 000, a prevalence rate of up to 1.4 per 1000, and a 3-year fatality rate of up to 84%.[1,2] The higher burden and poor outcomes of stroke among Africans have been attributed to the high prevalence of undiagnosed and untreated cardiovascular risk factors, greater severity of risk factors or higher sensitivity to the risk factors, and lack of access to care.[3]

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This paper was sent to Meng Lee, Guest Editor, for review by expert referees, editorial decision, and final disposition.

Supplemental Material is available at https://www.ahajournals.org/doi/suppl/10.1161/JAHA.122.027888

For Sources of Funding and Disclosures, see page 11.

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CLINICAL PERSPECTIVE

What Is New?

- We demonstrated enormous burden of severe stroke in this largest study on stroke in Africa.
- It is the broadest exploration of factors (sociodemographic, clinical, laboratory, and radiological) for severe stroke among indigenous Africans.
- Our study is the first to demonstrate the protective effects of vegetable consumption and reduced meat consumption against severe stroke.

What Are the Clinical Implications?

- Modifiable risk factors such as reduced meat consumption and increased vegetable consumption could be targeted for prevention of severe stroke among Africans.
- Other key independent risk factors for severe stroke include lesion volume, while risk factors for severe ischemic stroke include total anterior circulation infarction, posterior circulation infarction, and partial anterior circulation infarction.
- Patients with large lesion volume and specific stroke subtypes associated with severe stroke could benefit from more intensive acute care.

Nonstandard Abbreviations and Acronyms

SIREN	Stroke Investigative Research and Educational Networks
TACI	total anterior circulation infarction

Similarly, managing severe stroke places a tremendous strain on the West African subregion's underresourced health care system and health resources.[4–7] It is not only a difficult, life-threatening condition in most cases, but it also imposes a significant socioeconomic burden on a low-resource setting with limited government intervention.[8]

Little is known about the profile and sociodemographic, vascular, and radiological determinants of stroke severity among indigenous Africans.[2,9] Although various studies have explored the determinants of severe stroke in non-African populations, such studies are mostly among White individuals and have established associations between congestive cardiac failure and myocardial infarction, female sex, age at stroke onset, small-vessel strokes, intracerebral hemorrhages, left-sided brain infarcts, massive infarction, and the presence of atrial fibrillation and severe strokes.[10–14] Given the current increase in the region's stroke burden, there is an urgent need to identify the determinants of stroke severity in the African context. We investigated the sociodemographic data, vascular risk factors, and radiological features that influence stroke severity in West Africans.

METHODS

The data for this study can be accessed upon request from the data access committee (sibs2017@gmail.com).

Design

The SIREN (Stroke Investigative Research and Educational Networks) study is a case–control study conducted across 15 hospitals and adjoining communities.[15] For this study, we focused on patients with stroke who were recruited in the SIREN stroke project between January 1, 2013, and July 30, 2018.

Study Population

The SIREN project encompassed 2 West African countries, Nigeria and Ghana, with the 2 countries constituting 58.68% of the subregion population.[16,17] Stroke cases were adults aged >18 years with clinico-radiological diagnoses of stroke including cranial computerized tomographic scan/magnetic resonance imaging within 10 days of symptom onset to aid in radiographic differentiation of ischemic from intracerebral hemorrhages. The eligibility criteria for participants are available in Data S1.

Data Collection

All eligible adult patients fulfilling the case definition for stroke confirmed by neuroimaging were recruited into the study from medical wards, stroke units, intensive care units, emergency rooms, and outpatient stroke clinics of the participating centers by neurologists/stroke physicians.[15,18] Methods for stroke evaluation and phenotyping are available in Data S1.

After documenting their sociodemographic and clinical parameters (such as blood pressure, waist and hip circumferences, and height), the neurologists/stroke physicians assessed the stroke severity using the Stroke Levity Scale. Other cardiovascular risk factors were assessed through laboratory investigations such as fasting lipid profile, glycated hemoglobin level, fasting blood glucose, electrocardiography (ECG), echocardiography, and carotid Doppler ultrasound according to the published SIREN protocol.[15,18–20] Data were collected by trained research assistants. Sociodemographic data (such as age; sex; occupation; income; educational attainment; ethnicity; nationality; family history of stroke, cardiovascular, and

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metabolic diseases; dietary history; history of alcohol, substance, and tobacco use; physical activity and psychosocial stress) were obtained from patients or caregivers (when patients were unable to answer the questions) in line with our published protocol.[15,18] The detailed definitions of the vascular risk factors and procedures for assessing them are available in Data S1 and Table S1.[15,18] Stroke lesion volume was determined using the ellipsoid equation.[21]

Assessment of Stroke Severity

The validated Stroke Levity Scale was used to assess stroke severity at enrollment, with lower scores implying more severe strokes, and stratified as mild, moderate, or severe, with only minor predictive information lost.[22–27] The Stroke Levity Scale was classified as >5 (nonsevere stroke) or ≤5 (severe stroke).[23] The Stroke Levity Scale was validated with the National Institutes of Health Stroke Scale score with a strong correlation (rho=−0.79; $P<0.0001$).[22–27]

Statistical Analysis

Bivariate analyses were performed to determine the relationship between stroke severity (as stratified by stroke type) and associated participants' risk factors, such as clinical presentation, prior vascular risk factors, neuroradiological, carotid/vertebral artery Doppler studies, ECG, and echocardiographic determinant factors. Bivariate associations between risk factors and stroke severity were evaluated within stroke types (ischemic and hemorrhagic) using the chi-square (or Fisher's exact) test for categorical outcomes and the independent *t* test for comparing continuous data.

We used unconditional multivariate logistic regression models to determine the adjusted associations of risk factors with stroke severity in the combined stroke samples and stratified by stroke types (ischemic and hemorrhagic). Here, we adjusted for sociodemographic, vascular, and lifestyle risk factors. In general, covariates were selected for inclusion in adjusted models after literature review and empirical evidence on the basis of significant associations found in our initial bivariate analyses. The odds ratios and 95% CIs in our models were estimated.

Specifically, in model 1, we first assessed the association of stroke severity with established stroke risk factors on the basis of our previous investigations and bivariate analyses of the present study. In model 2, we assessed the association of stroke severity with sociodemographics, lifestyles, clinical characteristics, comorbidities, radiological features, and echocardiographic variables. The predictor variables were selected on the basis of bivariate significant association with stroke severity in the present study or evidence in the literature. Two risk factors (low vegetable consumption and lesion volume) were found to be independently associated with stroke severity, overall and in subgroup analysis of stroke primary types, and were used in 2-way interaction analysis with selected established stroke risk factors. The Hosmer-Lemeshow test was used to assess the goodness of fit of each multivariate logistic regression model. All statistical tests of hypotheses were 2-sided, with a P value <0.05 considered significant. Statistical analyses and graphics were produced with SPSS version 20 (IBM, Armonk, NY) and R statistical program version 3.4.2 (R Foundation for Statistical Computing, Vienna, Austria).

Ethical Approval

The SIREN study is a multicenter study, and institutional review boards at all study sites provided ethical approval for the study. Informed consent was obtained from all participants before enrollment. The overall coordinating institutional review board for the SIREN study was the University of Ibadan/University College Hospital Ibadan, Nigeria (Approval No.: UI/EC/13/0105).

RESULTS

Characteristics of All Participants

A total of 3660 participants (severe stroke=1854 [50.7%] and nonsevere stroke=1806 [49.3%]) were included in the study, with 70.1% (2292/3268) confirmed as ischemic stroke and 29.9% (976/3268) as hemorrhagic stroke on the basis of brain imaging. The mean age of participants was 59.8±14.4 years, with 43.7% men and 1772 (51.4%) aged ≥60 years.

Characteristics of Participants With Severe Stroke

Overall, 1854 (50.6%) had severe stroke, with 1090 of 2292 (47.6%) severe ischemic stroke and 548 of 976 (56.1%) severe intracerebral hemorrhage ($P\leq0.001$; Table 1). Those with severe stroke had less formal education, used less alcohol, consumed fewer vegetables and more meat before stroke occurrence, had less family history of cardiovascular diseases, had bigger lesion volumes, and had higher mean systolic blood pressure than those with nonsevere strokes (Table 1). Participants with severe ischemic stroke had less formal education; less family history of cardiovascular diseases; consumed less alcohol, fewer vegetables, and more meat before the stroke; and had bigger lesion volumes, higher systolic blood pressure, and higher diastolic blood pressure compared with those with nonsevere ischemic stroke (Table 2). Participants with severe intracerebral hemorrhage had less formal education; had less family history of cardiovascular

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Table 1. Distribution of Vascular Risk Factors for Stroke Stratified by Stroke Severity Status

Characteristics	All severe stroke N=1854	All nonsevere stroke N=1806	*P* value	Severe ischemic stroke N=1090	Severe hemorrhagic stroke N=548	*P* value
Country, Ghana, n (%)	501 (27.0)	699 (38.7)	<0.001	292 (26.8)	209 (38.1)	<0.001
Age, y, n (%)						
≤59	789 (42.6)	799 (44.2)	0.579	425 (39.0)	364 (66.4)	<0.001
≥60	848 (45.7)	826 (45.7)		664 (60.9)	184 (33.6)	
Sex, male, n (%)	900 (48.5)	936 (51.8)	0.159	545 (50.0)	355 (64.8)	<0.001
Domicile, n (%)						
Rural	161 (8.6)	133 (7.4)	0.244	110 (10.1)	51 (9.3)	0.679
Semiurban	462 (24.9)	467 (25.9)		313 (28.7)	149 (27.2)	
Urban	1009 (54.4)	1026 (56.8)		664 (60.9)	345 (63.0)	
Marital status, n (%)						
Never married/single	58 (3.1)	68 (3.8)	0.362	33 (3.0)	25 (4.6)	0.284
Married	1211 (65.3)	1193 (66.1)		773 (6.7)	438 (79.9)	
Monthly income >$100, n (%)	873 (47.1)	920 (50.9)	0.097	566 (51.9)	307 (56.0)	0.120
Education, some, n (%)	1281 (69.01)	1378 (76.3)	<0.001	819 (75.1)	462 (84.3)	<0.001
Living situation, n (%)						
Loneliness	78 (4.2)	99 (5.5)	0.101	53 (4.9)	25 (4.6)	0.794
Living with others	1547 (83.4)	1522 (84.3)		1029 (94.4)	518 (94.5)	
Risk factors, n (%)						
Hypertension	1575 (85.0)	1552 (85.9)	0.241	1036 (95.1)	539 (98.4)	<0.001
Dyslipidemia	1339 (72.2)	1401 (77.6)	0.001	921 (84.5)	418 (76.3)	<0.001
Diabetes	592 (31.9)	637 (35.3)	0.083	146 (13.4)	446 (81.4)	<0.001
Cardiac disease	203 (11.0)	185 (10.2)	0.363	162 (14.9)	41 (7.5)	<0.001
Waist-to-hip ratio raised, n (%)	1273 (68.7)	1254 (69.4)	0.035	857 (78.6)	416 (75.9)	0.045
BMI, kg/m^2, mean±SD	26.6±5.3	26.7±5.2	0.441	26.7±5.3	26.5±5.2	0.308
BMI >30 kg/m^2, n (%)	246 (13.3)	311 (17.2)	0.481	173 (15.9)	73 (13.3)	0.145
Physical inactivity, n (%)	85 (4.6)	58 (3.2)	0.021	58 (5.3)	27 (4.93)	0.721
Tobacco, any use, n (%)	150 (8.1)	171 (9.5)	0.186	95 (8.7)	55 (10.0)	0.385
Alcohol use categories, n (%)						
Never use	1151 (62.1)	999 (55.3)	<0.001	810 (74.3)	341 (62.2)	<0.001
Ever low use	262 (14.1)	340 (18.8)		150 (13.8)	112 (20.4)	
Ever high use	43 (2.5)	43 (2.4)		24 (2.2)	19 (3.5)	
Stress, n (%)	267 (14.4)	341 (18.9)	0.002	164 (15.1)	103 (18.8)	0.177
Cancer, n (%)	6 (0.3)	12 (0.7)	0.044	5 (0.5)	1 (0.2)	0.139
Depression, n (%)	107 (5.7)	138 (7.6)	0.065	69 (6.3)	38 (6.9)	0.904
Family history of CVD, n (%)	578 (31.2)	695 (38.5)	<0.001	372 (34.1)	206 (37.6)	0.166
Adding salt at table, n (%)	115 (6.2)	117 (6.5)	0.927	63 (5.8)	52 (9.5)	0.007
Low vegetable consumption*, n (%)	460 (24.8)	352 (19.5)	<0.001	289 (26.5)	171 (31.2)	0.059
Whole grain consumption, n (%)	1301 (70.2)	1258 (69.7)	0.061	859 (78.8)	442 (80.7)	0.620
Legume consumption, n (%)	1002 (54.1)	1024 (56.7)	0.500	667 (61.2)	335 (61.1)	0.745
Fruit consumption, n (%)	1262 (68.1)	1267 (70.2)	0.803	840 (77.1)	422 (77.0)	0.796
Sugar consumption or otherwise, n (%)	474 (25.6)	413 (22.9)	0.022	300 (27.5)	174 (31.8)	0.126
Regular meat consumption,† n (%)	1152 (62.1)	1046 (57.9)	<0.001	747 (68.5)	405 (73.9)	0.040
Fish consumption or otherwise, n (%)	1391 (75.0)	1386 (76.7)	0.730	915 (83.94)	476 (86.9)	0.266

(*Continued*)

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Table 1. (Continued)

Characteristics	All severe stroke N=1854	All nonsevere stroke N=1806	*P* value	Severe ischemic stroke N=1090	Severe hemorrhagic stroke N=548	*P* value
Lesion volume, cm^3, n (%)						
<10	717 (38.7)	972 (53.8)	<0.001	545 (50.0)	172 (31.4)	<0.001
10–30	327 (17.6)	297 (16.4)		153 (14.0)	174 (31.8)	
>30	401 (21.6)	185 (10.2)		237 (21.7)	164 (29.9)	
Blood pressure at presentation, mm Hg, mean±SD						
Systolic	162.9±32.2	153.8±29.1	<0.001	157.6±31.3	173.3±32.1	<0.001
Diastolic	97.7±19.2	95.4±119.7	0.421	93.85±17.9	105.33±20.0	<0.001
Fasting glucose, mean±SD	121.0±48.94	116.2±50.4	0.069	124.2±54.5	116.8±39.8	0.088
Neutrophil:lymphocyte ratio, mean±SD	7.4±30.5	5.2±22.0	0.053	7.3±38.7	8.4±13.9	0.624

Subgroup (ischemic and hemorrhagic stroke) analyses were based on individuals with data on stroke primary types confirmed by brain scan. BMI indicates body mass index; and CVD, cardiovascular disease.

