AGE, HYPERTENSION, AND PHYSICAL INACTIVITY AS DOMINANT RISK FACTORS FOR STROKE: A POPULATION-BASED STUDY IN YOGYAKARTA, INDONESIA

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ABSTRACT

Stroke remains a major public health challenge globally, with a growing burden in low and middle-income countries. Indonesia reports a high prevalence of stroke, particularly in the Special Region of Yogyakarta. However, population-based evidence on dominant individual-level risk factors remains limited. This study aims to analyze stroke risk factors in Yogyakarta based on data from the 2023 Indonesian Health Survey. This population-based cross-sectional study used secondary data from the 2023 Indonesian Health Survey. A total of 8,126 respondents aged ≥15 years residing in Yogyakarta Province were included. The outcome was a self-reported history of physician-diagnosed stroke. Independent variables included age, sex, hypertension, physical activity, diabetes mellitus, coronary heart disease, smoking status, and obesity. Multivariable logistic regression was performed to identify dominant risk factors for stroke. The prevalence of stroke was 0.7% (7 per 1,000 population). After adjustment for potential confounders, older age was strongly associated with stroke (adjusted odds ratio [AOR] = 15.35 for ≥65 years; AOR = 15.80 for 46–64 years). Hypertension was the most influential modifiable risk factor (AOR = 13.69; 95% CI: 6.63–28.25). Low physical activity significantly increased stroke risk (AOR = 3.71 for mild activity and 3.42 for moderate activity). Female sex was independently associated with a lower likelihood of stroke (AOR = 0.33; 95% CI: 0.17–0.63). Stroke risk in Yogyakarta Province is primarily driven by ageing, hypertension, and physical inactivity. Strengthening hypertension control and promoting physical activity, particularly from midlife onward, should be prioritized in primary healthcare and community-based prevention strategies.

Keywords: Hypertension, Indonesian Health Survey, Physical Inactivity, Stroke.

INTRODUCTION

Stroke remains one of the leading causes of mortality and long-term disability worldwide and continues to impose a substantial burden on individuals, families, and healthcare systems. According to the Global Burden of Disease (GBD) Study 2019, stroke accounted for more than 12 million incident cases annually and was responsible for over 6.5 million deaths globally, with the burden disproportionately

affecting low- and middle-income countries (Feigin et al., 2021). Recent updates from the World Stroke Organization further highlight a sustained increase in stroke-related morbidity and mortality, driven largely by population ageing and the rising prevalence of vascular risk factors (Feigin et al., 2025).

Indonesia is among the countries experiencing a rapid epidemiological transition, with non-communicable diseases, particularly stroke, emerging as a dominant public health challenge. National health surveys demonstrate a consistent increase in stroke prevalence over time, rising from 6 per 1,000 population in 2007 to 10.9 per 1,000 in 2018, and remaining high at 8.3 per 1,000 in the 2023 Indonesian Health Survey (Kemenkes RI, 2007, 2018, 2023).

Notably, the Special Region of Yogyakarta has consistently reported the highest stroke prevalence nationwide, positioning the province as a critical setting for understanding stroke epidemiology in Indonesia. The trend in the prevalence of stroke in Yogyakarta Province also shows an increase. In 2007, the prevalence of stroke was 7.1 per 1,000 people, which doubled to 14.6 per 1,000 in 2018. According to the 2023 Indonesian Health Survey, Yogyakarta Province reported the highest prevalence in the country, with a rate of 11.4 per 1,000 population, compared to the national average of 8.3 per 1,000.(Kemenkes RI, 2007, 2018, 2023)

Stroke is a multifactorial disease influenced by a complex interaction of non-modifiable and modifiable risk factors. Age is the strongest non-modifiable determinant, with stroke risk increasing sharply after midlife due to cumulative vascular damage and physiological ageing processes (Joundi et al., 2022). Among modifiable factors, hypertension has been consistently identified as the most important contributor to both ischemic and hemorrhagic stroke, accounting for a substantial proportion of the global stroke burden (Feigin et al., 2021; O'Donnell et al., 2016). Physical inactivity further exacerbates stroke risk through its adverse effects on blood pressure regulation, glucose metabolism, lipid profiles, and body weight (Cao et al., 2024).

