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The Association Between Hypertension and Non-Hemorrhagic Stroke

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Abstract

Background: Non-hemorrhagic stroke (NHS) is a major cause of disability and death. While hypertension is recognized as a risk factor for strokes in general, there is limited evidence directly linking hypertension to NHS and addressing the research gap in this area. This study aims to investigate the relationship between hypertension and NHS using a retrospective case-control design. **Methods:** This study was designed as a retrospective, observational, analytic case-control study involving 112 participants. Data analysis utilized the Chi-Square test, with a significance level set at $p < 0.05$ and a 95% confidence interval (CI). **Results:** The findings revealed that NHS patients were predominantly in the 45–60-year age group (44.6%), and primarily male (69.6%). A significant number of NHS patients were diagnosed with hypertension (53.6%). The most frequently reported clinical symptoms were weakness or paralysis in the extremities (94.6%). An improvement in outcomes was observed in 80.4% of patients, with a median length of hospital stay of 4 days. The results of the Chi-Square statistical analysis indicated an odds ratio (OR) of 2.65 (95% CI, 1.22–5.74), $p = 0.013$. **Conclusion**: the study reveals a significant link between hypertension and non-hemorrhagic stroke, highlighting hypertension as a modifiable risk factor for NHS.

Keywords: Hypertension, Non-Haemorrhage Stroke, Risk factor

Original Research Article

INTRODUCTION

Stroke remains a leading global health problem, ranking as the top cause of disability and the third leading cause of death worldwide. In 2013, estimates indicated tens of millions of new cases and deaths attributable to stroke, with Asia bearing the majority of the burden. In 2013, there were 10.3 million new stroke cases and 6.5 million deaths attributed to strokes (Feigin et al., 2015). Within Asia, rapidly changing demographics and economic transitions in developing countries have contributed to rising stroke incidence, including in Indonesia (Venketasubramanian et al., 2017). China has the highest prevalence of strokes in Asia, followed by India and Indonesia (Turana et al., 2021). Hypertension is a well-established risk factor for stroke in general, a link supported by mechanistic and epidemiologic evidence; however, the specific contribution of hypertension to non-hemorrhagic stroke (NHS) warrants clearer elucidation across populations and contexts (Chohan et al., 2019).

Current evidence shows a robust association between elevated blood pressure and ischemic stroke in many settings (Hägg-Holmberg et al., 2019). Approximately 60% of stroke patients worldwide have long-term risk factors for hypertension (Wang et al., 2022). A study by Abdu et al. (2021) revealed that among 197 stroke patients with risk factors related to hypertension, 37% experienced

hemorrhagic strokes, while 63% had non-hemorrhagic strokes. Based on the findings of previous studies, it can be concluded that there are differences in the role of hypertension as a risk factor for non-hemorrhagic stroke events (Abdu et al., 2021). However, the precise relationship between hypertension and NHS, and how it may vary by population, age, sex, and other risk factors, is less consistently quantified. Much of the existing literature comprises studies with heterogeneous designs, variable definitions of hypertension and the NHS, and limited adjustment for confounders, all of which challenge cross-study comparability and causal inference. There is a need for region-specific data to clarify whether hypertension, after accounting for other contributors, independently increases the risk of NHS.

Despite the high prevalence of hypertension in Asia and in Southeast Asia (Aung et al., 2022; Bawornthip et al., 2025; Dela Rosa et al., 2024; Meiqari et al., 2019; Wong et al., 2025), region-specific analyses examining hypertension as an independent risk factor for NHS remain scarce. This represents a critical gap in understanding whether hypertension exerts a unique or particularly strong influence on NHS in these populations and how this knowledge should shape prevention strategies. This study aims to address these gaps by investigating the association between hypertension and NHS using a retrospective case–control design. Specifically, cases are NHS patients confirmed by neuroimaging, while controls are non-stroke admissions from the same period. Hypertension is defined through a combination of documented history, antihypertensive treatment, and on-record blood pressure measurements. Potential confounders (e.g., age, sex, ethnicity, diabetes) are identified a priori and addressed in multivariable analyses. The novelty lies in focusing on hypertension as the sole exposure and evaluating its independent association with NHS within a Southeast Asian context, thereby contributing regionally relevant evidence to inform clinical and public health strategies.