*Low vegetable consumption was defined as a self-reported frequency of vegetable consumption less than once per month; 12 months before stroke.

†Regular meat consumption was defined as a self-reported frequency of meat intake more than once (including daily) per month; 12 months before stroke occurrence.

diseases; consumed less alcohol, fewer vegetables, and more meat before the stroke; and had bigger lesion volumes and higher systolic blood pressure compared with those with nonsevere hemorrhagic stroke (Table 2).

The relationship between stroke subtype and stroke severity is presented in Table 3 for ischemic stroke and Table 4 for hemorrhagic stroke. Further characterization of the participants is available in Tables S2 through S10.

Factors Associated With Severe Stroke Phenotypes

Total or partial anterior circulation infarcts were more severe than lacunar stroke (Table 3), while hypertensive or nonlobar hemorrhagic strokes were more severe than other hemorrhagic stroke phenotypes (Table 4). Reduced ejection fraction was associated with severe hemorrhagic stroke (Table 5).

Factors Independently Associated With Severe Stroke

Meat consumption (adjusted odds ratio [aOR], 1.97 [95% CI, 1.43–2.73]) and low vegetable consumption (aOR, 2.45 [95% CI, 1.93–3.12]) were independently associated with all severe strokes after adjusting for age, hypertension, dyslipidemia, diabetes, obesity, cigarette smoking, stress, cardiac disease, alcohol, depression, physical inactivity, salt intake, and atrial enlargement (Table 6, Figure 1). Similarly, meat consumption and low vegetable consumption were independently associated with severe ischemic stroke and severe hemorrhagic stroke (Table 6).After including more covariates (Table 6, Figure 2), lesion volume was progressively associated with severe stroke, with an aOR of 1.67 (95% CI, 1.03–2.72) for lesions 10–30 cm^3 and 3.88 (95% CI, 1.93–7.81) for lesions >30 cm^3. For ischemic strokes, other clinical subtypes were independently associated with severe stroke relative to lacunar stroke, while increasing age (years) (aOR, 2.56 [95% CI, 1.25–5.24]) and lesion volume >30 cm^3 (aOR, 6.16 [95% CI, 1.97–19.25]) were independently associated with severe intracerebral hemorrhage (Table 6, Figures S1).

Meat consumption, low vegetable intake, and lesion volume were the significant risk factors independently associated with severity. Therefore, interactions between these factors and with the key candidate vascular risk factors were examined (Tables S10–S15). There were significant interactions between lesion volume and hypertension, vegetable consumption and hypertension, and lesion volume and meat consumption (Tables S11–S15).

DISCUSSION

This is the largest study of stroke severity in sub-Saharan Africa to date, and it examines a broad range of candidate variables spanning the sociodemographic, vascular risk factors, radiological, electrocardiographic, and echocardiographic categories. The key findings of this study are the high proportion of severe stroke and the independent role of lesion volume in all stroke types. Furthermore, predictors for stroke severity were lesion volume in the hemorrhagic stroke subtype and lesion location for ischemic stroke. There was also the interesting finding of independent effect of meat consumption and low vegetable intake on severe stroke.

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Table 2. Vascular Risk Factors for Stroke Severity Stratified by Primary Stroke Type

Characteristics	Ischemic stroke*			Hemorrhagic stroke*		
	Severe N=1090	Nonsevere N=1202	*P* value (exact test)	Severe N=548	Nonsevere N=428	*P* value (exact test)
Country, Ghana, n (%)	292 (26.8)	431 (35.9)	<0.001†	209 (38.1)	268 (62.6)	<0.001
Age, n (%)						
≤59 y	425 (39.0)	507 (42.2)	0.117	364 (66.4)	292 (68.2)	0.451
≥60 y	664 (60.9)	693 (57.7)		184 (33.6)	133 (31.1)	
Sex, male, n (%)	545 (50.0)	673 (56.0)	0.004†	355 (64.8)	263 (61.5)	0.284
Living situation, n (%)						
Loneliness	53 (4.9)	58 (4.8)	0.957	25 (4.6)	41 (9.6)	0.002†
Living with others	1029 (94.4)	1138 (94.7)		518 (94.5)	384 (89.7)	
Domicile, n(%)						
Rural	110 (10.1)	101 (8.4)	0.372	51 (9.3)	32 (7.5)	0.570
Semiurban	313 (28.7)	351 (29.2)		149 (27.2)	116 (27.1)	
Urban	664 (60.9)	748 (62.2)		345 (63.0)	278 (65.0)	
Marital status, n (%)						
Never married/single	33 (30.2)	32 (26.6)	0.517	25 (45.6)	36 (84.1)	0.008
Married	25 (22.9)	36 (29.9)		438 (79.9)	310 (72.4)	
Monthly income >$100, n (%)	566 (51.9)	681 (56.7)	0.030†	307 (56.0)	239 (55.8)	0.860
Education (some), n (%)	819 (75.1)	995 (82.8)	<0.001†	462 (84.3)	383 (89.5)	0.022†
Hypertension, n (%)	1036 (95.1)	1135 (94.4)	0.618	539 (98.4)	417 (97.4)	0.312
Dyslipidemia, n (%)	921 (84.5)	1053 (87.6)	0.028†	418 (76.3)	348 (81.3)	0.065
Diabetes, n (%)	146 (13.4)	506 (42.1)	0.567	446 (81.4)	131 (30.6)	0.171
Cardiac disease, n (%)	162 (14.9)	159 (13.2)	0.262	41 (7.5)	26 (6.1)	0.395
Waist-to-hip ratio raised, n (%)	857 (78.6)	943 (78.5)	0.107	416 (75.9)	311 (72.7)	0.066
BMI, kg/m^2, mean±SD	26.6±5.5	26.8±5.2	0.380	26.6±5.3	26.5±5.1	0.740
BMI >30 kg/m^2, n (%)	173 (15.9)	243 (20.2)	0.631	73 (13.3)	68 (15.9)	0.851
Physical inactivity, n (%)	58 (5.3)	45 (3.7)	0.066	27 (4.9)	13 (3.0)	0.129
Tobacco, any use, n (%)	95 (8.7)	128 (10.7)	0.109	55 (10.0)	43 (10.1)	0.987
Alcohol use categories, n (%)						
Never use	810 (74.3)	778 (64.7)	0.001†	341 (62.2)	221 (51.6)	0.009†
Ever low use	150 (13.8)	223 (18.6)		112 (20.4)	117 (27.3)	
Ever high use	24 (2.2)	27 (2.3)		19 (3.47)	20 (4.7)	
Stress, n (%)	164 (15.1)	249 (20.7)	0.002†	103 (18.8)	92 (21.5)	0.408
Cancer, n (%)	5 (0.5)	9 (0.8)	0.272	1 (0.2)	3 (0.7)	0.147
Depression, n (%)	69 (6.3)	102 (8.5)	0.138	38 (6.9)	36 (8.4)	0.290
Family history of CVD, n (%)	372 (34.1)	490 (40.8)	0.001†	206 (37.6)	205 (47.9)	0.001†
Adding salt at table, n (%)	63 (5.8)	75 (6.2)	0.681	52 (9.5)	42 (9.8)	0.940
Low vegetable consumption, n (%)	289 (26.5)	261 (21.7)	0.009†	171 (31.2)	91 (21.3)	<0.001†
Whole grains consumption, n (%)	859 (78.8)	181 (15.1)	0.199	442 (80.7)	69 (16.1)	0.155
Legumes consumption, n (%)	667 (61.2)	736 (61.2)	0.988	335 (61.1)	288 (67.3)	0.203
Fruit consumption, n (%)	840 (77.1)	929 (77.3)	0.705	422 (77.0)	338 (79.0)	0.835
Sugar consumption or otherwise, n (%)	300 (27.5)	295 (24.5)	0.117	174 (31.8)	118 (27.6)	0.125
Regular meat consumption, n (%)	747 (68.5)	767 (63.8)	0.025†	405 (73.9)	279 (65.2)	<0.001†
Fish consumption or otherwise, n (%)	915 (83.9)	1006 (83.7)	0.647	476 (86.9)	380 (88.8)	0.921

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Table 2. (Continued)

Characteristics	Ischemic stroke*			Hemorrhagic stroke*		
	Severe N=1090	Nonsevere N=1202	*P* value (exact test)	Severe N=548	Nonsevere N=428	*P* value (exact test)
Lesion volume, cm^3, n (%)						
<10 cm^3	545 (50.0)	779 (64.8)	<0.001†	172 (31.4)	193 (45.1)	<0.001†
10–30 cm^3	153 (14.0)	145 (12.1)		174 (31.8)	152 (35.5)	
>30 cm^3	237 (21.7)	123 (10.2)		164 (29.9)	62 (14.5)	
Blood pressure at presentation, mm Hg, mean±SD						
Systolic	157.31±31.3	150.0±27.0	<0.001†	173.3±32.1	163.57±32.3	<0.001†
Diastolic	93.85±17.9	90.1±15.7	<0.001†	105.33±20.0	111.09±243.3	0.583
Fasting glucose, mg/dL, mean±SD	124.24±54.5	118.1±52.9	0.084	116.75±39.8	113.1±43.9	0.386
Neutrophil:lymphocyte ratio, mean±SD	7.3±38.7	4.48±22.4	0.101	8.36±13.9	7.2±24.5	0.452

*Subgroup (ischemic and hemorrhagic stroke) analyses were based on individuals with data on primary stroke types confirmed by brain scan. BMI indicates body mass index; and CVD, cardiovascular disease.
†*P* value <0.05 was considered significant.

There was a high proportion of severe stroke among participants, with approximately half of all strokes classified as severe, and more severe strokes among hemorrhagic than ischemic. A similar high burden has been demonstrated in smaller populations derived from a single centers in Nigeria and Ethiopia.[12,28] A similar high stroke severity in hemorrhagic stroke was found in the Copenhagen Stroke Study.[29] Aside from the high-fatality severe stroke causes, it also portends a high level of impairment among survivors, thereby predisposing to the high burden of care.[30] This finding highlights potential enormous strain on the stroke care system in the subregion and undermines the already fragile health care system.[30]

Our findings reinforce the observed racial disparity, with a high proportion of severe stroke among Black individuals compared with other racial groups.[31,32] This is partly explained by high hypertension and diabetes burden among Black individuals[31] as observed in this study, with hypertension in 85% and diabetes in 32% of the patients with stroke. Other factors may play a role in such disparity including the burden of comorbid vascular risk, increased likelihood of motor deficits, increased likelihood of hemorrhagic stroke type, and poor access to the usage of preventative therapy such as carotid endarterectomy among Black individuals and underserved populations such as the sub-Saharan region.[33]

Table 3. Ischemic Stroke Subtypes Stratified by Severity Status

Variables	Subvariables	Ischemic stroke, n (%)		*P* value
		Severe N=1090	Nonsevere N=1202	
TOAST classification*	Large-artery arteriosclerosis	394 (36.2)	318 (26.5)	<0.001
	Cardioembolism	80 (7.4)	75 (6.3)	
	Small-vessel occlusion	233 (21.4)	492 (41)	
	Other determined etiology	3 (0.3)	6 (0.5)	
	Undetermined etiology	237 (21.8)	230 (19.2)	
OCSP subtype†	Total anterior circulation infarct	179 (16.5)	117 (9.8)	<0.001
	Partial anterior circulation infarct	359 (33)	327 (27.3)	
	Posterior circulation infarct	112 (10.3)	94 (7.9)	
	Lacunar infarct	296 (27.2)	560 (46.6)	
ASCO subtype‡	Atherosclerosis	199 (18.3)	197 (16.4)	<0.001
	Small-vessel disease	299 (27.5)	538 (44.8)	
	Cardioembolism	125 (11.4)	124 (10.4)	
	Other causes	22 (2.1)	21 (1.8)	

*Trial of Org 10172 in acute stroke treatment.
†Oxfordshire Community Stroke Project classification.
‡A for atherosclerosis, S for small vessel disease, C for cardiac source, O for other cause (phenotypic) classification of stroke.

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Table 4. Hemorrhagic Stroke Subtypes Stratified by Severity Status

Variables	Subvariables	Hemorrhagic stroke, n (%)		*P* value
		Severe N=548	Nonsevere N=428	
Location of lesion	Lobar	107 (9.6)	117 (27.4)	0.004
	Nonlobar	441 (80.5)	311 (72.7)	
SMASH-U	Structural	16 (3.0)	20 (4.7)	0.027
	Medication related	0 (0)	4 (1)	
	Amyloid angiopathy	2 (0.4)	7 (1.7)	
	Systemic disease	1 (0.2)	3 (0.8)	
	Hypertensive	436 (79.6)	337 (78.8)	
	Undetermined	12 (2.2)	8 (1.9)	

While numerous vascular risk factors are implicated in stroke etiology, many were not found to be significant in all stroke or stroke subtype severe outcomes. This is particularly interesting for hypertension and dyslipidemia, which played a vital role in stroke occurrence but not severity. Our previous report demonstrated that hypertension had an aOR of 19.36 (95% CI, 12.11–30.93) for stroke occurrence.[18] Although, dyslipidemia was found in 4 of 5 participants, it did not play a significant independent role for severe stroke. The overarching implication of this observation is that severity predictors are not necessarily etiological factors. Nevertheless, we observed the interactive effect of hypertension on vegetable and meat consumption and lesion volume. It would be interesting to unravel these interactions further in future studies.