Despite the well-established role of these risk factors globally, evidence from Indonesia remains limited, particularly from population-based studies. Most existing research relies on hospital-based or registry data, which may overrepresent severe cases and fail to capture stroke risk patterns in the general population. Population-level analyses using nationally representative survey data are essential to identify dominant risk factors that are most relevant for primary prevention strategies, especially within primary healthcare systems.

The 2023 Indonesian Health Survey presents a unique opportunity to examine stroke risk factors at the population level, utilizing standardized data collected across all provinces. Leveraging this dataset enables a more comprehensive assessment of stroke determinants beyond clinical settings, providing insights that are directly applicable to community-based prevention programs and primary care interventions.

Therefore, this study aims to identify the dominant individual-level risk factors associated with stroke among adults in Yogyakarta Province using data from the 2023 Indonesian Health Survey. By focusing on age, hypertension, physical activity, and other key

behavioral and clinical factors, this study seeks to generate population-based evidence to inform targeted stroke prevention strategies and strengthen non-communicable disease control efforts in primary healthcare settings.

LITERATUR REVIEW

Risk factors for stroke can be categorized into two main groups: non-modifiable and modifiable. Non-modifiable factors include age, sex, and genetic predisposition, while modifiable factors consist of hypertension, diabetes, smoking, obesity, unhealthy dietary habits, and physical inactivity. It is noteworthy that approximately fifty percent of stroke-related deaths are associated with preventable factors. This emphasizes the critical need for effective community-based prevention strategies, supported by comprehensive public policy, to significantly reduce the incidence of stroke (Boehme et al., 2017; Powers et al., 2019).

In stroke epidemiology, age is understood as a non-modifiable determinant reflecting accumulated vascular risk exposure and progressive biological changes in the cardiovascular system. With age, stroke risk increases due to the dominance of atherosclerosis, endothelial dysfunction, hemodynamic changes, and increased arterial stiffness, which exacerbates cerebral vascular vulnerability. Cohort-based risk modeling studies confirm that age often "dominates" risk prediction scores, necessitating approaches that consider the varying contributions of risk factors across age groups (Hunter & Kelleher, 2022).

Hypertension is the most consistent and strongest modifiable determinant of stroke incidence, as chronic high blood pressure triggers endothelial damage, vascular remodeling, microangiopathy, and increases the risk of thrombosis and intracranial hemorrhage. Clinical-epidemiological literature places blood pressure control as a pillar of primary and secondary stroke prevention, including in the pre-stroke phase through early detection and adherence to therapy (Gorelick et al., 2020). Contemporary evidence also confirms that optimizing blood pressure management is the most impactful strategy for preventing recurrence and reducing the burden of stroke, although implementation is often hampered by adherence, access, and inequities in service quality. Recent reviews indicate that the effectiveness of hypertension control increases with system support (monitoring, digital health, and evidence-based management), but still requires strong integration into primary care (Silva et al., 2024).

Physical activity is a behavioral determinant that plays a protective role against stroke by improving blood pressure, glucose metabolism, lipid profiles, body composition, and endothelial function. A recent prospective meta-analysis showed that varying levels of leisure-time physical activity—even levels traditionally considered “low”—still confer stroke prevention benefits, suggesting that public health messages should emphasize “starting at a minimum” as a realistic and population-wide strategy (De Santis et al., 2024). Conversely, prolonged sedentary behavior has been identified as an independent risk factor, with a non-linear relationship: stroke risk increases significantly as sitting duration exceeds a certain threshold. Dose-response meta-analyses have shown that high sedentary time is associated with increased stroke

risk, reinforcing the need for dual interventions: increasing physical activity while reducing sitting duration (Wang et al., 2022).

