



## Clinical short communication

# Secondhand smoke exposure is independently associated with stroke among non-smoking adults in West Africa



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## ABSTRACT

**Background:** Stroke is a leading cause of disability and mortality worldwide, but little is known about the contribution of secondhand smoke exposure (SHSE) to stroke epidemiology among indigenous Africans.

**Objective:** To evaluate the association of SHSE with stroke among indigenous Africans.

**Methods:** We analyzed the relationship of SHSE with stroke among 2990 case-control pairs of adults who had never smoked (identified in the SIREN study) using conditional logistic regression at a two-sided  $P < 0.05$ .

**Results:** Multivariable-adjusted odds ratio and 95% confidence interval; 1.25 (1.04, 1.50;  $P = 0.02$ ) revealed SHSE was positively associated with stroke independent of stroke subtypes.

**Conclusion:** Culturally relevant primary prevention strategies targeted at SHSE might be promising in preventing stroke among Africans.

## 1. Introduction

Stroke is one of the most significant causes of disability and mortality worldwide [1,2], including among Africans [3,4]. Several studies have highlighted the significance of secondhand smoke exposure (SHSE) in vascular events [5–8], but this relationship is yet to be established among Africans. Characterizing the relationship between SHSE and stroke among Africans is likely to facilitate the design of culturally-

**Table 1**

Characteristics of all non-active smokers stratified by stroke status in the SIREN Study.

| Characteristics                         | Stroke status                   |                         | P-value |
|-----------------------------------------|---------------------------------|-------------------------|---------|
|                                         | Stroke-free controls (n = 2990) | Stroke Cases (n = 2990) |         |
| Country                                 |                                 |                         |         |
| Ghana                                   | 970 (32.4)                      | 913 (30.5)              |         |
| Nigeria                                 | 2020 (67.6)                     | 2077 (69.5)             |         |
| Sex                                     |                                 |                         |         |
| Females                                 | 1561 (52.2)                     | 1561 (52.2)             |         |
| Males                                   | 1429 (47.8)                     | 1429 (47.8)             |         |
| Age (years), mean $\pm$ SD              | 58.24 $\pm$ 14.08               | 59.23 $\pm$ 12.20       |         |
| <60 years                               | 1505 (50.3)                     | 1469 (49.1)             | 0.78    |
| $\geq$ 60 years                         | 1485 (49.7)                     | 1521 (50.9)             |         |
| Education                               |                                 |                         |         |
| None                                    | 706 (23.6)                      | 599 (20.0)              | <0.01   |
| Primary school                          | 746 (24.9)                      | 603 (20.2)              |         |
| Secondary school and above              | 1538 (51.4)                     | 1788 (59.8)             |         |
| Monthly Income                          |                                 |                         |         |
| < \$100                                 | 1858 (62.1)                     | 1416 (47.4)             | <0.01   |
| $\geq$ \$100                            | 1132 (37.9)                     | 1574 (52.6)             |         |
| Lifestyle factors                       |                                 |                         |         |
| Ever alcohol use (Yes)                  | 687 (23.0)                      | 745 (24.9)              | 0.08    |
| Family history of CVD                   | 718 (24.0)                      | 1078 (36.1)             | <0.01   |
| Physical inactivity                     | 79 (2.6)                        | 116 (3.9)               | 0.01    |
| WHR, mean $\pm$ SD                      | 0.91 $\pm$ 0.08                 | 0.94 $\pm$ 0.08         | <0.01   |
| WHR $\geq$ 0.90 (men) & 0.85 (women)    | 2107 (70.5)                     | 2514 (84.1)             | <0.01   |
| BMI (kg/m <sup>2</sup> ), mean $\pm$ SD | 26.31 $\pm$ 5.74                | 26.83 $\pm$ 5.34        | <0.01   |
| BMI $\geq$ 30 kg/m <sup>2</sup>         | 662 (22.1)                      | 659 (22.0)              | 0.93    |
| SBP (mmHg), mean $\pm$ SD               | 137.37 $\pm$ 24.44              | 158.80 $\pm$ 31.06      | <0.01   |
| DBP (mmHg), mean $\pm$ SD               | 83.03 $\pm$ 14.40               | 95.45 $\pm$ 18.32       | <0.01   |
| Diabetes (Yes)                          | 333 (11.1)                      | 1140 (38.1)             | <0.01   |
| Dyslipidemia (Yes)                      | 1688 (56.5)                     | 2471 (82.6)             | <0.01   |

