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FACTORS ASSOCIATED WITH HIGH STROKE RISK AMONG ADULTS: A CROSS-SECTIONAL STUDY

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ABSTRACT
Stroke remains a major public health concern due to its high burden of mortality and long-term disability. Early identification of demographic and clinical factors associated with high stroke-risk classification is essential to support community-based prevention strategies. This study aimed to identify factors associated with high stroke-risk classification among adults, focusing on age, sex, hypertension, diabetes mellitus, smoking status, and obesity. A quantitative cross-sectional study was conducted among 300 respondents attending community-based health posts (Posbindu), selected through purposive sampling. Stroke risk was classified into low-risk and high-risk categories. Data were analysed using descriptive statistics, chi-square or Fisher's exact tests, and multivariable binary logistic regression. Associations were expressed as adjusted odds ratios (aORs) with 95% confidence intervals (CIs), using a significance level of $p<0.05$. Of the 300 respondents, 60 (20.0%) were classified as having high stroke risk. Multivariable analysis identified significant associations with age ⩾60 years (aOR=5.08; 95% CI: 2.48 – 10.40; $p<0.001$), male sex (aOR=2.86; 95% CI: 1.39 – 5.88; $p=0.004$), hypertension (aOR=13.85; 95% CI: 5.60 – 34.30; $p<0.001$), and diabetes mellitus (aOR=5.15; 95% CI: 2.49–10.67; $p<0.001$). Current smoking ($p=0.126$) and obesity ($p=0.139$) were not significantly associated with high stroke-risk classification after adjustment. Conclusion: Older age, male sex, hypertension, and diabetes mellitus were significantly associated with high stroke-risk classification.

Keywords: age; diabetes mellitus; hypertension; risk assessment; sex; stroke

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INTRODUCTION

Stroke remains a major global public health concern because of its substantial contribution to mortality and long-term disability. This condition also imposes a considerable burden on families and healthcare systems, particularly in terms of patient care and rehabilitation. According to estimates from the Global Burden of Disease (GBD) Study, approximately 11.9 million new stroke cases and 7.3 million stroke-related deaths occurred worldwide in 2021. In addition, tens of millions of people live with the consequences of stroke, which can affect their quality of life and ability to perform daily activities (GBD 2021 Stroke Risk Factor Collaborators, 2024). This substantial burden highlights the importance of stroke prevention through risk factor management and early detection.

Stroke development involves multiple factors related to individual characteristics and health conditions. The multifactorial model of disease causation explains that diseases may develop through the interaction of several factors rather than a single cause. In the context of stroke, these factors include demographic characteristics, such as age and sex; clinical conditions, such as hypertension and diabetes mellitus; and behavioral and metabolic factors, such as smoking and obesity. These factors warrant attention because their contributions to stroke risk may vary according to population characteristics and individual health conditions (Boehme et al., 2017; Wang et al., 2022).

Hypertension is one of the major risk factors for stroke. Persistently elevated blood pressure can damage blood vessels and increase the risk of cerebrovascular disorders. Diabetes mellitus is also associated with an increased risk of stroke through metabolic disturbances and vascular damage. Meanwhile, smoking can cause endothelial dysfunction and accelerate atherosclerosis. Obesity is another important factor because it is associated with several metabolic disorders, including hypertension and insulin resistance. The INTERSTROKE study demonstrated that several modifiable risk factors contribute to stroke occurrence across different countries (O'Donnell et al., 2016). Other studies have shown that patterns of stroke risk factors may differ according to population characteristics and geographical regions (Wang et al., 2014; Yuan et al., 2022). These associations may also vary by age, sex, and stroke subtype (Joundi et al., 2022; Peters et al., 2020; Price et al., 2018).