The previous SIREN report found vegetable intake as protective against stroke.[18] It is, however, interesting that it also plays a key role in all stroke types and the subtypes in addition to meat consumption with low vegetable consumption independently associated with severe stroke. While the evidence of this role has been established, the mechanism is poorly understood.[18,34,35] The likely link for the vegetable consumption may be the dose–response relationship of in vivo homocysteine level and stroke severity.[18,34–36] Other important factors in vegetables, especially green leafy ones, are micronutrients and vitamins. The nitrate–nitrite–nitric oxide pathway has also been suggested.[18,34–36] The pathophysiologic mechanism associated with excessive meat consumption include the high heme iron in red meat.[37] Iron is a redox-active metal and catalyzes the formation of hydroxyl free radicals in the Fenton reaction.[37] Iron may lead to oxidative stress, a state with increased peroxidation of lipids, protein modification, and DNA damage.[37]

Depending on the classification, there was a significant association of ischemic stroke with large-artery atherosclerosis in the Trial of Org 10172 in Acute Stroke Treatment classification and partial anterior circulation infarcts in Oxfordshire Community Stroke Project subtype.[38,39] A previous study suggested that total anterior circulation infarction (TACI) is associated with worse stroke outcome.[40] This is similar to our study, which demonstrated a 3-fold increased risk of severe outcome with TACI.[41] On the other hand, nonlobar and hypertensive hemorrhagic stroke were more severe, none was independently associated with severe hemorrhagic stroke. Nevertheless, lesion volume ≥30 cm^3 was independently associated with

Table 5. Echocardiographic and Electrocardiographic Determinants of Severe Stroke Patients by Stroke Levity Scale

Variable	Nonsevere ischemic stroke N=1202	Severe ischaemic stroke; f (%) N=1090	*P* value (exact test)	Nonsevere hemorrhagic stroke N=428	Severe hemorrhagic stroke; f (%) N=548	*P* value (exact test)
Sinus arrhythmia	26 (2.2)	23 (2.2)	0.382	11 (2.6)	14 (2.6)	0.550
Atrial fibrillation	38 (3.2)	44 (4.1)	0.495	2 (0.5)	8 (1.5)	0.200
Atrial flutter, ECG determined	3 (0.2)	7 (0.7)	0.223	0 (0.0)	1 (0.2)	1.000
Atrial enlargement, right/left	197 (16.4)	170 (15.6)	0.026	92 (21.5)	92 (16.8)	0.099
Ejection fraction						
≤40%	58 (4.8)	53 (4.9)	0.078	5 (1.2)	15 (2.8)	0.037
41%–50%	61 (5.1)	55 (5.1)		14 (3.3)	8 (1.5)	
≥51%	394 (32.8)	252 (23.2)		93 (21.7)	93 (17.0)	

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Table 6. Factors Associated With Stroke Severity by Stroke Levity Scale

Risk factor	Model 1		
	All severe stroke	Severe ischemic stroke	Severe hemorrhagic stroke
	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)
Age, y	1.21 (0.93–1.58)	1.09 (0.75–1.56)	1.81 (1.13–2.89)†
Hypertension	1.00 (0.56–1.79)	1.03 (0.52–2.02)	1.47 (0.29–7.28)
Dyslipidemia	0.96 (0.70–1.31)	0.90 (0.58–1.37)	1.11 (0.63–1.95)
Diabetes	0.78 (0.62–1.00)	0.89 (0.67–1.19)	0.59 (0.36–0.98)
Obesity	0.93 (0.71–1.22)	1.07 (0.77–1.50)	0.62 (0.35–1.10)
Cigarette smoking	1.01 (0.52–1.93)	1.11 (0.43–2.87)	0.89 (0.29–2.72)
Stress	0.99 (0.75–1.32)	0.84 (0.59–1.20)	1.34 (0.76–2.36)
Cardiac disease	0.93 (0.66–1.30)	0.83 (0.56–1.22)	1.37 (0.57–3.27)
Alcohol	0.88 (0.67–1.16)	0.72 (0.50–1.03)	0.95 (0.57–1.60)
Meat consumption	1.97 (1.43–2.73)†	1.50 (1.03–2.20)†	6.16 (2.88–13.18)†
Low vegetable consumption	2.45 (1.93–3.12)†	2.23 (1.66–3.00)†	4.34 (2.60–7.23)†
Depression	0.98 (0.64–1.48)	1.17 (0.70–1.96)	0.60 (0.26–1.36)
Physical inactivity	1.11 (0.59–2.08)	0.95 (0.44–2.04)	2.91 (0.78–10.88)
Salt intake	1.05 (0.71–1.56)	1.01 (0.61–1.69)	0.79 (0.39–1.61)
Right/left atrial enlargement	1.00 (0.78–1.27)	0.96 (0.70–1.31)	0.97 (0.60–1.58)
Model 2			
Age, y	1.18 (0.73–1.91)	0.92 (0.52–1.64)	2.56 (1.25–5.24)†
Dyslipidemia	0.77 (0.38–1.55)	1.22 (0.52–2.84)	0.63 (0.24–1.65)
Obesity	0.93 (0.56–1.55)	0.82 (0.48–1.39)	0.92 (0.39–2.17)
Low vegetable consumption	1.05 (0.65–1.69)	1.22 (0.72–2.07)	1.14 (0.45–2.90)
Physical inactivity	0.70 (0.27–1.78)	1.04 (0.39–2.79)	0.18 (0.02–1.72)
Right/left atrial enlargement	0.89 (0.55–1.45)	0.92 (0.56–1.51)	0.69 (0.33–1.45)
Lesion volume, cm^3			
≥10	1.67 (1.03–2.72)†	1.01 (0.53–1.95)	1.86 (0.92–3.76)
≥30	3.88 (1.93–7.81)†	1.80 (0.83–3.89)	6.16 (1.97–19.25)†
Systolic blood pressure at presentation	1.00 (1.00–1.01)	1.00 (0.99–1.01)	1.00 (0.99–1.01)
Fasting glucose	1.00 (0.99–1.01)	1.00 (1.00–1.01)	0.99 (0.98–1.01)
Neutrophil:lymphocyte ratio	1.00 (0.99–1.01)	NA	NA
Stroke type, ICH vs ischemic	0.80 (0.50–1.27)	NA	NA
Nonlobar vs lobar	NA	NA	1.01 (0.46–2.21)
Causes of ICH, hypertensive vs others	NA	NA	1.38 (0.41–13.87)
Ischemic stroke subtypes	NA	NA	
OCSP subtypes	NA		NA
LACI (ref)	NA		NA
TACI	NA	3.15 (1.45–6.82)†	NA
PACI	NA	1.97 (1.19–3.26)†	NA
POCI	NA	2.16 (1.10–4.21)†	NA

aOR indicates adjusted odds ratio; ICH, intracerebral hemorrhage; LACI, lacunar infarct; NA, not applicable; OCSP, Oxfordshire Community Stroke Project; PACI, partial anterior circulation infarct; POCI, posterior circulation infarct; and TACI, total anterior circulation infarct.

†*P* value <0.05 was considered significant.

severe stroke among all stroke types and patients with hemorrhagic stroke, while ≥10 cm^3 lesion volume was associated with severity of all strokes combined.[42] Furthermore, there was strong interaction between lesion volume and hypertension, lesion volume and meat consumption, and hypertension and low vegetable consumption.

Conversely, for ischemic stroke the location of the lesion was more relevant,[43] with TACI, partial anterior circulation infarcts, and posterior circulation infarcts

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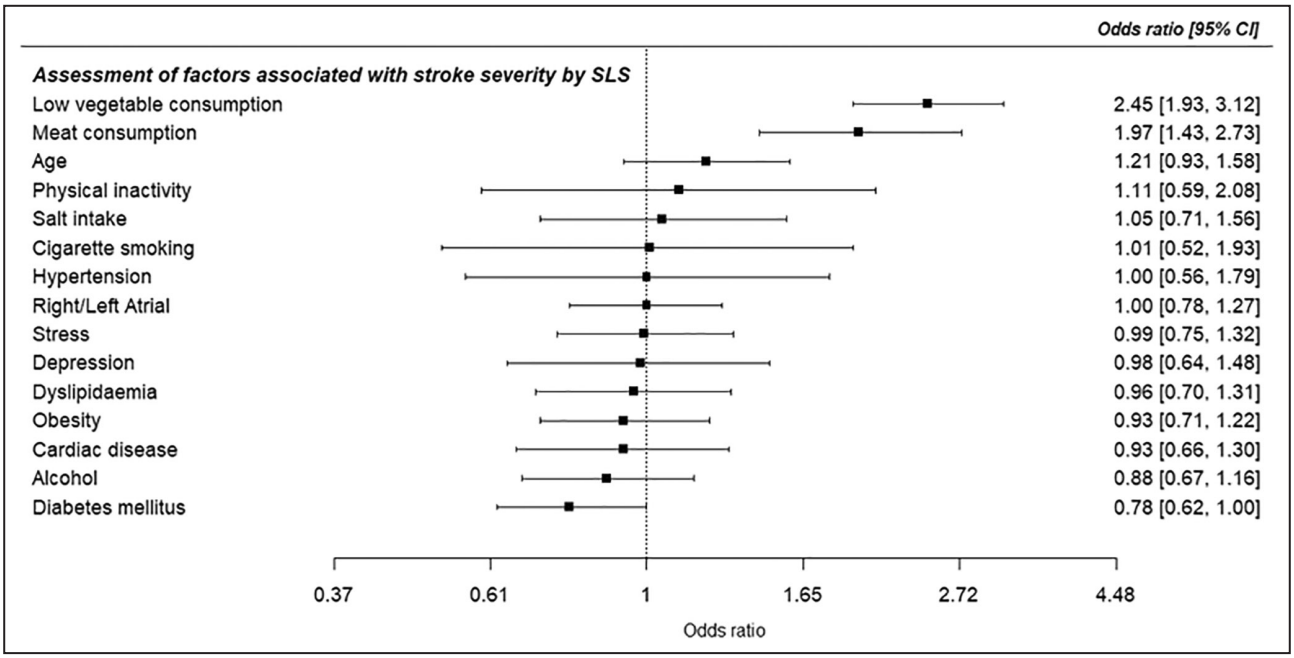

Figure 1. **Forest plot of the factors associated with stroke severity by Stroke Levity Scale (SLS) (model 1).**

being more severe. Although the severity of TACI could be attributable to its larger size,[40] TACI can result in fatal complications like transtentorial herniation, whereas posterior circulation infarcts can interfere with vital brain stem structures.[40,43]

Our study has several strengths. First, the characterization of the burden of severe stroke in the largest study of stroke in Africa will facilitate planning of the treatment protocol in this population, particularly in the early phase of care, which is associated with high

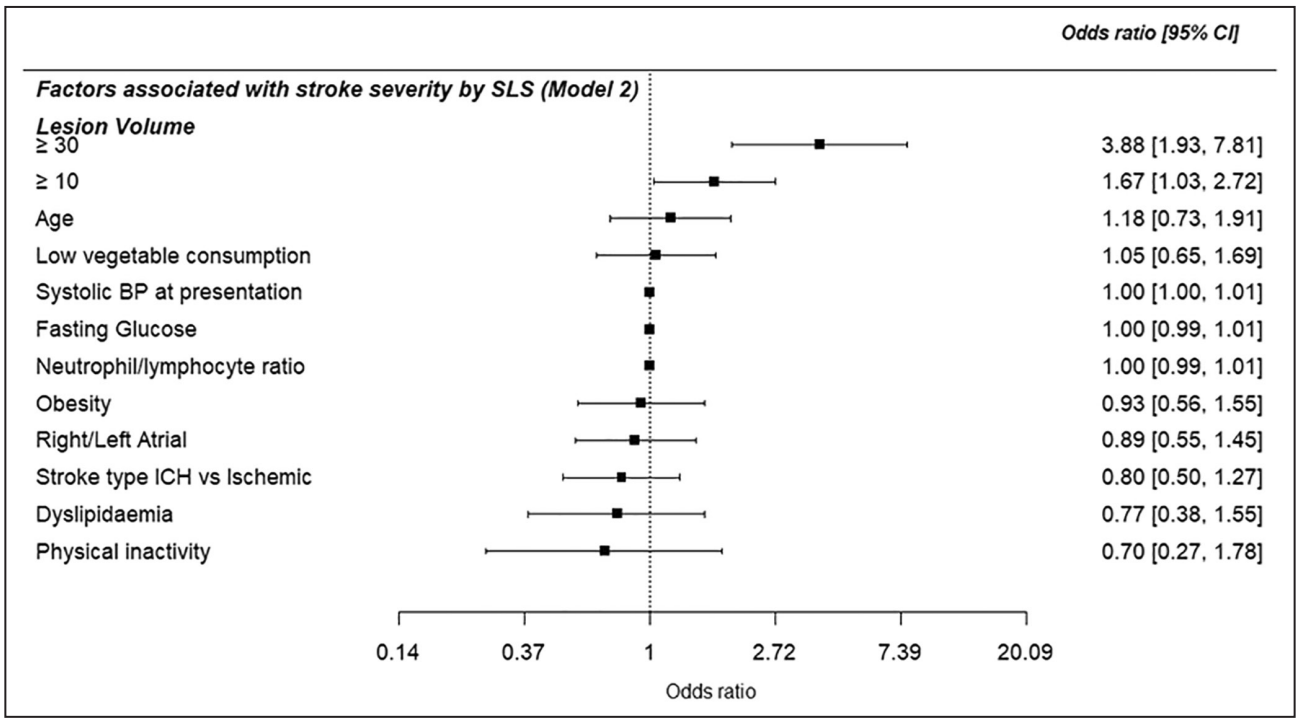

Figure 2. **Forest plot of the factors associated with stroke severity by Stroke Levity Scale (SLS) (model 2).**
BP indicates blood pressure; and ICH, intracerebral hemorrhage.

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mortality.[12,41,44–46] Moreover, the identified novel modifiable risk factors for severe stroke can be targeted for prevention of severe stroke.

Our study has some limitations. The burden of severe stroke may be exaggerated because of missing cases as patients with mild strokes may not visit hospitals because of poor resources. Nevertheless, we had an active community engagement strategy to facilitate presentation of stroke cases from the catchment population for enrollment into the study and mitigate presentation bias. There was also disparity in severe stroke burden in the 2 countries in this study. This may be attributable to diversity in the variable mix of urban/suburban domicile, sex distribution, vascular risk factor burden, and other factors.

CONCLUSIONS

In this study, we described an enormous burden of severe stroke among all stroke types and subtypes, with significant implications for the stroke care system in West Africa. We also discovered dietary and radiological factors independently associated with stroke severity. Reduced meat consumption and high vegetable consumption could reduce the likelihood of developing severe stroke in this population.

APPENDIX

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ARTICLE INFORMATION

Received August 22, 2022; accepted January 12, 2023.