Continuous data are presented as mean  $\pm$  standard deviation and compared using the t-test;

Categorical data are presented as n (%) and compared using the McNemar test.

relevant public health guidelines for mitigating the impact of SHSE on the burden of stroke among Africans. This study assessed the association of SHSE with stroke among West Africans from Ghana and Nigeria who had never smoked or used any form of tobacco product in their lifetime.

## 2. Materials and methods

All respondents in the current study had never smoked or used any form of tobacco. For this present report, we identified adults ( $\geq$  18 years); 2990 stroke case-control pairs matched for age ( $\pm$  5 years), sex and ethnicity in the Stroke Investigation Research and Educational Network (SIREN) study. Standardized instruments were administered to collect data on sociodemographic and lifestyle factors, anthropometry, and clinical examinations by skilled medical practitioners and trained personnel [3,9]. SHSE definition in this study was adapted from the self-report validated method suggested by the National Health Nutrition Examination Survey [10]. It was defined as self-reported exposure to smoke from a burning cigarette or exhaled from a smoker in any indoor area at least once a week in the last 12 months preceding the study or before the onset of stroke. Stroke was defined based on clinical evaluation and brain neuroimaging (computerized tomography or magnetic resonance imaging); electrocardiogram, transthoracic echocardiography, and carotid doppler ultrasound were carried out using standard operating procedures at each hospital site [3]. Controls were validated stroke-free adults recruited from catchment communities around the study hospitals where stroke cases reside [11]. Respondents' characteristics were compared between stroke cases and stroke-free controls using McNemar's test for categorical data and t-test for continuous data. Besides the matching for age, sex, and ethnicity, stepwise conditional regression models were used to estimate the adjusted odds ratio (OR) and 95% confidence interval (CI) for the risk of stroke by SHSE status, adjusting for the highest education completed, monthly income, alcohol use, physical inactivity, obesity, diabetes mellitus, systolic and diastolic blood pressures and dyslipidaemia. Similarly, we conducted subgroup analyses by stroke status (ischaemic or haemorrhagic), sex (female or male), age group (<60 years or  $\geq$  60 years) and country (Ghana or Nigeria). Test of interaction was conducted using a likelihood ratio test. All statistical analyses were carried out using IBM SPSS Statistics for Windows, version 21 (IBM Corporation, Armonk, NY USA) and R statistical program (version 3.6.2) at a two-sided  $P < 0.05$ .

## 3. Results

Stroke cases had higher rates of higher education and higher income than stroke-free controls (Table 1). Similarly, stroke cases had higher