In Indonesia, stroke remains an important public health concern. The 2018 Basic Health Research (Riskesdas) reported a physician-diagnosed stroke prevalence of 10.9 per 1,000 population among individuals aged 15 years and older. Meanwhile, the 2023 Indonesian Health Survey (SKI) reported a prevalence of 8.3 per 1,000 population in a comparable age group (Kementerian Kesehatan Republik Indonesia, 2018, 2024). These differences should be interpreted cautiously because they may reflect variations in survey methods, population composition, and measurement procedures. In addition to stroke, hypertension is a major concern in cardiovascular disease prevention. The 2023 SKI reported a hypertension prevalence of 30.8% based on blood pressure measurements among adults aged 18 years and older. This finding emphasizes the importance of regular blood pressure screening, as hypertension may occur without symptoms and increase the risk of complications when inadequately controlled.

In Central Java, stroke also represents a considerable public health concern. The 2018 Riskesdas reported a physician-diagnosed stroke prevalence of 11.8 per 1,000 population among individuals aged 15 years and older, whereas the 2023 SKI reported a prevalence of 8.4 per 1,000 population in a comparable age group (Kementerian Kesehatan Republik Indonesia, 2018, 2024). These figures provide an overview of the provincial stroke burden. However, stroke prevalence differs from stroke-risk categories determined using risk assessment instruments. Prevalence refers to the proportion of individuals who have experienced stroke, whereas risk categories indicate an individual's level of risk based on predefined assessment criteria. Therefore, these indicators should be interpreted according to their respective purposes and measurement methods.

Risk assessment is an approach used to identify individuals with cardiovascular risk factors. For example, the WHO CVD Risk Chart Working Group (2019) developed cardiovascular risk assessment charts adapted to geographical regions and incorporating several risk factors to estimate the likelihood of cardiovascular disease. In practice, risk assessment results must be interpreted according to the instruments and criteria applied. A high-risk classification does not indicate that an individual has experienced a stroke. Rather, it indicates that the individual meets specific criteria within a risk assessment system. Therefore, understanding the factors associated with risk classifications may help identify individuals who require greater attention in preventive healthcare.

Several factors, including age, sex, hypertension, diabetes mellitus, smoking, and obesity, have been extensively investigated in stroke research. However, their associations with stroke-risk classifications may vary depending on individual characteristics and the assessment methods used. Therefore, these factors need to be examined to determine their associations with stroke-risk classification and to assess whether these associations remain evident when multiple factors are analyzed simultaneously. This study aimed to describe the distribution of low and high stroke-risk categories and to analyze the associations of age, sex, hypertension, diabetes mellitus, current smoking, and obesity with high stroke-risk classification among 300 records included in the analysis. Bivariate analyses were conducted to examine the association between each factor and stroke-risk classification, followed by multivariable logistic regression to assess their simultaneous

associations. The findings are expected to provide insights into the demographic and clinical factors associated with stroke-risk classification and inform considerations for stroke prevention strategies.

METHOD

This study employed a quantitative cross-sectional design involving 300 respondents attending community-based integrated health posts (Posbindu). Participants were selected using purposive sampling based on predefined inclusion and exclusion criteria. The dependent variable was stroke-risk classification, categorized as low risk or high risk. The independent variables included age (<60 years and ≥60 years), sex (female and male), hypertension, diabetes mellitus, current smoking status, and obesity. Data were obtained from respondents' demographic and clinical characteristics and stroke-risk assessments conducted during the study. Variable measurement and classification followed the operational definitions and assessment criteria applied in the research.

Stroke-risk classification was based on the risk categories recorded in the study documentation. The assessment considered demographic and clinical characteristics, including age, sex, hypertension, diabetes mellitus, current smoking status, and obesity. Participants were categorized into low-risk and high-risk groups according to the classifications available in the dataset. The assessment of measurement validity requires clearly defined operational criteria and documented classification procedures. However, the available documentation did not provide sufficient information on the original assessment instrument, scoring algorithm, classification thresholds, or specific validity and reliability testing. Therefore, the validity and reliability of the stroke-risk classification could not be independently established. These limitations were considered when interpreting the associations between the examined factors and recorded stroke-risk categories.