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Sources of Funding

The study and investigators are supported by the National Institutes of Health grants Stroke Investigative Research and Educational Network (SIREN) (U54HG007479), Systematic Investigation of Blacks with Stroke-Genomics (SIBS Genomics) (R01NS107900), African Neurobiobank for Precision Stroke Medicine (U01HG010273), Facilitating Implementation Science within SIBS Genomics Study (SIBS-Gen-Gen) (R01NS107900-02S1), ARISES (R01NS115944-01), H3Africa Cardiovascular Diseases (CVD) Supplement (3U24HG009780-03S5), CaNVAS (1R01NS114045-01), sub-Saharan Africa Conference on Stroke Conference 1R13NS115395-01A1, and Training Africans to Lead and Execute Neurological Trials & Studies (TALENTS) D43TW012030. The funding bodies played no role in the design of the study or the collection, analysis, or interpretation of data or in writing the manuscript.

Disclosures

None.

Supplemental Material

Data S1
Tables S1–S15
Figures S1–S4
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SUPPLEMENTAL MATERIAL

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Data S1. Supplemental Methods

Eligibility Criteria

The patients considered for the study were specifically those who presented to the SIREN project hospital sites in Nigeria and Ghana. Only one admission episode was recorded for each individual. To be included in this study, participants had to be at least 18 years of age with clinical features of acute stroke confirmed by Cranial Computerized Tomography (CT)/Magnetic Resonance Imaging (MRI).

For this study, stroke was defined clinically based on American Heart Association (AHA)/American Stroke Association (ASA) Expert Consensus Document.[26] Eligible cases were patients with the first stroke admitted within 8 days of current symptoms onset or "last seen without deficit" and CT or MRI scan within ten days of symptom onset.

Evaluation of stroke

We excluded patients with extra-axial haemorrhage, tumour or brain abscess, primary subarachnoid haemorrhage, current hospitalization for coronary heart disease, or unable to communicate or provide consent with no valid surrogate available. Age, Sex, marital status, type of domicile, level of education, living situation, ethnic group, family history of stroke, smoking, and alcohol consumption were among the socio-demographic variables assessed. Hypertension, diabetes, dyslipidaemia, obesity, transient ischemic attack (TIA), HIV, chronic kidney disease, heart disease, sickle cell anaemia, and atrial fibrillation were among the vascular risk factors evaluated. Other variables assessed included: history of neck injury, recurrent miscarriage, bronchitis, cancer, a dental problem in past one year, use of oral contraceptives, sleep disorders, febrile illness in last four weeks, use of anticoagulants, migraine, obstructive sleep apnoea and neck manipulation. The methods for assessment of the various variables have been described in the previously published protocols and articles from SIREN.[15,47,48]

Brain imaging variables included: the location of the lesion (cortical, subcortical white matter, subcortical, cerebellar, brainstem, ventricles, circulation type), size and volume of lesion, age of lesion (hyper-acute, acute, sub-acute, chronic), TOAST (Trial of ORG 10172 in acute stroke treatment) classification (large artery atherosclerosis, cardio-embolism, the stroke of other

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determined aetiology, small vessel occlusion, the stroke of undetermined origin), and presence or absence of incidental findings.[49]

Stroke Phenotyping

Stroke diagnosis and phenotyping were based on clinical evaluation and brain neuroimaging (computed tomography or magnetic resonance imaging), ECG, transthoracic echocardiography, and carotid Doppler ultrasound performed according to standardized protocols at each site as have been previous been described.[15] Presumed etiologic subtypes of ischemic stroke were defined using the TOAST (Trial of ORG 10172 in Acute Stroke Treatment)[49] and intracerebral hemorrhage was classified etiologically into SMASH-U causes (Structural, Medication-Related, Amyloid Angiopathy, Systemic/Other Disease, Hypertension and Undetermined).[19,20,50]

The lesion volume was measured using the ellipsoid formula (A x B x C/ 2) after the axial slice with the largest lesion is selected by visual inspection.[21] On the selected slice, A is the longest dimension of the infarct lesion, B is perpendicular to A at the widest dimension while C is the slice thickness multiplied by the number of axial slices on which the infarct lesion is seen.[21]

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Definition of Stroke Severity

Both SLS and NIHSS tool was used to defined stroke severity in SIREN study. Severe stroke was defined as Stroke Levity Scale score of ≤ 5 or NIHSS score of > 20.

Risk Factor Definitions and Measurements

Definition of Risk Factors

Basic demographic and lifestyle data including, socioeconomic status, cardiovascular risk profile, dietary patterns, routine physical activity, stress using a validated INTERSTROKE instrument, depression, cigarette smoking, and alcohol use.[15,51,52] See Table S1 for more details.

Measurement of risk factors

Hypertension

We measured blood pressure using a standard sphygmomanometer (Omron or Accoson England mercury sphygmomanometer). Systolic blood pressure was determined by Korotkoff phase 1

while diastolic pressure was recorded at Korotkoff phase V. Subject was resting for ≥5 minutes, and had not smoked for at least 30 minutes before the measurement. We ensured an adequate cuff size with bladder encircling and covering 2/3 of length of arm with the bladder over the brachial artery and the lower border should be 1 inch (2-3cm) above the antecubital space. The bladder was deflated slowly and exact values to the nearest 2mmHg were recorded. Blood pressure (average of three measurements used) was recorded at time of admission (from patient's medical notes), the morning after admission (from patient's medical notes) and daily for 7 days or until death. At time of interview blood pressure was again measured by research personnel using an automated blood pressure monitor. Adjustments to systolic BP based on reported associations between pre-morbid BP and acute post-stroke pressure in the Oxford Vascular Study (OXVASC) were applied. Typically stroke subjects present for care late after about 72 hours of stroke onset during which time the acute rise in blood pressure in response to stroke may have started to subside.

Weight

The scales were standardized to 0 before each use. Weight was measured in undergarments using a platform scale to the nearest 0.2kg. We recorded the participant's weight twice in kilogram (kg). Height: We recorded the participant's height in meters (cm). If the participant was able to stand, standing height was measured with the subject bare footed, back square against the bed and eyes looking straight ahead. Supine height was measured with the subject in bare feet, lying on their back square against the bed and eyes looking straight upward. Height was measured to the nearest 0.5cm.

Body Mass Index (BMI)

This was calculated by dividing weight (in kg) by square of the height (in meters). Waist and hip circumferences were measured in the standing and supine positions. Where cases were unable to stand due to disability, these measurements were conducted in the supine position only. Standing waist and hip measurements were used in the present analysis where available.

Waist circumference

This was measured to the nearest 0.1cm using a non-stretchable standard tape measure attached to a spring balance exerting a force of 750gm over the unclothed abdomen at the midway between

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the costal margin and the iliac crest. The tape measure was kept horizontal for standing measurement and vertical for supine measurement with the subject relaxed with arms held loosely at sides.[51]

Hip circumference

This was measured to the nearest 0.1cm using a non-stretchable standard tape measure attached to a spring balance exerting a force of 750gm. Measurements were taken over light clothing at the level of the greater trochanters (usually the widest diameter around the buttocks). The tape measure was kept horizontal for standing measurement and vertical for supine measurements.[51,52]

Psychosocial factors assessment

We used a combined measure of psychosocial stress employed in INTERHEART[52] and INTERSTROKE[53], which combined self-report of stress at home or and work, life events and depression. Psychosocial stress at home/work was defined as the experience, in the two weeks prior to the stroke, of irritability, anxiety, or sleep difficulties as a result of conditions at work or home. For life events, respondents were asked to give a 'yes' or 'no' response to questions about whether, in the two weeks before the stroke, they experienced a stressful life event such as the death of a spouse, death/major illness of a close family member, marital separation/divorce, major personal injury or illness, loss of crop, loss of job/retirement, business failure, major intra-family conflict, violence (including kidnapping, assault, theft, etc.), financial stress, home-related stress, work-related stress, or other major stress.

Depression

For the assessment of depression, respondents were first screened for the presence of depressed mood in the four weeks before the stroke. Those who answered in the affirmative were next asked if, for at least two weeks during the four- week period before the stroke, they also experienced at least four out of seven other depression symptoms: loss of interest, feeling tired or low on energy, significant changes in weight, trouble falling asleep as usual, difficulty concentrating, thoughts of death, or feelings of worthlessness.

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Dietary History

We used a food frequency questionnaire to collect data on the frequency of food consumption in the past 12 months preceding a stroke. We evaluated whether or not subjects consumed cooking oil, vegetable intake, sprinkling salt at table, meat consumption, fruits, whole grains, refined grains, dairy products, poultry, eggs, fish and seafood, legumes, prickled food, deep fried foods, salty snacks, confectionary and carbonated beverages. For each of the food items, subjects had to record the number of times it was consumed per month or per week or per day. Regular consumption of a food item was defined as intake of at least once a day, a week, or a month whilst consumption rates less than once a month or never was defined as 'not regular'.

Determination of blood glucose level, HBA1c and lipid profile

Blood samples were collected from each case within 10 days of symptom onset, and from each control upon enrolment after an overnight fast and into relevant anticoagulant bottles tubes. All blood samples collected were centrifuged at 3000rpm for 20 minutes (2,500rpm for samples in Sodium citrate tubes) and separated into relevant fractions [serum, plasma, buffy coat and red cell concentrates] within 2 hours of collection. Fractions were stored at -20o C in non-self defrosting freezers at peripheral sites before transfer to central biorepository. A daily temperature chart was kept on every freezer to monitor the freezer temperature in order to maintain the samples' integrity Spot determination of plasma glucose level was carried out across all study sites using the ACCU-CHEK Active Blood Glucose Monitoring Device (Roche Diagnostics, GmBH, Germany), the principle of which was based on the reaction of blood glucose with glucose dehydrogenase enzyme resulting in colour changes which the meter converted to numerical values. Values obtained in mg/dl were converted to mmol/L.[54] Glycated haemoglobin (HbA1c) level was also determined on whole blood from all subjects within 24 hours of sample collection using the Clover A1c Test Catridge System (Infopia Co. Ltd., Korea). The Clover A1c system uses the principle of boronate affinity chromatographic method for the determination of HbA1c in whole blood.[55] Reagents in the system lyse red cells and bind haemoglobin, also the boronate resins bind the cis-doils of glycated haemoglobin. These are measured separately within the system and the ratio of glycated haemoglobin to total haemoglobin were expressed as percentage. Fasting lipid profile of subjects was determined by quantitative determination of cholesterol, triglycerides, HDL cholesterol using

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commercially available kits (Randox Laboratories Ltd., UK; Biolabo S.A., France) and the LDL cholesterol was calculated using Friedwald equation.[56]

Cholesterol and Triglycerides were determined using the enzymatic hydrolysis/colorimetric method while HDL-cholesterol was determined by precipitation method and the cholesterol fraction measured as previously described.[56,57] Values obtained in mg/dl were converted to mmol/L.[51,58] To ensure equivalence across all sites, a standard operating procedure (SOP) was developed on the above laboratory tests and applied across all SIREN sites after a 3- day hands-on-training involving laboratory scientists from across all sites. Refresher trainings were also organized every year. The same brand of test equipment, reagents and test strips were procured and utilized across study sites.

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Table S1. Definition of risk factors

Variables	Definitions
Hypertension	A sustained elevation of BP ≥140/90 mm Hg >72 hours after stroke, a premorbid history of hypertension, use of antihypertensive drugs before stroke or >72 hours after stroke onset.
Diabetes mellitus	History of diabetes mellitus, use of medications for diabetes mellitus, an HBA1c >6.5% or a fasting blood glucose levels of >7.0 mmol/L measured after the post-acute phase because of the known acute transient elevation of glucose as a stress response after stroke.
Dyslipidemia	Fasting total cholesterol ≥5.2 mmol/L, HDL-C (high-density lipoprotein cholesterol) ≤1.03 mmol/L, triglyceride ≥1.7 mmol/L, or LDL-C (low-density lipoprotein cholesterol) ≥3.4 mmol/L or use of statin before stroke onset.
Cardiac disease	Defined after evaluation by study cardiologists based on history or current diagnosis of atrial fibrillation, cardiomyopathy, heart failure, ischemic heart disease, rheumatic heart disease, or valvular heart diseases.
Obesity	Cut offs of waist-to-hip ratio of 0.90 (men) and 0.85 (women) ; body mass index of-30 kg/m^2
Family history of cardiovascular risk/diseases	Family history of cardiovascular risk/diseases was defined based on self-reported history of any of hypertension, diabetes mellitus, dyslipidemia, stroke, cardiac disease, or obesity in participants' father, mother, sibling, or second-degree relative.
Physical inactivity	Individuals were classified as physically inactive if they do not regularly involved in moderate exercise (walking, cycling, or gardening) or strenuous exercise (jogging, football, and vigorous swimming) for at least 4 hours or more per week.
Alcohol intake	Alcohol use was categorized into current users (users of any form of alcoholic drinks) or never/former drinker, whereas alcohol intake was categorized as low drinkers (1–2 drinks per day for female and 1–3 drinks per day for male) and high drinker (>2 drinks per day for female and >3 drinks per day for male; 1 drink or 1 U of alcohol=8 g of alcohol).
Smoking status	Defined as current smoker (individuals who smoked any tobacco in the past 12 months) or never/former smoker.