Gender influences stroke risk through the interaction of biological factors (hormonal, hemostatic, vascular responses) and socio-behavioral factors. Synthesized evidence suggests differences in stroke incidence patterns across young age groups, including indications that young women in certain age groups may have a higher relative risk of ischemic stroke compared to their male counterparts, although findings across studies are not always consistent (Leppert et al., 2022). Accordingly, the latest primary stroke prevention guidelines emphasize traditional risk factor-based prevention strategies while also incorporating sex-specific risk considerations and a lifespan prevention approach. Thus, gender is not simply a descriptive variable but a critical element in sharpening the targeting of education, screening, and risk factor control in primary care (C. Bushnell et al., 2024).

Based on recent theoretical studies and empirical evidence, age, hypertension, physical activity, and gender are individual determinants that consistently play a significant role in stroke incidence. Although the association of these factors with stroke has been widely studied globally, population-based evidence from Indonesia is still relatively limited and mostly comes from hospital data or clinical studies, which potentially underrepresent stroke risk in the general population. Furthermore, the context of the Special Region of Yogyakarta Province as the region with the highest stroke prevalence nationally makes it especially urgent to understand the dominant risk factors operating at the individual level. Therefore, this study has significant significance in filling this knowledge gap by utilizing large-scale and representative data from the 2023 Indonesian Health Survey (SKI), so that the results can provide a strong scientific basis for the formulation of stroke prevention strategies based on primary health care services. In line with this objective, the research question posed in this study is: What individual risk factors are most dominantly associated with stroke incidence in the population of the Special Region of Yogyakarta Province based on the 2023 Indonesian Health Survey data?

RESEARCH METHODS

This quantitative research involved an analytical observational study with a cross-sectional design. The study utilized secondary data from the 2023 National Health Survey, which is a nationally representative, large-scale survey conducted every five years by the Health Development Policy Agency of the Indonesian Ministry of Health (MoH). It covers all 38 provinces in Indonesia. The survey aims to collect data on various aspects of population health, including infectious diseases, non-communicable diseases, maternal and child health, nutritional status, health behaviors, and access to healthcare in Indonesia. The 2023 National Health Survey was conducted from August 9 to September 25, 2023. The analysis of the survey took place from June to September 2025. Secondary data for this research was obtained from the dataset of the 2023 National Health Survey, focusing specifically on Yogyakarta Province..

All residents of Yogyakarta Province who are over 15 years old are included in the study population. The inclusion criteria for this study

were residents aged over 15 who participated in the 2018 Riskesdas interview in Yogyakarta Province. The exclusion criteria involved cases of incomplete data. Out of 10,843 respondents, 1,644 were under 15 years old, and 1,073 had missing data. Using a formula from Lemeshow (1997), the minimum sample size required was calculated to be 4,736 respondents. This study used total sampling, incorporating all relevant data that met the inclusion criteria, resulting in a total of 8,126 respondents.

The dependent variable to be studied was the history of clinically diagnosed stroke, while the independent variables included age, gender, physical activity, risky food consumption, smoking status, hypertension, heart disease, diabetes mellitus, obesity, area of residence, economic status, and access to health centers. All variables were obtained from household questionnaires (blocks I, IV, and V) and individual questionnaires (block XI) in the 2023 National Health Survey. These variables were measured based on the results of interviews conducted through the questionnaires. In the survey, the incidence of stroke was determined based on self-reports from respondents, which included diagnostic information provided by doctors as well as questions about any sudden symptoms they experienced. The history of hypertension, heart disease, and diabetes mellitus is determined solely through self-reports and diagnostic information provided by doctors to the respondents. In contrast, the history of obesity is assessed using the Body Mass Index (BMI), which is calculated based on measurements of weight and height.

This study has received ethical approval from the Ethics Committee of Mohammad Husni Thamrin University, with the reference number 019/S.Ket/KEPK/UMHT/VI/2025.

The data utilized in this research has been authorized by the Health Development Policy Agency of the Republic of Indonesia (BKPK Kemenkes RI). Furthermore, the use of data in this study adheres to the terms and conditions established by the BKPK of the Ministry of Health of the Republic of Indonesia.

Data analysis was performed to identify relationships between risk factors and stroke incidence. All statistical analyses were performed using IBM SPSS Statistics software.

