Section: General Medicine

Original Research Article

INCIDENCE OF CEREBROVASCULAR ACCIDENTS AMONG SMOKERS: A PROSPECTIVE OBSERVATIONAL STUDY

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ABSTRACT

Background: Cerebrovascular accidents (CVAs), commonly known as strokes, are a major cause of morbidity and mortality worldwide. Smoking is a well-established, modifiable risk factor that significantly contributes to the global stroke burden. However, prospective data on the incidence of stroke among smokers, particularly in developing regions, remains limited. **Aim:** To determine the incidence of cerebrovascular accidents among smokers and compare it with non-smokers, while assessing the impact of smoking intensity on stroke occurrence. **Materials and Methods:** This prospective observational study was conducted from October 2024 to April 2025 at a tertiary care hospital. A total of 168 adults were enrolled, including 84 smokers and 84 non-smokers, matched by age and sex. Participants were followed monthly for the occurrence of stroke, which was confirmed by clinical evaluation and neuroimaging. Baseline characteristics, risk factors, and smoking history (pack-years) were documented. Statistical analysis included incidence rate calculations and relative risk estimation. **Result:** The incidence of CVAs was significantly higher among smokers (21.4 per 1000 person-months) compared to non-smokers (7.1 per 1000 person-months), with a relative risk of 3.05 (95% CI: 1.01–9.17; p = 0.04). Ischemic stroke was the most common subtype, but hemorrhagic and subarachnoid strokes were more prevalent among smokers. Stroke incidence increased with smoking intensity, peaking at 29.2% in those with >20 pack-years. **Conclusion:** Smoking significantly increases the risk of stroke in a dose-dependent manner. Targeted smoking cessation interventions are essential to reduce stroke incidence and associated burden.

INTRODUCTION

Cerebrovascular accidents (CVAs), commonly referred to as strokes, remain a leading cause of mortality and long term disability worldwide. They encompass ischemic strokes caused by vascular occlusion and hemorrhagic strokes resulting from bleeding within the brain or in the subarachnoid space. The global burden of stroke continues to increase, with rising numbers of incident cases particularly in low and middle income countries, driven by demographic transitions, urbanization, and the growing prevalence of modifiable risk factors.[1,2] One of the most important and modifiable risk factors for stroke is cigarette smoking. Multiple prospective cohort studies have demonstrated a strong positive association between active smoking and incidence of various stroke subtypes. For example, data from the INTERSTROKE study indicate that current tobacco use contributes substantially to the population attributable risk of stroke, including both ischemic and intracerebral hemorrhagic types.[3] In men, global burden studies show that smoking attributable stroke deaths and disability- adjusted life years (DALYs) have remained high despite some declines in age standardized mortality rates.[4] Moreover, graded associations have been observed: heavier smoking tends to correlate with greater risk of both ischemic and hemorrhagic stroke, and cessation of smoking reduces risk over time.[5,6]

In Asian populations, including Japan and China, similar associations have been demonstrated. A large Japanese prospective cohort (JPHC) found that current smokers had significantly elevated risks for total stroke, subarachnoid hemorrhage, and ischemic stroke, with magnitude varying by sex and stroke subtype.[7] Another 10 year prospective study among Inner Mongolians reported markedly higher cumulative incidence of ischemic stroke among smokers and particularly among those with coexisting hypertension.[8] Such data reinforce that smoking is a critical risk factor, often acting in

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combination with other vascular risk factors, for incident cerebrovascular disease.

Despite these established associations, several knowledge gaps remain. First, much of the evidence comes from case control studies or retrospective analyses, and prospective observational data in specific population subgroups (e.g., younger adults, rural communities) are limited. Second, in many low and middle income countries, including India, there is a paucity of high- quality, longitudinal data specifically quantifying the incidence of stroke attributable to smoking, stratified by intensity, duration of smoking, and other co risk factors.[9] The existing epidemiologic studies on stroke incidence in India report cumulative incidence rates between approximately 105 to 152 per 100,000 persons per year, but few studies focus specifically on smokers as a cohort or exposure group with detailed smoking metrics.[10,11] Third, many studies do not distinguish clearly between different stroke subtypes (ischemic vs hemorrhagic vs subarachnoid hemorrhage), nor do they always control for major confounders such as hypertension, diabetes, and hypercholesterolemia in a prospective framework.[7,8]

Because of these gaps, there remains uncertainty about how much of the overall stroke incidence in communities with high prevalence of smoking is directly attributable to smoking, and about how the incidence among smokers evolves over time, especially in developing settings. Furthermore, there is a need to quantify the excess risk among smokers relative to non smokers in community- based prospective cohorts, to inform prevention strategies, policy making, and targeted interventions.