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Dietary history	Dietary history included regularity of intake of food items such as meat, green leafy vegetables, fish, addition of salt at table, nuts, sugar, and other local staple food items. Regular intake was defined as intake on daily, weekly, or at least once monthly versus none in a month and non- regular intake is the reverse. Low vegetable consumption was defined as a self-reported frequency of vegetable consumption less than once per month; 12 months before stroke. Similarly, regular meat consumption was defined as a self-reported frequency of meat intake more than once (including daily etc) per month; 12 months before stroke occurrence.
Psychosocial stress	Psychosocial stress combined measures of stress at home/work (eg, irritability, anxiety, or sleeping difficulties) and life events, experienced in the 2 weeks preceding the stroke

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Table S2. Distribution of vascular risk factors for Stroke by National Institutes of Health Stroke Scale score

Characteristics	All severe stroke N=1027	All non-severe stroke N=1701	P-value	Severe Ischemic Stroke N=649	Severe Hemorrhagic stroke N=378	P-value
Country, Ghana, n (%)	412(40.1)	644(37.9)	0.255	242(37.3)	170(45.0)	0.015
Age						<0.001
<60	462(45.0)	893(52.5)	<0.001	212(32.7)	250(66.1)	
≥60	563(54.8)	805(47.3)		437(67.3)	126(33.3)	
Sex, Male, n (%)	560(54.5)	988(58.1)	0.069	327(50.4)	233(61.6)	<0.001
Domicile						
Rural, n (%)	89(8.7)	136(8.0)	0.666	56(8.6)	33(8.7)	0.993
Semi-urban, n (%)	282(27.5)	486(28.6)		179(27.6)	103(27.3)	
Urban, n (%)	656(63.9)	1068(62.8)		414(63.8)	242(64.0)	
Marital status						
never married/single	35(3.4)	73(4.3)	0.308	14(2.16)	21(5.6)	0.013
married	751(73.13)	1264(74.3)		459(70.7)	292(77.3)	
Monthly Income >$100, n (%)	553(53.85)	970(57.0)	0.115	337(51.9)	216(57.1)	0.109
Education, (some) n (%)	810(78.9)	1439(84.6)	<0.001	314(48.38)	496(31.2)	0.013
Living situation						
loneliness	47(4.6)	97(5.7)	0.220	27(4.2)	20(5.3)	0.387
living with others	969(94.4)	1600(94.1)		617(95.1)	352(93.1)	
Comorbidities						

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Hypertension, n (%)	996(97.0)	1616(95.0)	0.009	626(96.5)	370(97.9)	0.122
Dyslipidemia, n (%)	370(36.0)	1449(85.2)	0.738	565(87.1)	73(19.3)	0.006
Diabetes	375(36.5)	624(36.7)	0.944	271(41.8)	104(27.5)	<0.001
Cardiac Disease, n (%)	103(10.0)	194(11.4)	0.270	86(13.3)	17(4.5)	<0.001
Waist-to-hip Ratio raised, n (%)	791(77.0)	1326(78.0)	0.697	510(78.6)	281(74.3)	0.053
BMI*** (kg/m2), mean ± SD	26.4±5.0	26.8±5.2	0.023	26.7±5.3	26.5±5.2	0.308
BMI*** >30kg/m^2, n (%)	148(14.4)	329(19.3)	0.014	95(16.64)	53(14.0)	0.984
Physical (Inactivity), n (%)	51(5.0)	63(3.7)	0.114	36(5.6)	15(4.0)	0.253
Tobacco (any use), n (%)	80(7.8)	176(10.4)	0.022	49(7.6)	31(8.2)	0.709
Alcohol use categories:						
Never Use, n (%)	698(68.0)	1080(63.5)	0.168	463(71.3)	235(62.2)	0.002
Ever Low Use, n (%)	180(17.5)	339(19.3)		97(15.0)	83(22.0)	
Ever High Use, n (%)	31(3.0)	51(3.0)		15(2.3)	16(4.2)	
Stress, n (%)	175(17.0)	337(19.8)	0.171	102(15.7)	73(19.3)	0.279
Cancer, n (%)	6(0.6)	11(0.7)	0.006	6(0.9)	0(0.0)	0.165
Depression, n (%)	84(8.2)	123(7.2)	0.539	51(7.9)	33(8.7)	0.850
Family history of CVD, n (%)	381(37.1)	692(40.7)	0.063	231(35.6)	150(39.7)	0.191
Adding salt at table, n (%)	89(8.7)	115(6.8)	0.059	50(7.7)	39(10.3)	0.155
Low vegetable consumption, n (%)	353(34.4)	364(21.4)	<0.001	227(35.0)	126(33.3)	0.615

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Whole grains consumption, n (%)	821(79.9)	1340(78.8)	0.195	512(78.9)	309(81.8)	0.224
Legumes consumption, n (%)	549(53.5)	1129(66.4)	<0.001	337(51.9)	212(56.1)	0.152
Fruit consumption, n (%)	784(76.3)	1341(78.8)	0.278	493(76.0)	291(77.0)	0.525
Sugar consumption or otherwise, n (%)	316(30.8)	434(25.5)	0.002	194(29.9)	122(32.2)	0.369
Regular Meat consumption %	680(66.2)	1134(66.7)	0.881	415(63.9)	84(22.2)	0.037
Fish consumption or otherwise, %	879(87.9)	1452(85.4)	0.503	555(85.5)	324(85.7)	0.941
Lesion volume						
<10	431(42.0)	1023(60.1)	<0.001	320(49.3)	111(29.4)	<0.001
10-30	231(22.5)	292(17.2)		97(15.0)	134(35.5)	
>30	259(25.2)	195(11.5)		145(22.3)	114(30.2)	
Blood pressure at presentation						
Systolic Mean±SD	163.4±*32.8*	154.3±*29.0*	<0.001	158.0±*32.0*	172.9±*32.5*	<0.001
Diastolic Mean±SD	97.0±*19.2*	96.1±*116.7*	<0.001	92.8±*17.7*	104.0±*20.0*	<0.001
Fasting Glucose Mean±SD	124.4±*56.7*	113.1±*43.7*	<0.001	126.0±*61.2*	125.1±*52.3*	0.883
Neutrophil/ lymphocyte ratio	7.1±*29.4*	5.5±*27.2*	0.236	7.4±*38.1*	7.2±*7.3*	0.950

*Compared to corresponding table for SLS, less variables have significant results in this National Institutes of Health Stroke Scale score results

BMI-Body mass index

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Table S3. Vascular risk factors for stroke severity stratified by Stroke primary type by National Institutes of Health Stroke Scale score

Characteristics	All severe stroke N=1027	Ischemic Stroke			Hemorrhagic stroke		
		Severe N=649	Not severe N=1283	p-value (Exact test)	Severe N=378	Not severe N=418	p-value (Exact test)
Country, Ghana, n (%)	412(40.1)	242(37.3)	398(31.0)	0.006	170(45.0)	246(58.9)	**<0.001**
Age							
≤59	462(45.0)	212(32.7)	596(46.5)	<0.001	250(66.1)	297(71.1)	0.150
≥60	563(54.8)	437(67.3)	437(34.1)		126(33.3)	120(28.7)	
Sex, Male, n (%)	560(54.5)	327(50.4)	713(55.6)	0.034	233(61.6)	275(65.8)	0.238
Domicile							
Rural, n (%)	89(8.7)	56(8.6)	109(8.5)	0.690	33(8.7)	27(6.5)	0.493
Semi-urban, n (%)	282(27.5)	179(27.6)	377(29.4)		103(27.25)	112(26.8)	
Urban, n (%)	656(63.9)	414(63.8)	794(61.9)		242(64.0)	274(65.6)	
Monthly Income >$100, n (%)	553(53.9)	337(51.9)	723(56.4)	0.068	216(57.14)	248(59.3)	0.622
Living situation							0.197
loneliness	47(4.6)	27(4.2)	65(5.1)	0.388	20(5.3)	32(7.7)	
living with others	969(94.4)	617(95.1)	1214(94.6)		352(93.12)	386(92.3)	
Education, (some) n (%)	810(78.9)	314(48.4)	1058(82.5)	0.002	496(131.2)	381(91.2)	**<0.001**

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Hypertension, n (%)	996(97.0)	626(96.5)	1207(94.1)	0.025	370(97.9)	409(97.9)	0.766
Dyslipidemia, n (%)	370(36.0)	565(87.1)	1120(87.3)	0.882	73(19.3)	329(78.7)	0.488
Diabetes	375(36.5)	271(41.8)	508(39.6)	0.360	104(27.5)	116(27.8)	0.959
Cardiac Disease, n (%)	103(10.0)	86(13.3)	171(13.3)	0.972	17(4.5)	23(5.5)	0.522
Waist-to-hip Ratio raised, n (%)	791(77.0)	510(78.6)	1015(79.1)	0.675	281(74.3)	311(74.4)	0.411
BMI*** (kg/m2), mean ± SD	26.4±5.0	26.2±5.2	26.9±5.3	0.010	26.44±4.8	26.5±5.2	0.76
BMI*** >30kg/m^2, n (%)	148(14.4)	95(16.6)	261(20.3)	0.014	53(14.0)	68(16.3)	0.695
Physical Activity (Inactivity), n (%)	51(5.0)	36(5.6)	1216(94.8)	0.055	15(4.0)	397(95.0)	0.928
Tobacco (any use), n (%)	80(7.8)	49(7.6)	131(10.2)	0.050	31(8.2)	45(10.8)	0.207
Alcohol use categories:							
Never Use, n (%)	698(68.0)	463(71.3)	860(67.0)	0.189	235(62.2)	220(52.6)	0.115
Ever Low Use, n (%)	180(17.5)	97(15.0)	230(17.93)		83(22.0)	109(26.1)	
Ever High Use, n (%)	31(3.0)	15(2.3)	30(2.3)		16(4.2)	21(5.0)	
Stress, n (%)	175(17.0)	102(15.7)	256(20.0)	0.050	73(19.3)	81(19.4)	0.959
Cancer, n (%)	6(0.6)	6(0.9)	8(0.6)	0.012	0(0.0)	0(0.0)	0.017
Depression, n (%)	84(8.2)	51(7.9)	94(7.3)	0.668	33(8.7)	29(6.9)	0.605
Family history of CVD, n (%)	381(37.1)	231(35.6)	495(38.6)	0.200	150(39.7)	197(47.3)	0.034

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Adding salt at table, n (%)	89(8.7)	50(7.7)	78(6.1)	0.171	39(10.3)	37(8.9)	0.411
Low vegetable consumption, n (%)	353(34.4)	227(35.0)	265(20.7)	<0.001	126(33.3)	99(23.7)	<0.001
Whole grains consumption, n (%)	821(79.9)	512(78.9)	1000(77.9)	0.712	309(81.8)	340(81.3)	0.097
Legumes consumption, n (%)	549(53.5)	337(51.9)	831(64.8)	<0.001	212(56.1)	298(71.3)	0.001
Fruit consumption, n (%)	784(76.3)	493(76.0)	1002(78.1)	0.156	291(77.0)	339(81.1)	0.859
Sugar consumption or otherwise, n (%)	316(30.8)	194(29.9)	320(24.9)	0.031	122(32.3)	114(27.3)	0.043
Regular Meat consumption %	680(66.2)	415(63.9)	846(65.9)	0.311	84(22.22)	288(68.90)	0.122
Fish consumption or otherwise, %	879(85.5)	555(85.5)	1073(83.6)	0.503	324(85.7)	379(90.6)	0.300
Lesion volume							
<10	431(41.97)	320(49.31)	827(64.46)	<0.001	111(29.37)	196(46.89)	<0.001
10-30	231(22.49)	97(14.95)	153(11.93)		134(35.45)	139(33.25)	
>30	259(25.22)	145(22.34)	137(10.68)		114(30.16	58(13.88)	
Blood pressure at presentation							
Systolic Mean±SD	163.4±32.8	158.0±32.0	150.7±27.1	<0.001	172.9±32.5	164.3±32.8	<0.001
Diastolic Mean±SD	97.0±19.2	92.8±17.7	90.8±15.8	0.022	104.0±20.0	11100.6±19.6	0.017
Fasting Glucose Mean±SD	124.4±56.7	126.0±61.2	115.2±46.7	0.005	125.7±42.6	109.1±32.7	0.001
Neutrophil/lymphocyte ratio	7.1±29.35	7.4±38.1	5.0±29.2	0.240	7.2±7.3	7.8±27.5	0.735

Severe stroke was defined as National Institute of Health severity scale score >20

BMI-Body mass index

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Table S4. Association of Prior Vascular risk factors and comorbidities of severe stroke patients by Stroke Levity Scale

Variable	All severe stroke N=1854	Ischaemic Stroke		p-value (Exact test)	Haemorrhagic stroke		p-value (Exact test)
		Severe N=1090	Not severe N=1201		Severe N=548	Not severe N=428	
Hypertension	1575 (85.0%)	1036 (95.1%)	1135(94.4%)	0.618	539 (98.4%)	417(97.4%)	0.312
Diabetes Mellitus	592 (32.0%)	446 (41.0%)	506(42.1%)	0.567	146 (26.7%)	131(30.6%)	0.171
stroke	253 (13.7%)	199 (18.3%)	267(22.2%)	0.055	54 (9.9%)	48(11.2%)	0.760
Neck manipulation	78 (4.3%)	28(2.57%)	30(2.50%)	0.837	12(2.2%)	8(1.8%)	0.831
Dyslipidemia	1339 (72.3%)	921 (84.5%)	1053(87.60)	0.028	418 (76.3%)	348(81.31)	0.065
Obesity	246 (13.3%)	173 (15.9%)	243(20.2%)	0.631	73 (13.4%)	68(15.89)	0.851
History Of TIA	44 (2.4%)	36 (3.4%)	46(3.8%)	0.747	8 (1.5%)	1(0.2%)	0.133
HIV /AIDs	10 (0.6%)	8 (0.8%)	10(0.8%)	0.505	2 (0.4%)	2(0.5%)	0.525
History of Chronic Kidney Disease	14 (0.8%)	9 (0.9%)	11(0.9%)	0.965	5 (1.0%)	13(3.0%)	0.049
Sickle Cell disease	6 (0.4%)	4 (0.4%)	2(0.2%)	0.453	2 (0.4%)	3(0.7%)	0.650
Atrial fibrillation	14 (0.8%)	12 (1.2%)	12(1.0%)	0.899	2 (0.4%)	1(0.2%)	0.725
history of neck injury	13 (0.8%)	9 (0.9%)	10(0.8%)	0.974	4(0.8%)	9(2.1%)	0.104
schizophrenia	5 (0.3%)	5(0.5%)	5(0.4%)	0.372	4(0.7%)	2(0.5%)	0.386
history of recurrent miscarriage	21 (1.2%)	18 (1.7%)	27(2.3%)	0.370	3 (0.6%)	5(1.2%)	0.180
history of chronic bronchitis	3 (0.2%)	8(0.733)	15(1.3%)	0.457	1(0.2%)	1(0.2%)	0.981
history of cancer	6(0.4%)	5 (0.5%)	9(0.8%)	0.272	1 (0.2%)	3(0.7%)	0.147
history of tuberculosis	3 (0.2%)	2(0.2%)	4(0.3%)	0.548	1 (0.2%)	1(0.2%)	0.583
history of dental problem in last one year	83 (4.5%)	64 (5.9%)	98(8.1%)	0.101	19 (3.5%)	37(8.6%)	0.002
history of use of sleep disorders	53 (2.9%)	39 (3.6%)	53(4.4%)	0.761	14 (2.6%)	11(2.6%)	0.721
history of febrile illness in the last four weeks	141 (7.7%)	102 (9.4%)	129(10.730	0.360	39 (7.2%)	40(9.4%)	0.443
History of use of anticoagulants	17 (1.0%)	14 (1.3%)	9(0.8%)	0.446	3 (0.6%)	3(0.7)	251
History of Migraine	37(2.0%)	22(2.1%)	44(3.7%)	0.062	15(2.8%)	20(4.7%)	0.259
Stress in the last 2 weeks	267 (14.5%)	164(15.1%)	249(20.7%)	0.002	103 (18.8%)	92(21.5%)	0.408