RESEARCH RESULT

Table 1. Frequency Distribution of Research Variables

Variable	f	%
Incidence of stroke		
Yes	58	0,7
No	8068	99,3
Age		
≥65 years old	1035	12,7
46 – 64 years old	2498	30,7
15 – 45 years old	4593	56,5
Gender		
Female	4117	50,7
Male	4009	49,3

Physical Activity		
Mild	880	10,8
Moderate	4482	55,2
Heavy	2764	34
Risky foods		
Often	4611	56,7
Infrequently	3515	43,3
Smoke		
Active smokers	2368	29,1
Ever smoked	400	4,9
Never smoke	5358	65,9
Obesity	3042	37,4
Hypertension	953	11,7
Diabetes melitus	281	3,5
Coronary heart disease	155	1,9

The frequency distribution analysis presented in Table 1 reveals that the majority of respondents belong to the productive age group of 15 to 45 years, accounting for 56.5% of the sample. Additionally, there is a balanced distribution of genders among the participants. In contrast, only 12.7% of respondents are aged 65 years or older.

When examining modifiable factors, it is notable that over half of the respondents (55.2%) engage in moderate physical activity. However, several risk behaviors remain common, including unhealthy eating habits (56.7%), smoking (29.1%), obesity (37.4%), hypertension (11.7%), diabetes (3.5%), and coronary heart disease (1.9%).

Table 2. Relationship of Research Variables with Stroke Incidence

Variabel	Number of Stroke Case				p-value	PR (95% CI)
	Yes		No			
	f	%	f	%		
Age						
≥65 years old	23	2,2	1012	97,8	0,000	61,307 (11,452 - 328,184)
46 – 64 years old	33	1,3	2465	98,7	0,000	36,941 (7,075 - 192,877)
15 – 45 years old	2	0	4591	100	ref	
Gender						
Female	21	0,5	4096	99,5	0,46	0,559 (0,313 - 0,997)
Male	37	0,9	3972	99,1		
Physical Activity						
Mild	11	1,3	869	98,7	0,000	5,722 (2,188 - 14,962)
Moderate	41	0,9	4441	99,1	0,002	4,024 (1,678 - 9,651)
Heavy	6	0,2	2758	99,8	ref	
Risky foods						
Often	22	0,5	4589	99,5	0,015	

Infrequently	36	1	3479	99		0,478 (0,261 – 0,876)
Smoke						
Active smokers	13	0,5	2355	99,5	0,576	0,826 (0,422 – 1,618)
Ever smoked	9	2,3	391	97,7	0,001	3,574 (1,708 – 7,481)
Never smoke	36	0,7	5322	99,3	ref	
Obesity						
Yes	28	0,9	3014	99,1	0,115	
No	30	0,6	5054	99,4		1,523 (0,899 – 2,579)
Hypertension						
Yes	46	4,8	907	95,2	0,000	28,765 (14,935 – 22,402)
No	12	02	7161	99,8		
Diabetes melitus						
Yes	9	3,3	272	96,7	0,000	5,417 (2,57 – 11,419)
No	49	0,6	7796	99,4		
Coronary heart disease						
Yes	10	6,2	145	93,8	0,000	10,319 (4,992 – 21,332)
No	48	0,6	7923	99,4		

The bivariate analysis results presented in Table 3 indicate that age is the most significant determinant of stroke incidence. Individuals aged 65 years and older have an approximately 61-fold increased risk of stroke (OR = 61.3; 95% CI: 11.45–328.18), while those aged between 46 and 64 years are at about 37 times higher risk (OR = 36.9; 95% CI: 7.08–192.88) compared to the younger demographic (15–45 years). Notably, sex did not reveal a significant association with stroke incidence.

Among the modifiable factors, low levels of physical activity were linked to a substantial increase in stroke risk, with mild activity correlating to a 5.7-fold higher risk (OR = 5.72; 95% CI: 2.19–14.96) and moderate activity associated with a 4-fold higher risk (OR = 4.02; 95% CI: 1.68–9.65), relative to strenuous activity. Hypertension emerged as the most critical modifiable risk factor, elevating stroke risk nearly 29 times (OR = 28.8; 95% CI: 14.94–22.40).