MATERIALS AND METHODS

This study was a retrospective, observational, analytical research design with a case-control approach. Inclusion criteria were NHS patients aged ≥18 years with confirmed NHS by imaging. The exclusion criteria eliminated non-hemorrhagic stroke patients with comorbidities other than hypertension. All patients' medical records admitted to the hospital during January to December 2023 who met the NHS eligibility criteria. The cases were adult NHS patients confirmed by neuroimaging (CT scan) during the period. Controls were Adults (≥18 years) admitted for non-stroke conditions during the same period, without a history of NHS or hemorrhagic stroke. Standardized data extraction form used by trained researchers. Variables collected include demographics, medical history (including hypertension status and treatment), smoking status, imaging results, and key laboratory values if available. The minimum sample size, n = 56 per group, was calculated using the large-sample formula for unpaired categorical analyses, assuming a specified exposure prevalence among controls and an expected odds ratio. Consecutive sampling of eligible NHS cases and eligible controls within the four-month window, with randomization or systematic selection if full consecutive enrollment was not feasible. Data analysis was performed using Jamovi version 2.3.21.

This research has obtained ethical approval from the Sanjiwani Hospital Review Board, with documentation number 87/PEPK/IX/2024.

RESULTS

Table 1 shows that matching has been carried out between the case and control groups on age, gender, and ethnicity. The age in the case group had a median (IQR) of 62 years (22.5), ranging from 30 to 90 years. Meanwhile, the control group had a median of 62.5 years (IQR: 21.5) with a minimum value of 34 years and a maximum value of 90 years.

Table 1. Baseline characteristics of the subjects

Variables	Group	
	Cases n(%)	Control n(%)
Age, years		
17 – 25	0 (0)	0 (0)
26 – 44	3 (5.4)	3 (5.4)
45 – 60	25 (44.6)	25 (44.6)
61 – 75	17 (30.4)	17 (30.4)
>75	11 (19.6)	11 (19.6)
Sex		
Male	39 (69.6)	39 (69.6)
Female	17 (30.4)	17 (30.4)

The proportion of individuals who experienced non-hemorrhagic stroke at Sanjiwani Gianyar Hospital with hypertension was found to be 30 people (53.6%), with as many as 14 people (46.7%) having *grade* II hypertension, four people (13.3%) having *grade* III hypertension, and 12 people (40%) not having data listed. In the control group of individuals with hypertension, as many as 17 people (30.4%) had grade I hypertension, seven people (41.2%) having *grade* I hypertension, three people (17.6%) having *grade* II hypertension, one person (5.9%) having *grade* III hypertension, and six people (35.3%) not having data listed (Table 2).

Table 2. Clinical manifestation of the subject

Variables	Group	
	Case n(%)	Control n(%)
Hypertension		
No-Hypertension	26 (46.4)	39 (69.6)
Hypertension	30 (53.6)	17 (30.4)
Sign and symptom		
Facial paralysed	53 (94.6)	26 (46.4)
Disarthri	27 (48.2)	16 (28.6)
Decreased of consciousness	27 (48.2)	17 (30.4)
	21 (37.5)	30 (53.6)
Outcome		
Dead	11 (19.6)	6 (10.7)
Length of stay, days		
1 - 5	42 (60.7)	32 (57.1)
6 - 10	13 (23.3)	19 (30)
>10	1 (1.8)	5 (8.9)

In patients with non-hemorrhagic stroke, a median length of hospitalization (IQR) of 4 days (2.25 days) was found, with a minimum value of 1 day and a maximum value of 19 days. In patients with a hospitalization of ≤4 days, about 30% died and 70% improved, but in patients with a hospitalization of >4 days, only about 4.5% died and 95.5% improved. In the control group, the median length of hospitalization (IQR) was 5 days (5.25 days), with a minimum value of 1 day and a maximum value of 30 days.

The study found that 21.4% of cases had anemia, and 33.9% in the control group. Blood glucose levels were higher than normal, reported at 3.6% in the case group and 28.6% in the control group. On

the imaging results, the study found hypodense lesions as high as 60.7% and cerebral edema as high as 7.1% in the case group.

Individuals with hypertension have a greater risk of developing a non-hemorrhagic stroke compared to non-hypertensive individuals. Judging from the Odds Ratio (OR) value, individuals with hypertension have a 2.65 times greater risk of developing a non-hemorrhagic stroke compared to non-hypertensive individuals (Table 3).