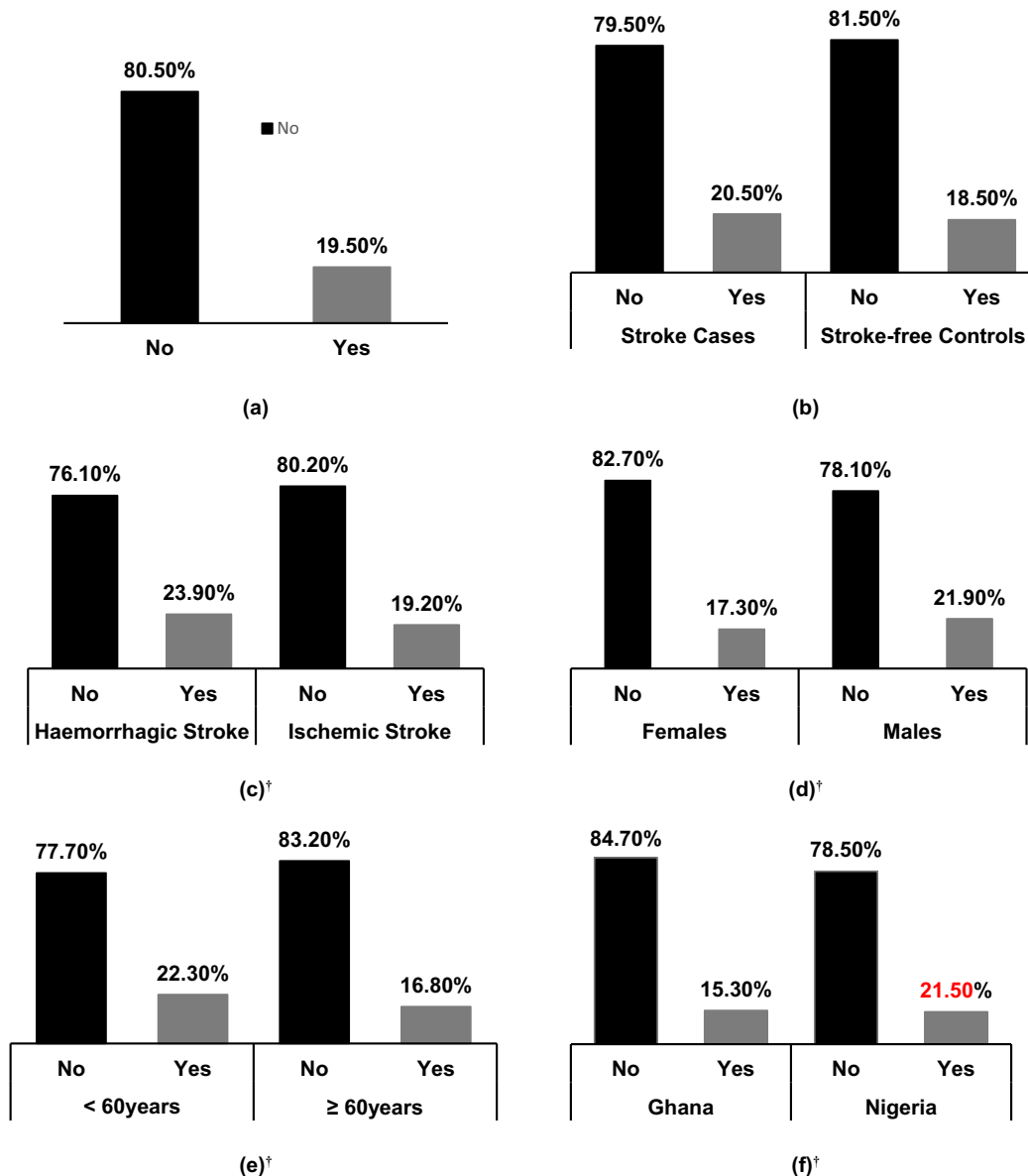


**Fig. 1.** Prevalence of SHSE in the entire sample (a), among cases and controls (b), stratified by stroke subtypes (c), sex (d), age groups (e) and country of residence (f) of respondents in the SIREN population. <sup>†</sup>Proportion of those with SHSE between the two groups was statistically different ( $P < 0.05$ ).

blood pressure profiles, with higher rates of physical inactivity, family history of cardiovascular diseases (CVD), abdominal obesity, DM and dyslipidemia than stroke-free controls. Overall (Fig. 1a), 19.5% of the entire sample had experienced SHSE. SHSE was more prevalent among stroke cases than among stroke-free controls (Fig. 1b), but this difference was statistically insignificant (20.5% vs 18.5%,  $P > 0.05$ ). There were significant differences based on stroke type (haemorrhagic stroke 23.9% vs ischemic stroke 19.2%  $P < 0.01$ , Fig. 1c), sex (females 17.3% vs males 21.9%,  $P < 0.01$ , Fig. 1d), age groups (<60 years 22.3% vs ≥60 years 16.8%,  $P < 0.01$ , Fig. 1e) and country of residence (Ghana 15.3% vs Nigeria 21.5%,  $P < 0.01$ , Fig. 1f).