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Depression in the last 4 weeks	107 (5.8%)	69 (6.4%)	102(8.5%)	0.138	38 (7%)	36(8.4%)	0.290
History of heart disease	50 (2.7%)	41 (3.8%)	48(4.0%)	0.904	9 (1.7%)	9(2.1%)	0.860

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Table S5. Table showing the clinical presentation of participants by Stroke Levity Scale

Clinical Presentation	All severe stroke N=1854	Ischaemic Stroke			Haemorrhagic stroke		
		Severe N=1090	Not severe N=1202	p-value (Exact test)	Severe N=548	Not severe N=428	p-value (Exact test)
Headache at first presentation	633(34.1%)	388(35.6%)	430(35.8%)	0.993	245(44.7%)	143(33.4%)	0.001
Vomiting at first presentation	369(19.9%)	170(15.6%)	160(13.3%)	0.107	199(36.3%)	140(32.7%)	0.327
Disturbed consciousness	853(46.0%)	496(45.5%)	335(27.9%)	<0.001	357(65.2%)	192(44.9%)	<0.001
Neck stiffness	183(9.9%)	98(9.0%)	75(6.2%)	0.012	85(15.5%)	74(17.3%)	0.370
Ictus occurred with activity	615(33.2%)	354(32.5%)	380(31.6%)	0.699	261(47.6%)	183(42.8%)	0.215
Ictus occurred at rest	733(39.5%)	578(53.0%)	674(56.1%)	0.144	155(28.3%)	117(27.3%)	0.895
Focal neurological deficit	1090(58.8%9)	731(67.1%)	377(31.4%)	0.220	359(65.5%)	275(64.3%)	0.844
Disturbed speech	705(38.0)	364(33.4%)	489(40.7%)	<0.001	341(62.2%)	220(51.4%)	0.002
Paraesthsiae	981(52.9%)	928(85.1%)	951(79.1%)	<0.001	53(9.7%)	57(13.3%)	0.065
Ataxic gait	150(8.1%)	103(9.5%)	160(13.3%)	0.004	47(8.6%)	46(10.8%)	0.212
Seizure	1006(54.3%)	931(85.4%)	405(33.7%)	0.06	75(13.7%)	41(9.6%)	0.071
Stroke affecting right	865(46.7%)	573(52.6%)	452(37.6%)	<0.001	292(53.3%)	133(31.1%)	<0.001
Stroke affects left	579(31.2%)	391(35.9%)	554(46.1%)	<0.001	188(34.3%)	206(48.1%)	<0.001
Stroke affecting both	130(7.0%)	84(7.7%)	85(7.1%)	<0.001	46(8.4%)	40(9.4%)	<0.001
Disability prior to stroke (Yes)	623(33.6%)	367(33.7%)	203(16.9%)	<0.001	256(46.7%)	344(80.4%)	<0.001
Gait(Normal)	209(11.3%)	130(11.9%)	268(22.3%)	<0.001	79(14.4%)	101(23.6%)	0.048

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Previous stroke	164(8.9%)	124(11.4%)	135(11.2%)	0.568	40(7.3%)	27(6.3%)	0.909
Previous Transient Ischemic attack	136(7.3%)	102(9.4%)	120(10.0)	0.102	34(6.2%)	22(5.1%)	0.785
Cranial nerve deficit	603(32.5%)	267(24.5%)	433(36.0%)	<0.001	336(61.3%)	226(52.8%)	0.006
Facial nerve deficit	1171(63.2%)	789(72.4%)	671(55.8%)	<0.001	382(69.7%)	234(54.7%)	<0.001
Language deficit	871(47.0)	569(52.2%)	336(28.0)	<0.001	302(55.1%)	105(24.5%)	<0.001
Visual field deficit	309(16.7%)	201(18.4%)	112(9.3%)	<0.001	108(24.7%)	48(11.2%)	<0.001
Speech articulation deficit	732(39.5%)	485(44.5%)	445(37.0%)	<0.001	247(45.1%)	161(37.7%)	<0.001
Ideomotor apraxia	497(26.8%)	305(28.0%)	189(15.7%)	<0.001	192(35.0%)	140(32.7%)	<0.001
Constructional apraxia	171(9.2%)	109(10.0%)	77(6.4%)	<0.001	62(11.3%)	32(7.48)	<0.001
Tactile agnosia	143(7.7%)	86(7.9%)	56(4.7%)	<0.001	57(10.4%)	22(5.1%)	<0.001
Cortical sensory loss	112(6.0%)	89(8.2%)	42(3.5%)	<0.001	23(4.2%)	62(14.5%)	<0.001
Hemineglect	147(7.9%)	59(5.4%)	28(2.3%)	<0.001	88(16.1%)	64(15.0)	<0.001
Abnormal involuntary movement (tremor, dystonia, chorea etc. in affected limbs)	64(3.5%)	45(4.1%)	51(2.2%)	<0.001	19(3.5%)	11(2.6)	<0.001
Vibration/Joint position deficit	37(2.0%)	22(2.0%)	16(1.3%)	<0.001	15(2.7%)	7(1.6%)	<0.001
Cerebellar deficit	45(2.4%)	28(2.6%)	55(4.6%)	<0.001	17(3.1%)	19(4.4%)	<0.001
Pseudobulbar affectation	99(5.3%)	64(5.9%)	56(4.7%)	<0.001	35(6.4%)	12(2.8%)	<0.001
Intermitent claudication	34(1.8%)	29(2.7%)	37(3.1%)	<0.001	5(0.9%)	5(1.2%)	0.005
angina	32(1.7%)	21(1.9%)	25(2.1%)	<0.001	11(2.0%)	7(1.6%)	0.004
palpitation	133(7.2%)	93(8.5%)	145(12.1%)	<0.001	40(7.3%)	44(10.3%)	0.001
Differential warmth in extremities	58(3.1%)	12(1.1%)	5(0.4%)	0.105	46(8.4%)	32(7.5%)	0.368
Thickened arterial wall	481(25.9%)	336(30.8%)	360(30.0)	0.105	145(26.5%)	94(22.0)	0.073

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Locomotor brachialis	387(20.9%)	278(25.5%)	300(25.0)	0.205	109(19.9%)	69(16.1%)	0.068
Heaving apex	394(21.3%)	261(23.9%)	173(14.4%)	<0.001	133(24.3%)	78(18.2%)	0.028
Cardiac murmurs	101(5.5%)	80(7.3%)	36(3.0%)	<0.001	21(3.8%)	11(2.6%)	0.164
displaced apex	477(25.7%)	327(30.0%)	288(24.0%)	0.001	150(27.4%)	120(28.0%)	0.598
DVT	37(2.0%)	31(2.8%)	11(0.9%)	<0.001	6(1.1%)	3(0.7%)	0.248
Heart failure	52(2.8%)	47(4.3%)	33(2.8%)	0.021	5(0.9%)	3(0.7%)	0.365
Unequal carotid	26(1.4%)	18(1.7%)	16(1.3%)	0.082	8(1.5%)	3(0.7%)	0.059

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Table S6. Table showing the clinical presentation of participants by National Institutes of Health Stroke Scale score

Clinical Presentation	All severe stroke N=1027	Ischemic Stroke			Hemorrhagic stroke		
		Severe N=649	Not severe N=1283	p-value (Exact test)	Severe N=378	Not severe N=418	p-value (Exact test)
Headache at first presentation	429(41.8%)	232(35.8%)	477(37.2%)	0.546	197(52.1%)	264(63.2%)	0.004
Vomiting at first presentation	258(25.1%)	518(79.8%)	1098(85.6%)	0.001	143(37.8%)	130(31.1%)	0.039
Disturbed consciousness	590(57.5%)	335(51.6%)	337(26.3%)	<0.001	255(67.5%)	172(41.2%)	<0.001
Neck stiffness	121(11.8%)	50(7.7%)	80(6.2%)	0.213	71(18.8%)	53(12.7%)	0.017
Ictus occurred with activity	427(41.6%)	366(56.4%)	405(31.6%)	0.098	195(51.6%)	163(39.0%)	<0.001
Ictus occurred at rest	373(36.3%)	268(41.3%)	517(40.3%)	0.614	105(27.8%)	114(27.3%)	0.837
Focal neurological deficit	641(62.4%)	405(62.4%)	839(65.4%)	0.134	236(62.4%)	267(63.9%)	0.744
Disturbed speech	680(66.2%)	440(67.8%)	705(46.0)	<0.001	240(63.5)	216(51.7%)	<0.001
Paraesthsiae	119(11.6%)	79(12.2%)	1819(14.1%)	0.235	40(10.6%)	49(11.7%)	0.691
Ataxic gait	103(10.0%)	65(10.0%)	169(13.2%)	0.045	38(10.1%)	46(11.0%)	0.667
Seizure	111(10.8%)	68(10.5%)	93(7.3%)	0.017	43(11.4%)	38(9.1%)	0.266
Stroke affecting right	486(47.3%)	310(47.8%)	544(42.4%)	0.007	176(46.6%)	174(41.6%)	0.471
Stroke affects left	412(40.1%)	261(40.2%)	564(44.0)	0.007	151(40.0)	172(41.2%)	0.471
Stroke affecting both	90(8.8%)	56(8.6%)	69(5.4%)	0.007	34(9.0%)	29(6.9%)	0.471
Disability prior to stroke (Yes)	273(26.6%)	195(30.1%)	168(13.1%)	<0.001	78(20.6%)	34(8.1%)	<0.001
Gait(Normal)	168(16.4%)	104(16.0%)	254(19.8%)	0.013	64(16.9%)	88(21.1%)	0.353
Previous stroke	114(11.1%)	82(12.6%)	125(19.8%)	0.057	32(8.5%)	26(6.2%)	0.227

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Previous Transient Ischemic attack	82(8.0)	54(8.32)	143(11.2%)	0.138	28(7.4%)	22(5.3%)	0.043
Cranial nerve deficit	687(66.9%)	451(69.5%)	726(56.6%)	<0.001	236(62.4%)	219(52.4%)	0.001
Facial nerve deficit	739(72.0%)	475(73.2%)	723(56.4%)	<0.001	264(69.8%)	229(54.8%)	<0.001
Language deficit	605(58.9%)	386(59.5%)	345(26.9%)	<0.001	219(57.9%)	105(25.1%)	<0.001
Visual field deficit	238(23.2%)	150(23.1%)	100(7.8%)	<0.001	88(23.3%)	36(8.6%)	<0.001
Speech articulation deficit	542(52.8%)	349(53.8%)	461(35.9%)	<0.001	193(51.1%)	162(38.8%)	<0.001
Ideomotor apraxia	230(22.4%)	144(22.2%)	140(10.9%)	<0.001	86(22.8%)	49(11.7%)	<0.001
Constructional apraxia	144(14.0%)	93(14.3%)	70(5.5%)	<0.001	51(13.5%)	23(5.5%)	<0.001
Tactile agnosia	122(11.9%)	74(11.4%)	46(3.6%)	<0.001	48(12.7%)	11(2.6%)	<0.001
Cortical sensory loss	122(11.9%)	69(10.6%)	35(2.7%)	<0.001	53(14.0%)	15(3.6%)	<0.001
Hemineglect	122(11.9%)	70(10.8%)	55(4.3%)	<0.001	52(13.8%)	21(5.0%)	<0.001
Abnormal involuntary movement (tremor, dystonia, chorea etc. in affected limbs)	50(4.9%)	32(4.9%)	40(3.1%)	0.007	18(4.8%)	6(1.4%)	0.001
Vibration/Joint position deficit	27(2.6%)	14(2.2%)	17(1.3%)	<0.001	13(3.4%)	4(1.0%)	<0.001
Cerebellar deficit	42(4.1)	21(3.2%)	52(4.1%)	<0.001	21(5.6%)	13(3.1%)	<0.001
Pseudobulbar affectation	86(8.4%)	52(8.0%)	39(3.0%)	<0.001	34(9.0)	3(0.7%)	<0.001
Intermitent claudication	20(2.0)	16(2.5%)	40(3.1%)	<0.001	4(1.1%)	7(1.7%)	0.001
angina	17(1.7%)	12(1.9%)	26(2.0%)	<0.001	5(1.3%)	5(1.2%)	0.055
palpitation	87(8.5%)	50(7.7%)	153(11.9%)	<0.001	37(9.8%)	32(7.7%)	0.003
Differential warmth in extremities	29(2.8%)	23(3.5%)	34(2.7%)	0.489	6(1.6%)	3(0.7%)	0.248
Thickened arterial wall	280(27.3%)	177(27.3%)	388(30.2%)	0.075	103(27.3%)	81(19.4%)	0.015
Locomotor brachialis	203(19.8%)	127(19.6%)	332(25.9%)	0.038	76(20.1%)	58(13.9%)	0.001

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Heaving apex	229(22.3%)	137(21.1%)	193(15.0%)	0.002	92(24.3%)	70(16.8%)	0.013
Cardiac murmurs	48(4.7%)	39(6.0%)	49(3.8%)	0.030	9(2.4%)	13(3.1%)	0.469
displaced apex	289(28.1%)	188(29.0%)	300(23.4%)	0.025	101(26.7%)	103(24.6%)	0.463
DVT	17(1.7%)	14(2.2%)	15(1.18%)	0.076	3(0.8%)	3(0.7%)	0.693
Heart failure	30(2.9%)	26(4.0%)	35(2.7%)	0.146	4(1.1%)	3(0.7%)	0.544
Unequal carotid	17(1.7%)	12(1.9%)	17(1.3%)	0.050	5(1.3%)	3(0.7%)	0.657

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Table S7. Radiological determinants of severe Ischemic stroke patients by National Institutes of Health Stroke Scale score

Variables	Sub-variables	Ischemic stroke		p-value
		Severe N=649	Non-severe N=1283	
TOAST classification	Large artery arteriosclerosis	230 (35.5%)	359 (28%)	<0.001
	Cardio-embolism	61 (9.4%)	76 (6%)	
	small vessel occlusion	168 (25.9%)	478 (37.3%)	
	Other determined etiology	1 (0.2%)	4 (0.4%)	
	Undetermined etiology	120 (18.5%)	260 (20.3%)	
OCSP Subtype	TACI	125 (19.3%)	110 (8.6%)	<0.001
	PACI	205 (31.6%)	372 (29%)	
	POCI	54 (8.4%)	108 (8.5%)	
	LACI	189 (29.2%)	572 (44.6%)	
ASCO Subtype	Atherosclerosis	107 (16.5%)	212 (16.6%)	0.010
	Small vessel disease	203 (31.3%)	538 (42%)	
	Cardio embolism	82 (12.7)	130 (10.2%)	
	Other causes	12 (1.9%)	25 (2%)	