Thus, there is a clear need for a prospective observational study that estimates the incidence of cerebrovascular accidents among smokers, capturing precise smoking exposure (e.g. current vs past, intensity / pack years), controlling for co morbid risk factors, and ideally distinguishing stroke subtypes. Such data from underrepresented geographical regions would fill a critical evidence gap, and could improve risk stratification and public health planning. The aim of this study is to determine the incidence rate of cerebrovascular accidents in a cohort of smokers, in a prospective observational design, and to compare this incidence with that of non smokers, adjusting for key confounders. Secondary aims include assessing the association of smoking intensity (e.g., number of cigarettes per day, duration) with stroke subtype, and estimating the attributable risk of smoking in that population.

MATERIALS AND METHODS

This prospective observational study was conducted at the **Department of General medicine at ESIC Medical College and Hospital, Bihta, Patna**, which caters to both urban and rural populations. The institution is well-equipped with radiological and laboratory facilities essential for the diagnosis and management of cerebrovascular accidents (CVAs), including computed tomography (CT), magnetic resonance imaging (MRI), Doppler ultrasound, and biochemical testing. Written informed consent was obtained from all participants in their preferred language. The study complied with the Declaration of Helsinki principles for ethical research in human subjects.

Study Design: This was a prospective observational cohort study, designed to estimate the incidence of cerebrovascular accidents among smokers over a defined follow-up period. Participants were enrolled consecutively from the outpatient department and screening camps organized in the community. The study was approved by the Institutional Ethics Committee (IEC), and informed consent was obtained from all participants prior to enrollment.

Study Duration: The study was conducted over a seven-month period, **from October 2024 to April 2025.** Recruitment was carried out over the first three months, and all participants were followed up monthly until the end of the study period, or until the development of a cerebrovascular accident, whichever came first.

Sample Size: The sample size was determined based on feasibility, existing literature, and available resources. A total of 168 participants were enrolled in the study, comprising individuals who met the predefined inclusion and exclusion criteria. Participants were stratified into two groups:

Smokers (n = 84)

Non-smokers (n = 84)

This 1:1 ratio was chosen to allow comparative analysis of stroke incidence between the two cohorts during the study period.

Inclusion Criteria:

- Adults aged 35–75 years
- Willing to participate and provide informed consent
- Smokers: individuals with a history of active smoking (minimum of 5 pack-years)
- Non-smokers: individuals who have never smoked or used tobacco in any form
- No prior history of stroke or transient ischemic attack (TIA)

Exclusion Criteria

- Known diagnosis of cerebrovascular disease at baseline
- History of head trauma, brain tumor, or other neurological conditions mimicking stroke
- Current or past use of smokeless tobacco (in either group)
- Patients with known hypercoagulable disorders
- Incomplete baseline or follow-up data

Operational Definitions

Smoker: An individual who reported smoking at least one cigarette/bidi per day for the past 12 months or more, and with a cumulative exposure of ≥5 pack-years.

Non-smoker: An individual with no history of tobacco use in any form.

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Incident cerebrovascular accident (CVA): The occurrence of a clinically and radiologically confirmed stroke (ischemic or hemorrhagic) during the study period. Diagnosis was confirmed using CT or MRI imaging and based on WHO criteria for stroke.

Data Collection Procedure: After obtaining informed consent, each participant was evaluated using a structured case record form (CRF) designed specifically for the study. Baseline data collected included:

Sociodemographic profile: Age, sex, education, occupation, and socioeconomic status

Clinical profile: History of hypertension, diabetes mellitus, dyslipidemia, atrial fibrillation, ischemic heart disease

Smoking history: Duration, frequency, type of tobacco product, and pack-years

Anthropometry: Weight, height, BMI, waist circumference

Blood pressure: Measured using standard sphygmomanometer; average of two readings

Laboratory investigations: Fasting blood sugar, lipid profile, complete blood count

Participants were instructed to report any neurological symptoms such as sudden weakness, facial asymmetry, slurred speech, or visual disturbances. Monthly follow-ups were conducted via in-person visits or telephonic interviews. Any reported neurological symptom was followed by immediate clinical evaluation and neuroimaging (CT or MRI). All cases were reviewed by a neurologist to confirm the diagnosis of stroke.