Data analysis included univariate, bivariate, and multivariable analyses. Univariate analysis was performed using frequencies and percentages. Bivariate associations were examined using the chi-square test or Fisher's exact test, as appropriate, accompanied by crude odds ratios (ORs) and 95% confidence intervals (CIs). Multivariable analysis was conducted using binary logistic regression, with all six independent variables entered simultaneously into the model. The results were expressed as adjusted odds ratios (aORs), 95% CIs, and p-values, with statistical significance set at $p<0.05$. The low-risk category served as the reference category for the dependent variable. The reference categories for the independent variables were age <60 years, female sex, absence of hypertension, absence of diabetes mellitus, non-current smoking, and absence of obesity. The study received ethical approval from the Health Research Ethics Committee of STIKES Guna Bangsa Yogyakarta, Indonesia (Approval No. 022/KEPK/XI/2026), issued on November 9, 2026.

RESULT

Distribution of Stroke Risk Categories

The distribution of stroke-risk categories among the 300 participants is presented in Table 1.

Table 1.
Distribution of Stroke Risk Categories

Stroke Risk Category	f	%
Low risk	240	80.0
High risk	60	20.0

As presented in table 1, among the 300 participants, 240 (80.0%) were classified as having low stroke risk, while 60 (20.0%) were classified as having high stroke risk. Thus, one-fifth of the study participants were categorized as having high stroke risk.

Participant Characteristics

The demographic and clinical characteristics of the participants, including age, sex, and vascular risk factors, are presented in table 2.

Table 2.
Demographic and Clinical Characteristics of Participants

Characteristics	f (%)
Age	
<60 years	196 (65.3)
≥60 years	104 (34.7)
Sex	
Female	152 (50.7)
Male	148 (49.3)
Hypertension	
No	146 (48.7)
Yes	154 (51.3)
Diabetes melitus	
No	222 (74.0)
Yes	78 (26.0)
Current smoking	
No	216 (72.0)
Yes	84 (28.0)
Obesity	
No	199 (66.3)
Yes	101 (33.7)

As presented in Table 2, 196 participants (65.3%) were younger than 60 years, while 104 (34.7%) were aged 60 years or older. A total of 152 participants (50.7%) were female and 148 (49.3%) were male. More than half of the participants had hypertension (154; 51.3%), whereas 146 (48.7%) did not. Diabetes mellitus was present in 78 participants (26.0%), while 222 (74.0%) did not have diabetes. Regarding smoking status, 216 participants (72.0%) were not current smokers, while 84 (28.0%) reported current smoking. Additionally, 101 participants (33.7%) were classified as obese, whereas 199 (66.3%) were not obese.

Bivariate Analysis

In the bivariate analysis, participants aged ≥60 years had 3.47 times the odds of being classified as having high stroke risk compared with those aged <60 years (OR = 3.47; 95% CI: 1.93–6.22; $p < 0.001$). Male participants had higher odds of high stroke-risk classification than female participants (OR = 2.04; 95% CI: 1.14–3.66; $p = 0.015$). Stronger associations were observed for hypertension (OR = 8.79; 95% CI: 4.00–19.32; $p < 0.001$) and diabetes mellitus (OR = 4.00; 95% CI: 2.20–7.27; $p < 0.001$). In contrast, current smoking (OR = 1.38; 95% CI: 0.75–2.53; $p = 0.304$) and obesity (OR = 0.81; 95% CI: 0.44–1.50; $p = 0.502$) were not statistically significantly associated with high stroke-risk classification. The associations between each independent variable and stroke-risk classification were examined using bivariate analysis, as presented in Table 3.