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Table S8. Echocardiographic determinant of severe stroke patients by National Institutes of Health Stroke Scale score

Variable	Non-severe ischemic stroke N=1283	Severe Ischaemic Stroke; f (%) N=649 N=418	p-value (Exact test)	Non-severe Hemorrhagic stroke N=428	Severe Haemorrhagic stroke; f (%) N=378	p-value (Exact test)
Sinus Arrythmia	25 (1.9)	18 (2.8%)	0.418	10 (2.3)	13 (3.5%)	0.392
Atrial Fibrillation	38 (3.0)	24 (3.7%)	0.588	1 (0.2)	1(0.3%)	1.000
Atrial Flutter(ECG determined)	4 (0.3)	6 (1.0%)`	0.180	0 (0.0)	0 (0%)	-
Atrial enlargement (Right/Left	38 (3.0)	24 (5.7)	0.580	1 (0.2)	1 (0.3)	0.236
Ejection fraction						
≤ 40%	57 (4.4)	33 (5.1%)		7 (14.0)	9 (2.4%)	
41-50%	71 (5.5)	26 (4.1%)	0.046	14 (3.3)	7 (1.9%)	0.254
≥51%	429 (32.8)	138 (21.3%)		95 (22.2)	53 (14.1%)	

Compared to corresponding table for SLS, less variables have significant results in this NIHSS results

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Table S9. Assessment of factors associated with stroke severity by National Institutes of Health Stroke Scale score

Risk Factor	All Severe Stroke	Severe Ischemic Stroke	Severe Hemorrhagic Stroke
Age	1.26(0.95 – 1.68)	1.42(0.94 – 2.16)	1.28(0.79 – 2.07)
Hypertension	1.35(0.69 - 2.62)	1.44(0.64 – 3.23)	1.76(0.29 – 10.55)
Dyslipidemia	1.09(0.77 – 1.53)	0.91(0.57 – 1.45)	1.72(0.95 – 3.11)
Diabetes mellitus	**0.76(0.59 – 0.98)**	0.89(0.65 – 1.22)	0.65(0.37 – 1.14)
Obesity	**0.74(0.55 – 0.98)**	0.75(0.50 – 1.10)	0.67(0.36 – 1.23)
Cigarette smoking	1.10(0.53 – 2.26)	**1.50(0.5 – 0.45)**	0.69(0.23 – 2.11)
Stress	0.83(0.60 – 1.15)	0.71(0.47 – 1.08)	1.19(0.64 – 2.18)
Cardiac disease	0.68(0.45 – 1.01)	0.75(0.48 – 1.19)	0.55(0.18 – 1.70)
Alcohol	0.76(0.56 – 1.03)	**0.61(0.40 – 0.93)**	0.74(0.43 – 1.27)
Meat consumption	1.31(0.92 – 1.86)	1.00(0.66 – 1.52)	3.65(1.66 – 8.00)
Low vegetable consumption	**2.54(1.97 – 3.28)**	**2.52(1.83 – 3.47)**	**3.38(2.02 – 5.67)**
Depression	1.34(0.84 – 2.12)	1.32(0.73 – 2.38)	1.63(0.68 – 3.85)
Physical inactivity	1.54(0.78 – 3.02)	1.40(0.63 – 3.14)	2.12(0.53 – 8.38)
Salt intake	1.03(0.67 – 1.57)	0.96(0.56 – 1.67)	0.87(0.41 – 1.84)
Right/Left Atrial	0.90(0.68 – 1.18)	0.88(0.61 – 1.25)	0.95(0.56 – 1.60)

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Table S10. Radiological determinants of severe stroke patients by National Institutes of Health Stroke Scale score

Variables	Sub-variables	Hemorrhagic stroke		p-value
		Severe N=378	Non-severe N=418	
Location of lesion	Lobal	73 (19.4%)	108(25.9%)	0.028
	Non-lobal	305 (80.7%)	310(74.2%)	
SMASH-U	Structural	8 (2.2%)	21 (5.1%)	
	Medication-related	0 (0%)	3 (0.8%)	0.054
	Amyloid Angiopathy	3 (0.8%)	1 (0.3%)	
	Systemic Disease	1 (0.3%)	3 (0.8%)	
	Hypertensive	307 (81.3%)	331 (79.2%)	
	Undetermined	10 (2.7%)	6 (1.5%)	

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Table S11. Assessment of factors associated with stroke severity by National Institutes of Health Stroke Scale score

	ALL STROKE	ISCHEMIC STROKE	ICH
	Adjusted OR (95% CI)	**Adjusted OR (95% CI)**	**Adjusted OR (95% CI)**
Right/Left Atrial Lesion Volume	0.94(0.59 – 1.52)	1.03(0.63 – 1.68)	0.92(0.45 – 1.88)
≥10	**2.00(1.29 – 3.11)**	1.45(0.79 – 2.68)	1.52(0.79 – 2.89)
≥30	**3.47(1.80 – 6.68)**	1.98(0.95 – 4.13)	**3.91(1.32 – 11.61)**
Systolic BP at presentation	1.00(0.99 – 1.01)	1.00(0.99 – 1.01)	1.00(0.99 – 1.01)
Fasting Glucose	**1.00(1.00 – 1.01)**	**1.00(1.00 – 1.01)**	**1.01(1.00 – 1.02)**
Neutrophil/lymphocyte ratio	1.00(0.99 – 1.01)	NA	NA
Stroke type ICH vs Ischemic	0.83(0.54 – 1.28)	NA	NA
Non-lobar vs lobar	NA	NA	1.13(0.55 – 2.29)
Causes of ICH, Hypertensive vs others	NA	NA	0.88(0.20 – 3.79)
Ischemic stroke subtypes	NA	NA	NA
OCSP] subtypes	NA		NA
LACI(Ref)	NA	1	NA
TACI	NA	**2.98(1.43 – 6.21)**	NA
PACI	NA	1.39(0.84 – 2.31)	NA
POCI	NA	1.44(0.73 – 2.82)	NA

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Table S12. Two-way interaction factors and low consumption of vegetables with Stroke severity by stroke levity scale

	ALL STROKE Adjusted OR (95% CI)	ISCHEMIC STROKE Adjusted OR (95% CI)	ICH Adjusted OR (95% CI)
Age	1.03(0.84 – 1.27)	0.88(0.66 – 1.18)	**1.47(1.04 – 2.08)**
Hypertension	**0.92(0.61 – 1.39)**	0.87(0.54 – 1.41)	1.73(0.55 – 5.48)
Dyslipidemia	**0.77(0.61 – 0.97)**	0.73(0.53 – 1.01)	0.85(0.55 – 1.29)
Meat consumption	1.41(1.08 – 1.83)	1.35(0.97 - 1.88)	**1.72(1.05 – 2.81)**
Low vegetable consumption	0.42(0.14 – 1.25)	0.32(0.09 – 1.17)	#
Depression	0.72(0.54 – 0.97)	0.68(0.47 – 0.98)	0.75(0.44 – 1.29)
Age * Low vegetable consumption	1.18(0.81 – 1.73)	**1.76(1.01 – 3.08)**	0.75(0.38 – 1.46)
Hypertension* Low vegetable consumption	1.97(0.78 – 5.00)	1.84(0.64 – 5.24)	#
Dyslipidemia* Low vegetable consumption	1.10(0.72 – 1.68)	1.23(0.68 – 2.21)	1.02(0.46 – 2.25)
Meat consumption* Low vegetable consumption	1.48(0.95 – 2.32)	1.26(0.73 – 2.17)	2.88 (1.16 – 7.16)
Depression* Low vegetable consumption	1.59(0.75 – 3.38)	1.60(0.67 – 3.80)	1.69(0.37 – 10.38)

 # Unstable odds ratio

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Table S13. Two-way interaction factors and low consumption of vegetables with Stroke severity by National Institutes of Health Stroke Scale score

	ALL STROKE Adjusted OR (95% CI)	ISCHEMIC STROKE Adjusted OR (95% CI)	ICH Adjusted OR (95% CI)
Age	**1.28(1.01 – 1.63)**	**1.58(1.09 - 2.28)**	1.44(0.97 – 2.13)
Hypertension	0.91(0.56 – 1.48)	0.76(0.42 – 1.37)	1.57(0.40 – 6.16)
Dyslipidemia	1.20(0.90 – 1.61)	1.07(0.70 – 1.63)	1.75(1.06 – 2.91)
Meat consumption	0.88(0.66 – 1.18)	**0.70(0.49 – 1.00)**	1.55(0.89 – 2.70)
Low vegetable consumption	0.44(0.12 – 1.64)	0.25(0.04 – 1.29)	#
Depression	1.30(0.94 – 1.81)	1.35(0.88 – 2.05)	1.36(0.75 – 2.47)
Age * Lesion Volume	1.11(0.73 – 1.69)	1.35(0.71 – 2.56)	0.80(0.40 – 1.59)
Hypertension* Lesion Volume	**3.40(1.11 – 10.45)**	**5.35(1.32 – 21.68)**	#
Dyslipidemia* Lesion Volume	0.64(0.40 – 1.03)	0.65(0.33 – 1.27)	0.61(0.26 – 1.41)
Meat consumption* Lesion Volume	**1.98(1.20 – 3.25)**	**2.37(1.29 – 4.32)**	2.13(0.77 – 5.93)
Depression* Lesion Volume	0.59(0.27 – 1.30)	0.48(0.19 – 1.21)	0.56(0.09 – 3.30)

 # Unstable odds ratio

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Table S14. Two-way interaction factors and lesion volume of vegetables with Stroke severity by stroke levity scale

	ALL STROKE Adjusted OR (95% CI)	ISCHEMIC STROKE Adjusted OR (95% CI)	ICH Adjusted OR (95% CI)
Age	0.86(0.54 – 1.35)	0.78(0.43 – 1.39)	1.12(0.51 – 2.48)
Hypertension	0.51(0.24 – 1.07)	0.56(0.24 – 1.30)	0.35(0.05 – 2.34)
Dyslipidemia	0.72(0.44 – 1.18)	0.60(0.33 – 1.08)	1.17(0.46 – 2.97)
Meat consumption	**2.32(1.41 – 3.83)**	**1.89(1.06 – 3.37)**	**4.95(1.67 – 14.65)**
Low vegetable consumption	1.19(0.78 – 1.81)	1.38(0.85 – 2.25)	0.90(0.39 – 2.10)
Depression	0.74(0.36 – 1.51)	0.75(0.32 – 1.74)	0.79(0.20 – 3.13)
Age * Lesion Volume	1.13(0.89 – 1.44)	1.18(0.85 – 1.63)	1.09(0.73 – 1.62)
Hypertension* Low vegetable consumption	**1.56(1.09 – 2.24)**	1.38(0.89 – 2.13)	**2.14(1.03 – 4.41)**
Dyslipidemia* Lesion Volume	1.09(0.83 – 1.42)	1.23(0.87 – 1.73)	0.87(0.54 – 1.40)
Meat consumption* Lesion Volume	0.83(0.63 – 1.10)	0.85(0.61 – 1.18)	0.67(0.38 – 1.17)
Low Vegetable consumption* Lesion Volume	1.16(0.92 – 1.46)	1.00(0.75 – 1.32)	1.45(0.94 – 2.25)
Depression* Lesion Volume	1.02(0.69 – 1.51)	0.99(0.61 – 1.62)	1.03(0.51 – 2.07)

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Table S15. Two-way interaction factors and lesion volume of vegetables with Stroke severity by National Institutes of Health Stroke Scale score

	ALL STROKE	ISCHEMIC STROKE	ICH
	Adjusted OR (95% CI)	**Adjusted OR (95% CI)**	**Adjusted OR (95% CI)**
Age	1.40(0.83 – 2.35)	1.63(0.81 – 3.29)	1.32(0.55 – 3.18)
Hypertension	0.50(0.21 – 1.19)	0.42(0.15 – 1.13)	0.51(0.06 – 4.26)
Dyslipidemia	0.92(0.52 – 1.63)	0.87(0.43 – 1.76)	1.24(0.43 – 3.51)
Meat consumption	1.49(0.84 – 2.62)	1.33(0.68 – 2.58)	2.67(0.82 – 8.75)
Low vegetable consumption	**1.98(1.26 – 3.11)**	**2.20(1.29 – 3.75)**	1.32(0.54 – 3.22)
Depression	1.36(0.61 – 3.02)	1.32(0.51 – 3.41)	1.61(0.34 – 7.50)
Age* Lesion Volume	0.96(0.74 – 1.26)	1.00(0.69 – 1.45)	1.02(0.66 – 1.58)
Hypertension* Low vegetable consumption	**1.90(1.26 – 2.88)**	**1.98(1.18 – 3.32)**	1.68(0.73 – 3.85)
Dyslipidemia* Lesion Volume	1.07(0.79 – 1.44)	1.01(0.68 – 1.50)	1.13(0.67 – 1.88)
Meat consumption* Lesion Volume	0.86(0.62 – 1.18)	0.81(0.55 – 1.18)	0.80(0.42 – 1.51)
Low Vegetable consumption* Lesion Volume	1.00(0.78 – 1.27)	0.95(0.70 – 1.28)	1.21(0.77 – 1.90)
Depression* Lesion Volume	1.01(0.64 – 1.58)	1.01(0.58 – 1.75)	0.98(0.42 – 2.28)

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Figure S1. Forest plot of the factors associated with ischaemic stroke severity by Stroke Levity Scale