SHSE was independently associated with higher odds of stroke after adjusting for multiple covariates (Fig. 2); OR: 1.25, 95% CI: 1.04, 1.50;  $P = 0.02$ . The association remained after stratifying by stroke subtypes, haemorrhagic stroke; OR: 1.53, 95% CI: 1.07, 2.18;  $P = 0.02$ , but was statistically insignificant for ischaemic stroke; OR: 1.14, 95% CI: 0.91, 1.42;  $P = 0.24$ , ( $P$  for Interaction = 0.05). Also, SHSE was associated with higher odds of stroke among males, OR: 1.41, 95% CI: 1.07, 1.84;  $P =$

0.01, but not among females, OR: 1.09, 95% CI: 0.84, 1.42;  $P = 0.49$ , ( $P$  for Interaction = 0.29). Similarly, SHSE was associated with higher odds of stroke among ≥60 years, OR: 1.33, 95% CI: 1.02, 1.75;  $P = 0.04$ , but not among <60 years, OR: 1.16, 95% CI: 0.88, 1.53;  $P = 0.28$ , ( $P$  for Interaction = 0.29). In the country-stratified analyses, we observed higher stroke odds among respondents from Ghana, OR: 1.45, 95% CI: 1.02, 2.04;  $P = 0.04$ , but not among those in Nigeria, OR: 1.01, 95% CI: 0.79, 1.28;  $P = 0.92$ , ( $P$  for Interaction < 0.01).

#### 4. Discussion

This study tested the relationship between SHSE and stroke among indigenous West Africans who had never smoked in a lifetime and found SHSE was independently associated with the risk of all stroke events in a relationship driven by haemorrhagic strokes. To our understanding, our study is the first to test the relationship between SHSE and stroke in an indigenous African population. The significance of our findings cannot be underestimated in designing culturally relevant primary prevention

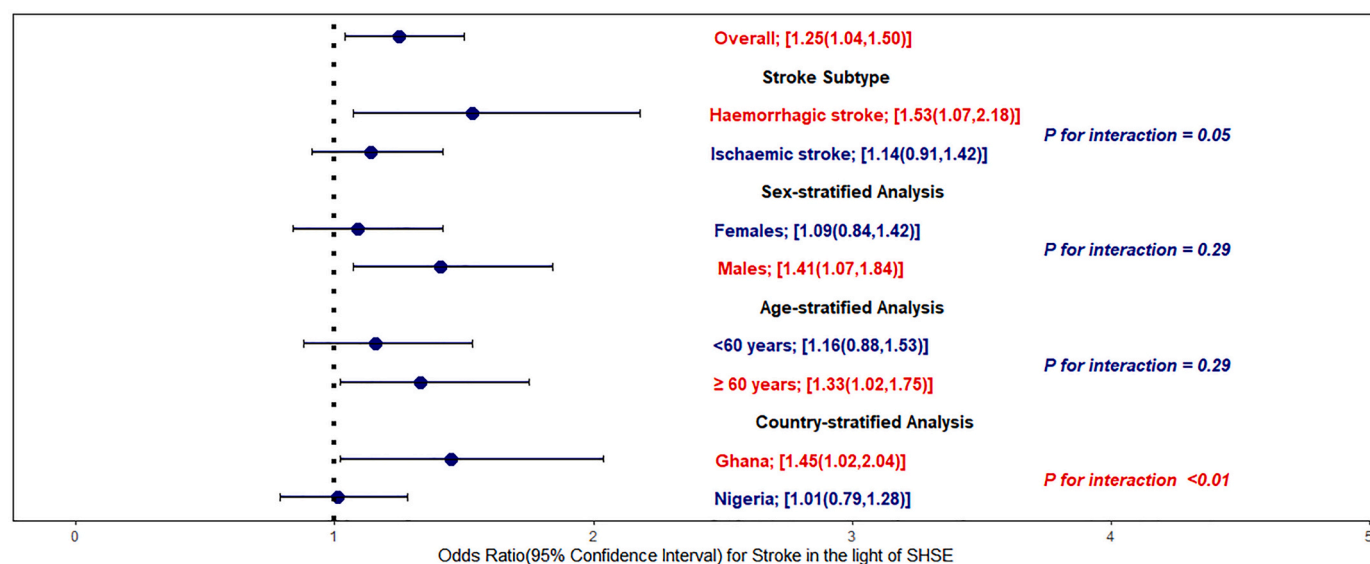


**Fig. 2.** Full model of the conditional logistic regression adjusting for highest education completed (none, primary school and above), monthly income (<\$100, ≥\$100), ever used alcohol (no, yes), physical Inactivity (no, yes), obesity (<30 kg/m<sup>2</sup>, ≥ 30 kg/m<sup>2</sup>), diabetes (no, yes), SBP (in mmHg, continuous), DBP (in mmHg, continuous) and dyslipidaemia (no, yes).