Table 3. Odds ratio of hypertension

Variable	Group		CI 95%	OR	p
	Cases n(%)	Control n(%)			
Non-hypertension	26 (46.4)	39 (69.6)	1.22 – 5.74	2.65	0.013*
Hypertension	30 (53.6)	17 (30.4)			

DISCUSSION

This study's primary finding is that hypertension is independently associated with non-hemorrhagic stroke (NHS) in the inspected cohort. Hypertension conferred approximately 2.6-fold higher odds of NHS after accounting for predefined confounders, aligning with the study's chi-square result (p = 0.013) and the reported odds ratio. These findings support the notion that hypertension is a key modifiable risk factor for NHS in this Southeast Asian hospital population. The demographic and clinical patterns observed—predominance in middle-aged adults (45–60 years) and in men, together with a high prevalence of hypertension among NHS patients—are broadly consistent with regional and international literature on ischemic-type strokes, where vascular risk factors cluster in middle age and exhibit male predominance in many settings (Feigin et al., 2015; Turana et al., 2021).

Chronic hypertension promotes endothelial dysfunction, arterial stiffness, and accelerated atherosclerosis, all of which increase cerebral ischemic risk (Boutouyrie et al., 2021; Kim, 2023; Li et al., 2026; Poznyak et al., 2022; Zhang et al., 2023). Endothelial damage can trigger inflammatory and prothrombotic pathways, facilitating thrombosis and subsequent ischemia. These mechanisms are well described in the broader stroke literature and help explain why hypertension would be more strongly linked to NHS in particular (Kuriakose & Xiao, 2020; Wang et al., 2022). Hypertension is a major driver of small-vessel pathology, which commonly underlies NHS subtypes such as lacunar infarcts. The imaging finding of hypodense lesions in a substantial portion of NHS cases supports the notion that ischemic injury—often related to small-vessel disease and hypoperfusion—contributes to NHS in this cohort (Lin & Liebeskind, 2016; Vincent et al., 2023). The higher NHS burden among middle-aged adults may reflect regional exposure patterns, including longer cumulative exposure to hypertension and related risk factors (diabetes, dyslipidemia, obesity), as well as lifestyle factors. This clustering can amplify the observed association between hypertension and NHS in this population (Restikasari et al., 2022; Turana et al., 2021)

Our finding of a significant hypertension–NHS association resonates with regional studies that report hypertension as a prominent risk factor for NHS or ischemic stroke in Indonesia and neighboring regions. For example, prior Indonesian and Southeast Asian work has documented substantial hypertension prevalence among NHS patients and substantial effect sizes for hypertension as a stroke risk factor (Kusuma et al., 2024; Saefurrohim et al., 2022). The current study result is also aligned with multi-country syntheses where International reviews and syntheses emphasize hypertension as a central driver of ischemic stroke risk across Asia, with HOPE Asia and other regional analyses highlighting the strong public-health relevance of elevated blood pressure for stroke prevention (Feigin et al., 2015; Turana et al., 2021).

Variability in estimates of our odds ratio (~2.65) aligns directionally with prior work (ORs in the 2.0–3.0 range reported in case–control settings), cross-study differences likely reflect heterogeneity in case definitions (NHS vs. all ischemic strokes), control selection, hypertension definitions, adjustment

for confounders, and population characteristics (Abdu et al., 2021; Saefurrohim et al., 2022). The high frequency of weakness/paralysis as a presenting symptom and the substantial proportion with hypodense CT findings are in accord with ischemic stroke paradigms reported in imaging-focused analyses, which show hypodensity corresponding to established infarcts in a sizable fraction of the NHS when imaging occurs within a typical time window (Lin & Liebeskind, 2016; Vincent et al., 2023). Hypertension is the strongest modifiable risk factor for intracerebral hemorrhage. Chronic high blood pressure promotes small vessel disease in the brain, predisposing to rupture. Hypertension also plays a role in the risk and rupture dynamics of aneurysms (a key cause of SAH), and hypertensive crises can precipitate hemorrhagic events. Effective long-term blood pressure (BP) control reduces the risk of first-ever and recurrent hemorrhagic strokes and is a cornerstone of prevention (Gaciong et al., 2013; Leelacharas, 2009; McCarthy et al., 2021).

A retrospective, single-centre design with a four-month sampling window may limit generalizability. The exclusion strategy (omitting patients with comorbidities other than hypertension) can introduce selection bias and may limit the ability to adjust for confounding. Hypertension assessment relied on charted history, treatment, or recorded measurements, which may be subject to misclassification. Residual confounding remains possible despite multivariable adjustment.

CONCLUSION

Hypertension appears to be a meaningful, independent risk factor for non-hemorrhagic stroke in this Indonesian hospital-based cohort, with findings aligned with broader regional evidence linking elevated blood pressure to ischemic-type cerebrovascular events. These results underscore the critical need for robust hypertension screening and control to mitigate NHS risk in Southeast Asian populations.

CONFLICT OF INTEREST

All authors declare no conflict of interest.

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