Additional significant associations were identified for coronary heart disease, which showed a 10-fold higher risk (OR = 10.3; 95% CI: 4.99–21.33), diabetes mellitus with a 5-fold higher risk (OR = 5.42; 95% CI: 2.57–11.42), and a history of smoking associated with a 3.6-fold higher risk (OR = 3.57; 95% CI: 1.71–7.48). However, obesity and current smoking status did not have a significant correlation with stroke incidence. Interestingly, the consumption of risky foods seemed to provide a protective effect (OR = 0.48; 95% CI: 0.26–0.88).

Table 3. Final Model of Multivariate Analysis

Variable	p-value	OR	95% CI
Age			
≥65 years old	0,001	15,347	2,882 – 81,717
46 – 64 years old	0,001	15,799	3,091 – 80,759
15 – 45 years old	-	Ref	-
Gender	0,001	0,328	0,171 – 0,63
Physical activity			
Mild	0,015	3,713	1,298 – 10,625
Moderate	0,01	3,42	1,342 – 8,716
Heavy	-	Ref	-
Consumption of risky foods	0,259	0,696	0,37 – 1,308
Hypertension	<0,001	13,685	6,63 – 28,246
Coronary Heart Disease	0,068	2,098	0,947 – 4,648

Based on the results of the final model from the multivariate analysis, several significant predictors of stroke incidence in Yogyakarta Province have been identified: age, sex, physical activity, and hypertension. Respondents aged 65 years and older exhibited a risk approximately 15 times greater (OR = 15.3; 95% CI: 2.88–81.7). Likewise, those aged 46 to 64 years faced about 16 times higher risk (OR = 15.7; 95% CI: 3.09–80.8) compared to the younger age group (15 to 45 years, reference). Gender also influenced risk, with women demonstrating a lower likelihood of experiencing a stroke (OR = 0.33; 95% CI: 0.17–0.63). Low physical activity levels correlated with a risk increase of 3 to 4 times; specifically, mild activity heightened risk by about 3.7 times (OR = 3.71; 95% CI: 1.30–10.63), while moderate activity raised risk by approximately 3.4 times (OR = 3.42; 95% CI: 1.34–8.72) when compared to those engaging in heavy activity.

Hypertension emerged as the strongest modifiable risk factor, increasing the risk of stroke by over 13 times (OR = 13.7; 95% CI: 6.63–28.25). Other variables, including coronary heart disease (OR = 2.10; 95% CI: 0.95–4.65), residential area (OR = 0.54; 95% CI: 0.19–1.56), and risky food consumption (OR = 0.70; 95% CI: 0.37–1.31), were not found to be statistically significant. These findings highlight the importance of biological and behavioral factors, especially age, hypertension, physical activity, and gender, as key determinants of stroke incidence in Yogyakarta Province after adjusting for other variables.

DISCUSSION

This population-based study identified age, hypertension, and physical inactivity as the dominant individual-level risk factors for stroke among adults in Yogyakarta Province, Indonesia. By utilizing nationally representative survey data, this study contributes contemporary evidence from a low- to middle-income country context, where population ageing and lifestyle transitions are occurring rapidly.

Age remained the strongest non-modifiable determinant of stroke, with markedly higher risks observed among individuals aged 46–64 years and ≥65 years. This finding

aligns with recent life-course epidemiological evidence indicating that cumulative exposure to vascular risk factors accelerates cerebrovascular damage beginning in midlife (Joundi et al., 2022; Roth et al., 2020). Importantly, recent global analyses have highlighted a shifting stroke burden toward younger and middle-aged populations, particularly in regions undergoing rapid socioeconomic and demographic change, emphasizing the need for earlier preventive interventions (Feigin et al., 2025).

Hypertension emerged as the most influential modifiable risk factor in the adjusted model, increasing stroke risk more than thirteenfold. This magnitude is consistent with recent global and regional analyses showing that uncontrolled hypertension remains the leading contributor to stroke incidence, especially in Asian populations (Mills et al., 2020).