strategies for stroke and CVD management among African populations. Some reports have documented the significance of active smoking in the epidemiology of CVD events [12,13], with limited evidence alluding to the implications of SHSE in stroke outcomes, especially among never smokers. Our findings mirrored conclusions from earlier observational studies [5–8]. For example, a population-based, longitudinal study in the United States found that SHSE accounted for a 30% increase in the overall risk of stroke [5]. Another longitudinal study in Britain reported a raised risk of myocardial infarction among never-smokers who lived with a smoker [14]. Similarly, two separate meta-analyses observed that SHSE was positively related to the risk of stroke [6,15].

Furthermore, SHSE has been linked with cognitive dysfunction [6], depressive symptoms [16], hypertension [17], impaired lipid metabolism [18] and heart failure [19]. Contrary to earlier reports [5–8], our study found a statistically insignificant positive association between SHSE and ischaemic stroke. This observation is likely driven by difference(s) in study design, SHSE assessment or perhaps statistically underpowered to detect an association rather than physiologic differences across populations. Also, our results revealed no evidence of interaction for the results by stroke subtypes, sex, or age group, but not by country of residence. Similarly, the interaction by country is unlikely due to racial, regional or environmental differences, but the degree of SHSE exposure might differ in both countries. Our study did not assess the magnitude of SHSE, which might be a reason for the absence of the statistically significant association between SHSE and ischemic stroke. The impact of SHSE on stroke events may be attributable to the apparent effect of smoke exposure on stroke and CVD outcome [8,12,13]. Similarly, SHSE has been linked to vascular dysfunction [20,21]. Also, nicotine is a principal constituent of smoke with a potential pharmacologic consequence that could induce the sympathetic nervous system to release catecholamines [22], which has been linked to the aggravated collapse of the blood-brain barrier and, consequently, severe stroke [23]. SHSE is a proxy for vulnerability to deprived living conditions [24] unconsidered in this study. Perhaps our findings offer insight into the significance of living conditions, quality of life and other unmeasured proximal and distal factors among Africans likely to be critical in stroke epidemiology and care. Still, public health interventions might be necessary to protect vulnerable populations from SHSE to reduce the snowballing burden of stroke and CVD among Africans.

There are some limitations in this study worth mentioning. First,

circulating cotinine levels is the gold standard for validating SHSE. Using self-reports might be subjective and very likely to underestimate the actual exposure. We did not determine the degree of SHSE, which would have better described the association between SHSE and stroke. Second, cognitive impairment might likely bias responses from older respondents, particularly after stroke, but key informants were at hand to validate/offering pertinent information on behalf of respondents where required. This study's strength includes the physician-adjudicated stroke definition, the large sample size, the multi-country sampling approach, the multivariate adjustment for potential confounders based on the clinical understanding of stroke and being the first to report these findings in an indigenous African population. Future longitudinal studies should consider discerning the magnitude and duration of SHSE among Africans.

## 5. Conclusion

Habitual exposure to SHSE may likely promote stroke risk among West Africans. Culturally relevant interventions such as public health education and policies targeted at managing SHSE might be necessary for the primary prevention of stroke among indigenous Africans.

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## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence

the work reported in this paper. The SIREN study was a multi-centre case-control study among West Africans from Nigeria and Ghana. The overall coordinating Institutional Review Board (IRB) for the SIREN study was the University of Ibadan/University College Hospital Ibadan, Nigeria (UI/EC/13/0105). IRB at all study sites approved the study, and all respondents provided written informed consent before participation in the study.

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