Tabel 3.
Bivariate Analysis of Factors Associated with High Stroke Risk

Variables	High risk, f (%)	Low risk f (%)	Crude OR (95% CI)	P value
Age ≥60 years	35 (33.7%)	69 (66.3%)	3.47 (1.93–6.22)	<0.001
Male sex	38 (25.7%)	110 (74.3%)	2.04 (1.14–3.66)	0.015
Hypertension	52 (33.8%)	102 (66.2%)	8.79 (4.00–19.32)	<0.001
Diabetes Melitus	30 (38.5%)	48 (61.5%)	4.00 (2.20–7.27)	<0.001
Current smoking	20 (23.8%)	64 (76.2%)	1.38 (0.75–2.53)	0.304
Obesity	18 (17.8%)	83 (82.2%)	0.81 (0.44–1.50)	0.502

As presented in Table 3, four variables were significantly associated with high stroke-risk classification: age ≥60 years (OR = 3.47; 95% CI: 1.93–6.22; $p < 0.001$), male sex (OR = 2.04; 95% CI: 1.14–3.66; $p = 0.015$), hypertension (OR = 8.79; 95% CI: 4.00–19.32; $p < 0.001$), and diabetes mellitus (OR = 4.00; 95% CI: 2.20–7.27; $p < 0.001$). In contrast, current smoking (OR = 1.38; 95% CI: 0.75–2.53; $p = 0.304$) and obesity (OR = 0.81; 95% CI: 0.44–1.50; $p = 0.502$) were not statistically significantly associated with high stroke-risk classification, as their p-values exceeded 0.05 and their confidence intervals included 1.

Multivariable Logistic Regression Analysis

The results of multivariable logistic regression analysis, which estimated the association between each factor and high stroke-risk classification after adjusting for other variables, are presented in Table 4.

Table 4. Multivariable Logistic Regression Analysis of Factors Associated with High Stroke Risk

Variabel	aOR	95% CI	p-value
Age ≥60 years	5.08	2.48–10.40	<0.001
Male sex	2.86	1.39–5.88	0.004
Hypertension	13.85	5.60–34.30	<0.001
Diabetes melitus	5.15	2.49–10.67	<0.001
Current smoking	1.82	0.85–3.90	0.126
Obesity	0.57	0.27–1.20	0.139

In the multivariable analysis, participants aged ≥60 years had 5.08 times the odds of being classified as having high stroke risk compared with those aged <60 years (aOR = 5.08; 95% CI: 2.48–10.40; p < 0.001). Male participants had 2.86 times the odds of high stroke-risk classification compared with female participants (aOR = 2.86; 95% CI: 1.39–5.88; p = 0.004). Hypertension demonstrated the strongest adjusted association with high stroke-risk classification (aOR = 13.85; 95% CI: 5.60–34.30; p < 0.001), while diabetes mellitus was associated with 5.15 times greater odds (aOR = 5.15; 95% CI: 2.49–10.67; p < 0.001).

In contrast, current smoking (aOR = 1.82; 95% CI: 0.85–3.90; p = 0.126) and obesity (aOR = 0.57; 95% CI: 0.27–1.20; p = 0.139) were not statistically significantly associated with high stroke-risk classification after adjustment for other variables. The overall logistic regression model was statistically significant based on the likelihood ratio test (p < 0.001), with a McFadden's pseudo-R^2 of 0.310. Model fit statistics included a sample size of 300 participants, a likelihood ratio test p-value < 0.001, and a McFadden's pseudo-R^2 of 0.310.

DISCUSSION

After all six variables were simultaneously included in the multivariable model, participants aged ≥60 years had 5.08 times the odds of being classified as having high stroke risk compared with those aged <60 years (aOR = 5.08; 95% CI: 2.48–10.40; p < 0.001). Male participants had 2.86 times the odds compared with female participants (aOR = 2.86; 95% CI: 1.39–5.88; p = 0.004). Participants with hypertension had 13.85 times greater odds (95% CI: 5.60–34.30; p < 0.001), whereas those with diabetes mellitus had 5.15 times greater odds (95% CI: 2.49–10.67; p < 0.001). Current smoking (aOR = 1.82; 95% CI: 0.85–3.90; p = 0.126) and obesity (aOR = 0.57; 95% CI: 0.27–1.20; p = 0.139) were not statistically significant. The overall model was statistically significant (likelihood ratio test, p < 0.001; McFadden's pseudo-R^2 = 0.310). These findings describe associations with recorded stroke-risk categories rather than actual stroke events.