A large pooled analysis of contemporary cohorts demonstrated that even modest elevations in systolic blood pressure substantially increase lifetime stroke risk, reinforcing the importance of early detection and sustained blood pressure control (Roth et al., 2020). These findings underscore hypertension as a critical entry point for stroke prevention within primary healthcare systems.

Physical inactivity was independently associated with stroke risk, with respondents reporting mild or moderate activity exhibiting a three- to four-fold increased risk compared with those engaging in heavy physical activity. This association is supported by recent prospective cohort studies and meta-analyses demonstrating that regular moderate-to-vigorous physical activity confers significant protection against both ischemic and hemorrhagic stroke (Cao et al., 2024; Zhang et al., 2020). Importantly, emerging evidence suggests that physical activity mitigates stroke risk not only through blood pressure reduction but also via improvements in endothelial function and systemic inflammation (De Ciuceis et al., 2023).

Sex differences in stroke risk were also evident, with female participants showing a lower likelihood of stroke compared with males. Recent population-based studies suggest that this difference may be partly explained by sex-specific patterns of vascular risk exposure, hormonal influences, and health-seeking behaviors (C. D. Bushnell et al., 2018). However, contemporary data indicate that the stroke incidence gap between men and women is narrowing in many countries due to increasing cardiometabolic risk among women, highlighting the need for gender-sensitive prevention strategies (Abdu & Seyoum, 2022).

Interestingly, several factors commonly associated with stroke—such as diabetes mellitus, coronary heart disease, smoking status, and obesity—did not retain statistical significance in the final multivariable model. This attenuation suggests potential mediation through dominant pathways such as hypertension and physical inactivity. Similar findings have been reported in recent multilevel and causal modeling studies, which demonstrate that the independent effects of these factors may diminish after controlling for blood pressure and physical activity (Magnussen et al., 2023). These results highlight the importance of prioritizing upstream determinants in population-level interventions.

From a public health perspective, the findings emphasize that stroke prevention strategies in

Yogyakarta Province should focus on early hypertension screening, sustained blood pressure control, and the promotion of physical activity across the life course. Community-based initiatives integrated into primary care—such as routine cardiovascular risk assessment and structured physical activity promotion—have been shown to be both cost-effective and impactful in reducing stroke incidence ((WHO), 2023).

Several limitations warrant consideration. The cross-sectional design limits causal inference, and the reliance on self-reported diagnoses may introduce recall bias. Nonetheless, recent validation studies suggest that self-reported physician-diagnosed stroke in large health surveys provides reasonably accurate estimates for epidemiological analysis (Abe et al., 2010). The strengths of this study include its large sample size, population-based design, and use of standardized national survey data.

In conclusion, this study provides updated population-level evidence that ageing, hypertension, and physical inactivity are the primary drivers of stroke risk in Yogyakarta Province. These findings support a strategic shift toward earlier and more aggressive primary prevention, particularly through hypertension control and physical activity promotion within primary healthcare and community settings.

CONCLUSION

This population-based study demonstrates that stroke risk in Yogyakarta Province is predominantly driven by ageing, hypertension, and low levels of physical activity, while female sex appears to confer a protective effect. Using nationally representative data from the 2023 Indonesian Health Survey, the findings highlight that biological and behavioral factors exert a substantially stronger influence on stroke occurrence than other individual characteristics.

Hypertension emerged as the most important modifiable risk factor, underscoring the urgent need for early detection and sustained blood pressure control within primary healthcare services. The strong association between physical inactivity and stroke further emphasizes the critical role of active lifestyles in cerebrovascular disease prevention. Importantly, the elevated risk observed among individuals aged 46 years and older suggests that preventive interventions should begin in midlife, rather than being limited to older populations.

These findings support a strategic shift toward strengthening primary prevention, particularly through routine cardiovascular risk screening, community-based physical activity promotion, and integrated non-communicable disease programs. Targeting hypertension control and physical inactivity may yield substantial reductions in stroke burden in high-prevalence regions such as Yogyakarta Province and similar settings in low- and middle-income countries..

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