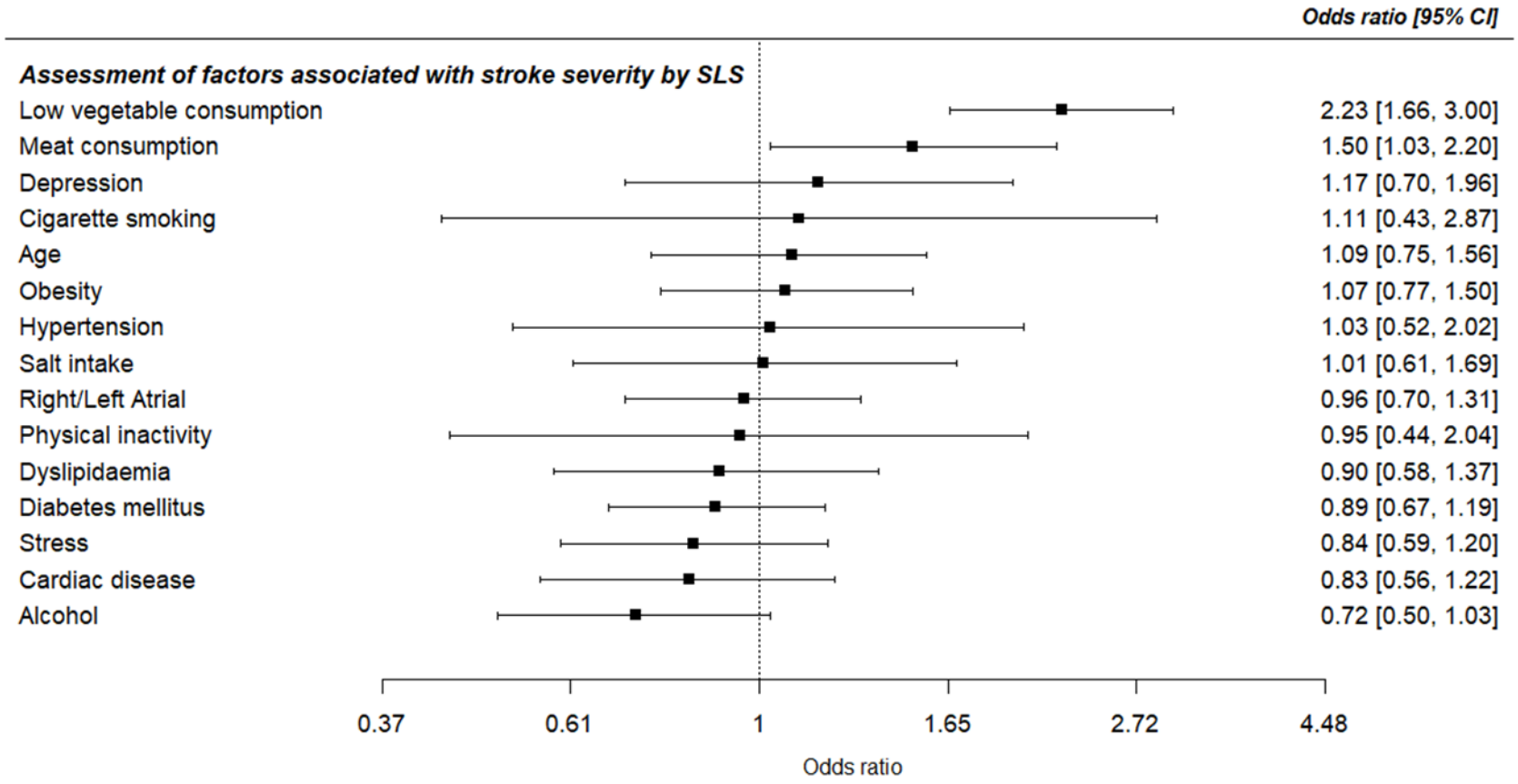

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Figure S2. Forest plot of the factors associated with hemorrhagic stroke severity by Stroke Levity Scale

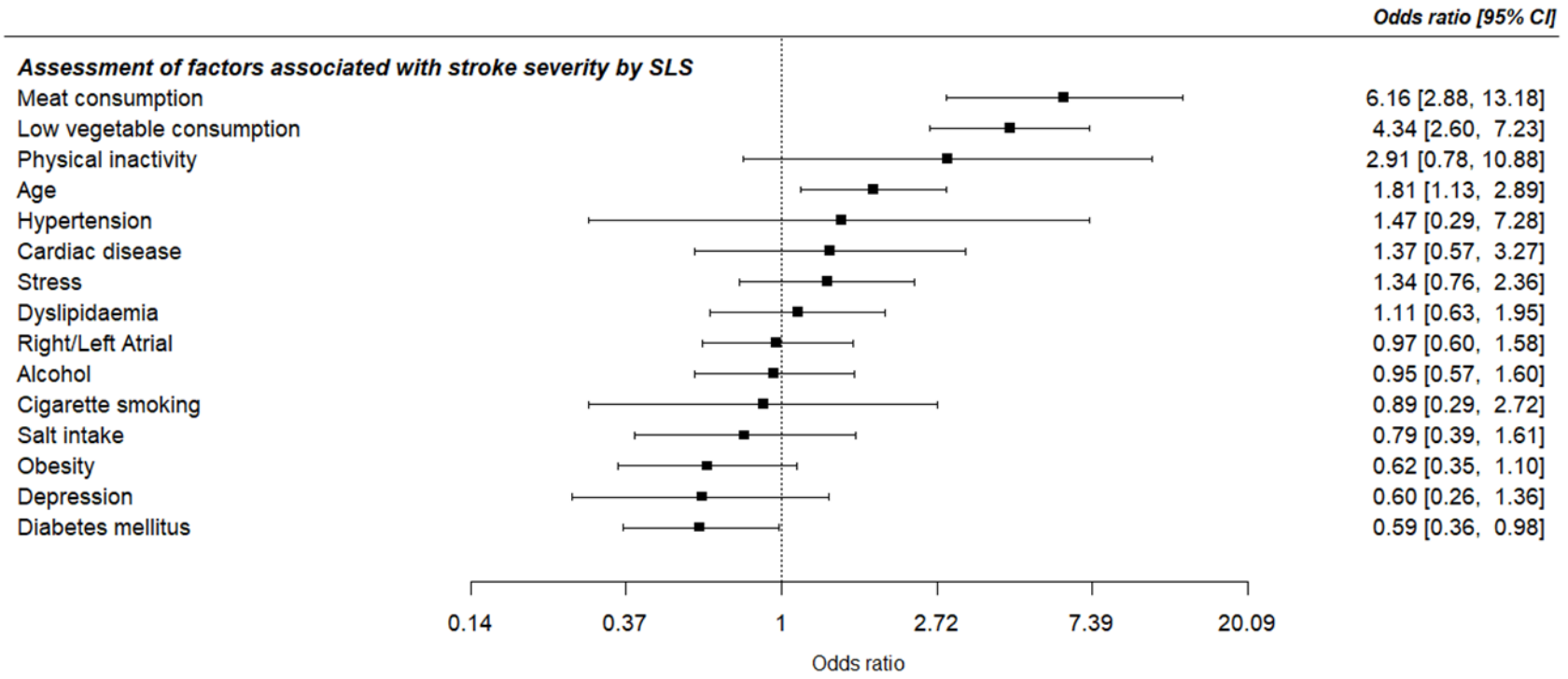

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Figure S3. Forest plot of the factors associated with ischemic stroke severity by Stroke Levity Scale

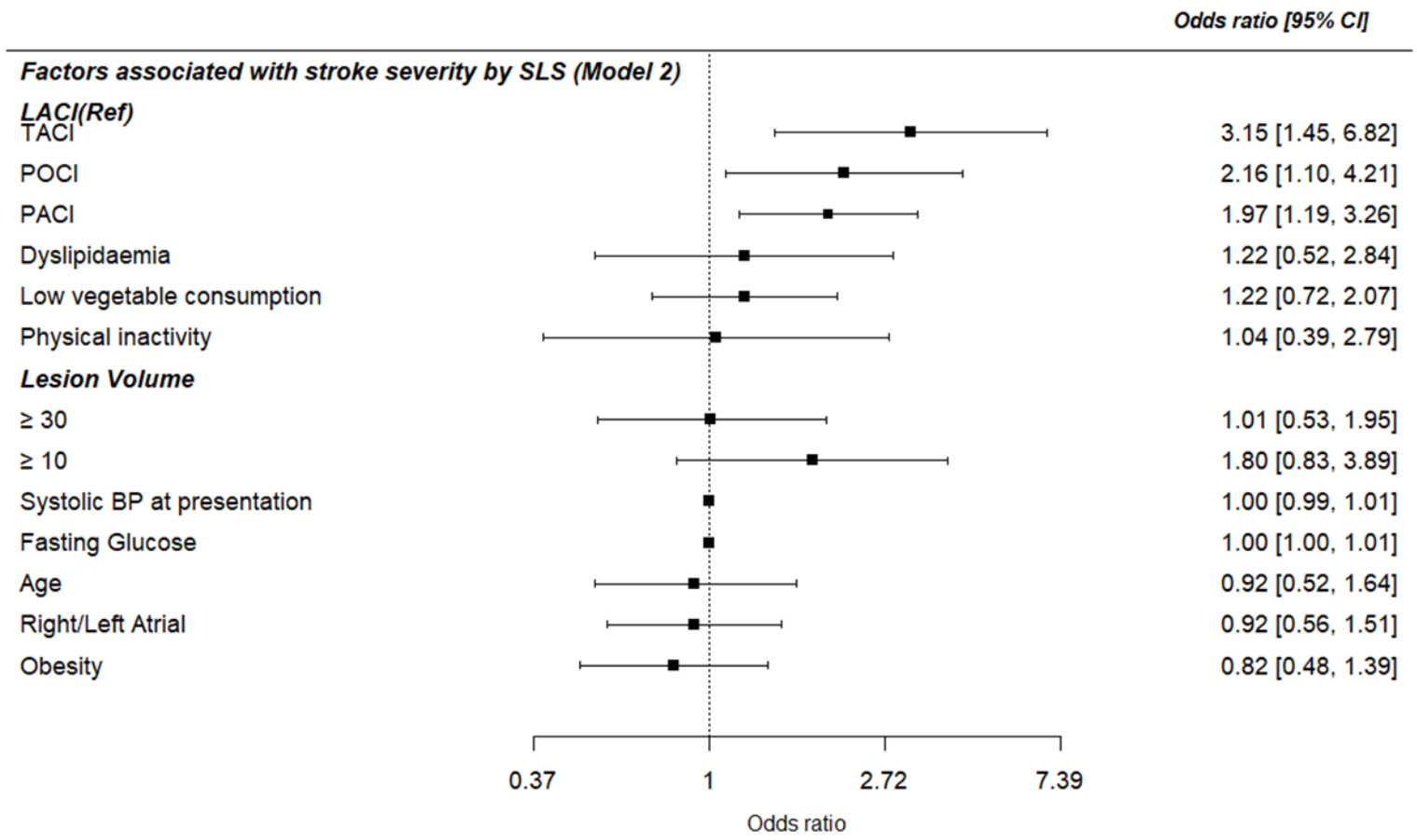

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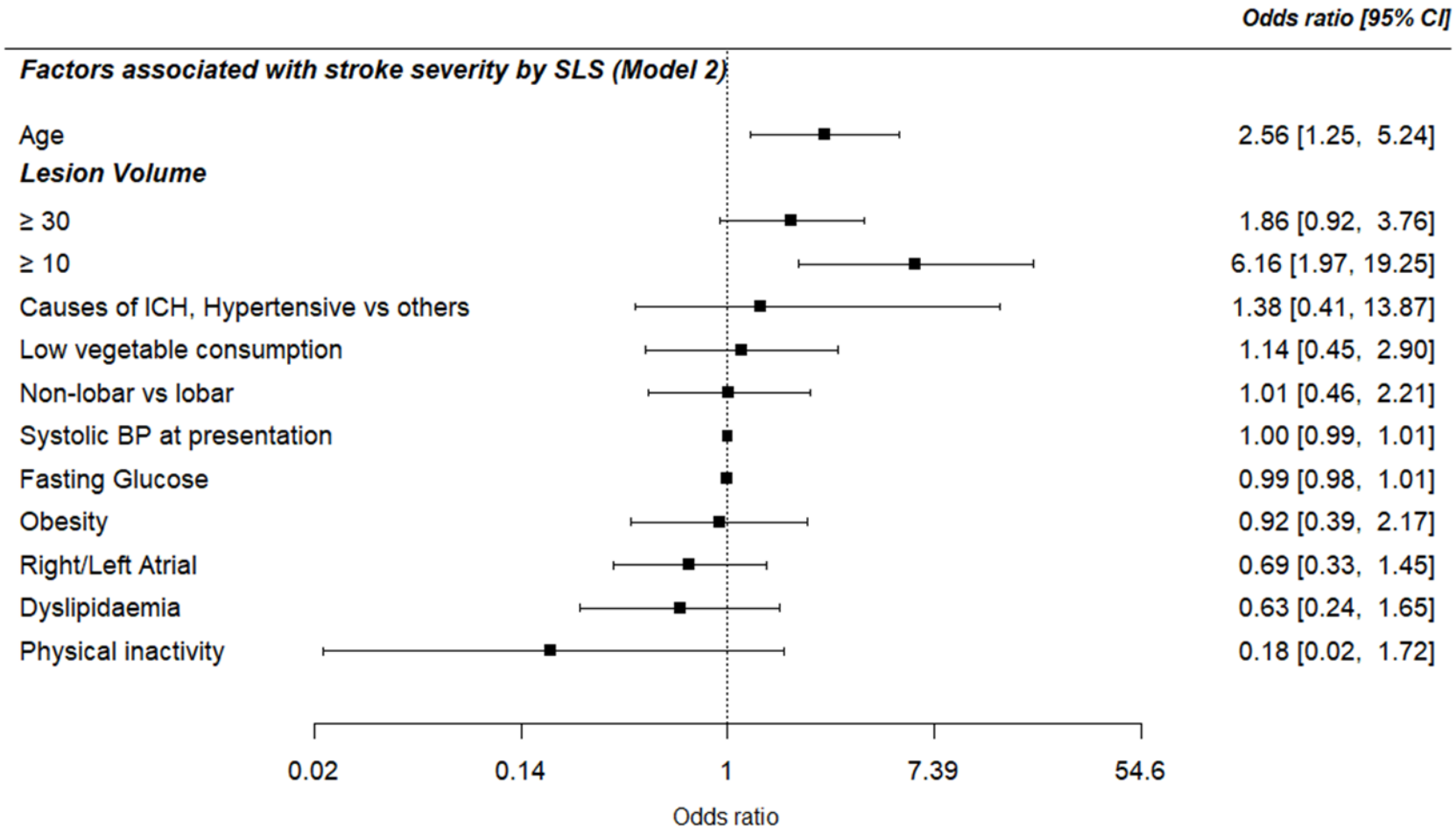
Figure S4. Forest plot of the factors associated with haemorrhagic stroke severity by Stroke Levity Scale



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