The main finding of this study was that 60 of the 300 participants (20.0%) were classified as having high stroke risk. In the multivariable model, age ≥60 years (aOR = 5.08; 95% CI: 2.48–10.40; p < 0.001), male sex (aOR = 2.86; 95% CI: 1.39–5.88; p = 0.004), hypertension (aOR = 13.85; 95% CI: 5.60–34.30; p < 0.001), and diabetes mellitus (aOR = 5.15; 95% CI: 2.49–10.67; p < 0.001) were significantly associated with high stroke-risk classification. In contrast, current smoking (aOR = 1.82; 95% CI: 0.85–3.90; p = 0.126) and obesity (aOR = 0.57; 95% CI: 0.27–1.20; p = 0.139) were not significantly associated with high stroke-risk classification after adjustment. These results should be interpreted as associations with recorded risk categories rather than estimates of new stroke events, given the cross-sectional design and the need to establish the instrument used to determine risk categories.

Hypertension showed the strongest association with high stroke-risk classification in the multivariable model (aOR = 13.85; 95% CI: 5.60–34.30). Biologically, persistently elevated blood pressure can cause endothelial damage, accelerate atherosclerosis, and increase vascular

susceptibility to ischemic and hemorrhagic events. This finding is consistent with evidence from a meta-analysis of prospective cohort studies demonstrating an association between hypertension and an increased risk of first-ever stroke (Yuan et al., 2022). It is also consistent with the INTERSTROKE study, which identified hypertension as a major modifiable factor contributing to stroke across different countries (O'Donnell et al., 2016; O'Donnell et al., 2010). Cardiovascular prevention guidelines similarly emphasize blood pressure detection and management as essential strategies for reducing vascular risk (Whelton et al., 2018; Arnett et al., 2019). However, the magnitude of the adjusted odds ratio in the present study cannot be directly compared with estimates of stroke incidence from prospective cohorts, as the outcome assessed was a risk classification rather than actual stroke occurrence.

Diabetes mellitus was also significantly associated with high stroke-risk classification (aOR = 5.15; 95% CI: 2.49–10.67; $p < 0.001$). Chronic hyperglycemia can contribute to endothelial dysfunction, inflammation, and vascular alterations, thereby increasing vascular risk. This finding is consistent with a prospective meta-analysis linking diabetes and elevated blood glucose levels to vascular disease (Sarwar et al., 2010), as well as a meta-analysis of cohort studies in China reporting an increased risk of stroke among individuals with diabetes (Yuan et al., 2022). Global evidence has also identified elevated blood glucose as an important factor contributing to the burden of stroke (Feigin et al., 2021; O'Donnell et al., 2016). These findings reinforce the importance of glycemic management and monitoring other vascular risk factors, although the association observed in the present study reflects the risk classification used rather than actual stroke incidence.

Participants aged ≥60 years had 5.08 times the odds of being classified as having high stroke risk compared with those aged <60 years (aOR = 5.08; 95% CI: 2.48–10.40; $p < 0.001$). Age is a nonmodifiable risk factor, and aging is associated with structural and functional changes in blood vessels and the cumulative effects of risk factor exposure throughout life. Studies on the global burden of stroke have demonstrated that stroke remains a leading cause of mortality and disability, with a substantial burden among older populations (Feigin et al., 2021; Katan & Luft, 2018; Hankey, 2017). Population-based studies covering a broad age range have also found that associations between vascular risk factors and stroke may vary across different stages of life (Joundi et al., 2022). Therefore, this finding supports the importance of regular risk assessment and vascular risk factor management, particularly among older adults. Nevertheless, interpretation remains dependent on the age definitions and procedures used to establish stroke-risk categories in the analyzed data.

Male sex was associated with greater odds of high stroke-risk classification than female sex (aOR = 2.86; 95% CI: 1.39–5.88; $p = 0.004$). Several population-based studies have reported sex differences in stroke incidence, although these patterns may vary according to age, stroke subtype, and the distribution of other risk factors (Peters et al., 2020; Price et al., 2018). A study by Peters et al. (2020), using data from the UK Biobank cohort, also demonstrated that associations between major risk factors and stroke were not necessarily identical in men and women. Therefore, the present findings should not be interpreted as evidence that men consistently have a higher stroke risk across all populations. Differences in age distribution, smoking exposure, blood pressure, metabolic factors, and risk assessment methods may influence the observed associations.