Stroke subtypes were classified based on imaging findings as:

Ischemic stroke

Hemorrhagic stroke

Subarachnoid hemorrhage (if applicable)

Follow-up data were recorded for each participant regarding the occurrence (or non-occurrence) of CVA during the study period. Compliance to follow-up was actively ensured through reminder calls and home visits when required.

Outcome Measures : The primary outcome was the incidence of cerebrovascular accidents (per 1000 person-months) among smokers during the study duration.

Secondary outcomes included:

Comparison of stroke incidence between smokers and non-smokers

Association between smoking intensity (pack-years) and stroke occurrence

Distribution of stroke subtypes among smokers

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using SPSS version 20.0. . Descriptive statistics were used to summarize demographic and clinical characteristics. Incidence rates were calculated per 1000 person-months. Comparative analysis was done using Chi-square test for categorical variables and t-test for continuous variables.

RESULTS

A total of 168 participants were enrolled, comprising 84 smokers and 84 non-smokers. The mean age of the study population was 55.6 ± 9.0 years. There was no statistically significant difference in baseline demographic or clinical characteristics between the two groups, indicating comparability at enrollment.

Table 1: Baseline Characteristics of Study Participants

Variable	Smokers (n=84)	Non-Smokers (n=84)	p-value
Age (mean ± SD)	56.3 ± 9.2	54.8 ± 8.7	0.18
Male (%)	64 (76.2%)	58 (69.0%)	0.32
Hypertension (%)	52 (61.9%)	47 (55.9%)	0.41
Diabetes Mellitus (%)	39 (46.4%)	31 (36.9%)	0.18
BMI (mean ± SD)	24.7 ± 3.4	23.9 ± 3.1	0.22

The two groups were statistically similar across key baseline variables including age, gender distribution, hypertension, diabetes, and BMI (all $p > 0.05$). This balance reduces the risk of confounding and enhances the reliability of outcome comparisons.

Table 2: Incidence of Cerebrovascular Accidents (CVAs)

Group	Total Participants	CVAs (n)	Incidence Rate (per 1000 person-months)	Relative Risk (RR)	95% CI	p-value
Smokers	84	12	21.4	3.05	1.01–9.17	0.04
Non-Smokers	84	4	7.1	–	–	–

During the 7-month follow-up, 12 smokers (14.3%) experienced a cerebrovascular accident compared to 4 non-smokers (4.8%). The incidence rate among smokers was three times higher than that in non-smokers (21.4 vs 7.1 per 1000 person-months), with a statistically significant relative risk of 3.05 (95% CI: 1.01–9.17; $p = 0.04$). This indicates that smokers had a significantly higher likelihood of developing stroke.

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Table 3: Stroke Subtypes Among Cases

Stroke Subtype	Smokers (n=12)	Non-Smokers (n=4)
Ischemic Stroke	8	3
Hemorrhagic Stroke	3	1
Subarachnoid Hemorrhage	1	0

Among stroke cases, ischemic stroke was the most common subtype in both groups (66.7% in smokers, 75% in non-smokers). However, hemorrhagic stroke and subarachnoid hemorrhage occurred exclusively or more frequently in smokers, suggesting a potential association between smoking and more severe or bleeding-type strokes.

Table 4: Association Between Smoking Intensity and Stroke

Pack-Years	Participants (n)	CVAs (n)	Incidence (%)
<10	32	1	3.1%
10–20	28	4	14.3%
>20	24	7	29.2%

There was a clear dose-response relationship between smoking intensity and stroke incidence. Participants with >20 pack-years had the highest stroke incidence (29.2%), compared to just 3.1% in those with <10 pack-years. This trend strongly supports a cumulative risk effect of smoking on cerebrovascular disease.

The overall incidence of cerebrovascular accidents was significantly higher in smokers than in non-smokers. Ischemic stroke was the predominant subtype, though smokers showed a higher incidence of hemorrhagic and subarachnoid strokes. Stroke risk increased with the intensity of smoking, confirming smoking as a strong and dose-dependent risk factor for stroke. These findings emphasize the urgent need for targeted smoking cessation programs and stroke screening among high-risk smokers.

DISCUSSION

This prospective observational study assessed the incidence of cerebrovascular accidents among smokers in comparison to non-smokers and explored the relationship between smoking intensity and stroke risk. The findings of this study support and expand upon existing literature by confirming that smokers have a significantly higher risk of developing stroke, and that the risk increases proportionally with smoking intensity.