Current smoking and obesity did not reach statistical significance in the adjusted model (current smoking: aOR = 1.82; 95% CI: 0.85–3.90; $p = 0.126$; obesity: aOR = 0.57; 95% CI: 0.27–1.20; $p = 0.139$). These findings do not establish that either factor is unrelated to stroke. For current smoking, the confidence interval remains compatible with a positive association, while classification based solely on current smoking status does not capture smoking intensity, duration, or previous smoking history. Evidence from INTERSTROKE and systematic reviews has identified tobacco use as a modifiable stroke risk factor (O'Donnell et al., 2010, 2016; Wang et al., 2014; Wang et al., 2022). A meta-analysis involving individuals with diabetes also demonstrated the relevance of smoking to

cardiovascular outcomes (Pan et al., 2015). Regarding obesity, its association with stroke may depend on body mass index definitions, body fat distribution, age, and underlying metabolic factors. A prospective meta-analysis found that excess body weight was associated with stroke incidence (Strazzullo et al., 2010), while other research identified differences in risk factors across stroke subtypes (Price et al., 2018). Accordingly, the nonsignificant associations observed in this sample may reflect sample size, simplified exposure measurements, confounding factors, or characteristics of the stroke-risk classification used.

From a practical perspective, these findings reinforce the importance of screening and managing vascular risk factors in community-based healthcare settings, particularly hypertension and diabetes mellitus. Preventive efforts should also include smoking cessation counseling, weight management, physical activity, and healthy dietary practices. Cardiovascular and stroke prevention guidelines recommend a multifactorial approach because vascular risk reflects the combined influence of demographic, clinical, and behavioral factors (Arnett et al., 2019; Kleindorfer et al., 2021; Bushnell et al., 2022).

The WHO cardiovascular risk charts highlight the importance of integrating key clinical information when estimating cardiovascular risk. However, their application requires clearly documented instruments, scoring algorithms, and classification thresholds (WHO CVD Risk Chart Working Group, 2019). In the present study, the instrument and cutoff values used to distinguish low and high stroke-risk categories need to be explicitly established before the findings can support conclusions regarding predictive performance or clinical recommendations.

A strength of this study was the simultaneous evaluation of six demographic, clinical, and behavioral characteristics using multivariable logistic regression, allowing adjusted associations to be examined alongside bivariate findings. Nevertheless, the cross-sectional design does not establish temporal relationships or causality. Furthermore, the available research documentation did not provide sufficient information regarding the instrument, scoring algorithm, and cutoff values used to classify stroke risk. If age, sex, hypertension, diabetes mellitus, smoking, or obesity were components of the dependent risk classification, analyzing these same characteristics as independent predictors could introduce incorporation bias or circular associations. Therefore, the results should be interpreted as associations with recorded risk classifications rather than independent validation of a stroke prediction model. The generalizability of the findings is also limited by the study population and sampling procedures. Future research should clearly document the assessment instrument, operational definitions, sampling procedures, and risk classification criteria, and validate the findings using independent datasets.

CONCLUSION

This study found that older age, male sex, hypertension, and diabetes mellitus were significantly associated with high stroke-risk classification among the study participants. Hypertension demonstrated the strongest adjusted association, followed by diabetes mellitus, older age, and male sex. In contrast, current smoking and obesity were not significantly associated with high stroke-risk classification after adjustment for other variables. These findings emphasize the importance of strengthening community-based screening and management of vascular risk factors, particularly hypertension and diabetes mellitus. However, the results should not be interpreted as evidence of actual stroke occurrence or causal relationships. The absence of complete documentation regarding the risk assessment instrument, scoring algorithm, and classification thresholds limits the interpretation of the findings. Further studies using validated assessment instruments and clearly defined risk classification criteria are needed to confirm these associations.

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