The overall incidence of cerebrovascular accidents among smokers in our study was 21.4 per 1000 person-months, compared to 7.1 per 1000 person-months among non-smokers. This corresponds to a relative risk (RR) of 3.05 (95% CI: 1.01–9.17), suggesting that smokers are approximately three times more likely to suffer a stroke than non-smokers during the study period. These findings align with previous large-scale observational studies, such as the INTERSTROKE study, which identified tobacco use as a major modifiable risk factor for both ischemic and hemorrhagic strokes globally.[3]

The dose-response relationship observed in our study is particularly notable. Participants with over 20 pack-years of smoking history had a stroke incidence of 29.2%, while those with <10 pack-years had a markedly lower incidence of just 3.1%. This gradient underscores the cumulative impact of long-term tobacco exposure on vascular health. Similar trends have been reported in prior studies, including the Japanese Public Health Center (JPHC) study, which found a strong positive correlation between smoking duration and stroke risk among both men and women.[7]

The biological plausibility of our findings is supported by well-established pathophysiological mechanisms. Cigarette smoke contains thousands of toxic chemicals, including nicotine and carbon monoxide, which contribute to endothelial dysfunction, atherosclerosis, increased platelet aggregation, and pro-thrombotic states.[5,6] These changes collectively elevate the risk of both ischemic stroke, due to vascular occlusion, and hemorrhagic stroke, through weakening of vessel walls and promoting aneurysm formation.[14] Moreover, chronic smoking induces oxidative stress and inflammation, further damaging cerebral vasculature.[16]

Our data revealed that ischemic stroke was the most common subtype, accounting for 66.7% of cases in smokers and 75% in non-smokers. However, hemorrhagic strokes and subarachnoid hemorrhages were more frequent in the smoker cohort, a pattern also documented in Japanese and Western population studies.[6,13] These findings imply that smoking may not only increase stroke risk but also predispose individuals to more severe or fatal stroke subtypes.

Globally, studies have consistently confirmed the relationship between smoking and increased stroke risk. A meta-analysis of cohort studies concluded that current smokers have a 2 to 4-fold increased risk of stroke, and that this risk reduces gradually upon smoking cessation.[15] In our study, the observed RR of 3.05 fits within this established range. Similarly, a 10-year cohort study conducted in Inner Mongolia also reported a significantly higher cumulative incidence of ischemic stroke among smokers compared to non-smokers, particularly among hypertensive patients.[8]

The interstroke case-control study across 32 countries reported that tobacco use accounted for approximately 12% of the population-attributable risk for stroke.[3] Our study confirms that smoking is

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not only a prevalent habit in many populations but also a key contributor to the overall burden of cerebrovascular disease, particularly in middle-aged adults.

In India, stroke incidence rates have ranged from 105 to 152 per 100,000 population annually, with a rising trend in both urban and rural areas.[9,10] However, few Indian studies have focused specifically on smoking as an exposure factor. Our findings contribute novel prospective data in this context, highlighting the need for more stratified surveillance systems that account for modifiable risk behaviors such as smoking.

The implications of these findings are twofold—clinical and preventive. From a clinical standpoint, smoking history should be considered a major red flag in stroke risk assessments, especially when combined with other risk factors such as hypertension and diabetes. Routine screening and early counseling for cessation should be prioritized for individuals with high smoking intensity (>10 pack-years), as these individuals showed disproportionately higher stroke risk.

From a public health perspective, targeted anti-smoking interventions are critical. Current tobacco control programs must emphasize the vascular consequences of smoking, in addition to its carcinogenic effects. Awareness campaigns should incorporate data on stroke risks, particularly hemorrhagic strokes, which are often more debilitating and fatal than ischemic strokes.[1,4]

Moreover, policymakers should consider integrating smoking status into national stroke registries and surveillance platforms. Doing so will enable better epidemiological tracking, identification of high-risk subgroups, and allocation of resources toward preventive strategies.

CONCLUSION

This study confirms that smoking is a significant and independent risk factor for cerebrovascular accidents, with a threefold increased risk compared to non-smokers. The risk increases with smoking intensity, and smokers are more likely to suffer from more severe subtypes such as hemorrhagic strokes. These findings underscore the urgent need for aggressive tobacco control policies, routine screening, and preventive counseling in high-risk populations.

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