

# Epidemiological Burden, Modifiable Risk Factors, and Health System Challenges of Ischemic Stroke in Indonesia: A Systematic Review

Fitriani Agustina<sup>1</sup>, Handry Darussalam<sup>2</sup>

<sup>1</sup>Nursing Study Program, Al Ma'arif Baturaja College of Health Sciences, Indonesia

<sup>2</sup>Public Health Study Program, Al Ma'arif Baturaja College of Health Sciences, Baturaja, Indonesia

\*Corresponding author: [fitrianiagustina2802@gmail.com](mailto:fitrianiagustina2802@gmail.com)

## Article Info:

Received:  
(2026-07-19)

Revised:  
(2026-09-14)

Approved:  
(2026-09-21)

Published:  
(2026-09-25)

## Abstract

**Background:** Ischemic stroke is a major cause of mortality and disability in Indonesia. This immense burden reflects complex interactions between population-level risk factors, delayed prehospital care-seeking behavior, and structural health-system limitations under the national health insurance (JKN) scheme. **Aims:** To systematically review the epidemiological burden, primary modifiable risk factors, and health-system and financing challenges of ischemic stroke in Indonesia. **Methods:** Guided by the PRISMA 2020 framework, literature from major databases (PubMed, Scopus, Garuda, Google Scholar) and official health reports published through December 2025 was searched. Thirty eligible Indonesia-specific studies were narratively synthesized across three domains: epidemiological burden, risk factors, and health-system challenges; an additional 15 international and global studies were separately reviewed as comparator literature for the Discussion. **Results:** Nationally representative surveys show stroke prevalence rising from 7‰ (2013) to 10.9‰ (2018) and 8.3‰ (2023), with pronounced interprovincial disparity (4.9–14.7 per 100,000) and ischemic stroke accounting for the vast majority of cases; GBD modelling situates Indonesia's age-standardized incidence (293.3/100,000) and mortality (193.3/100,000) among the highest in Southeast Asia. Major clinical risk factors include hypertension (62.6%–87.2%), diabetes mellitus (40.5%–51%), and dyslipidemia. Structurally, acute care access is severely hindered: only 2.4%–14.3% of patients arrive within the therapeutic window for intravenous thrombolysis. This access barrier is exacerbated by a severe geographic maldistribution of neurointerventional specialists (56.2% of the 105 national specialists practice in Java) and an estimated 27.7% deficit between INA-CBGs reimbursement tariffs and actual hospital costs. **Conclusion:** Indonesia's ischemic stroke crisis is driven by an overwhelming epidemiological burden, uncontrolled cardiometabolic risk factors, and systemic barriers to acute treatment. Urgent interventions must prioritize community FAST education, primary care strengthening, the geographic redistribution of stroke-ready facilities, and JKN tariff revisions to sustainably fund acute reperfusion therapies.

**Keywords:** ischemic stroke; epidemiology; modifiable risk factors; health system; INA-CBGs; Indonesia



This is an Open Access article distributed under the terms of the Creative Commons Attribution-NonCommercial 4.0 International License, which allows others to remix, tweak, and build upon the work non-commercially as long as the original work is properly cited. The new creations are not necessarily licensed under the identical terms

**Cite this as:** Agustina, F., & Darussalam, H. (2026). Epidemiological Burden, Modifiable Risk Factors, and Health System Challenges of Ischemic Stroke in Indonesia: A Systematic Review. *Journal of Pubnursing Sciences*, 4(03), 135–152. <https://doi.org/10.69606/jps.v4i03.535>

© The Author(s) 2026

## Introduction

Stroke is among the leading causes of death and long-term disability worldwide. The Global Burden of Disease (GBD) 2019 estimates attribute approximately 331,349 annual deaths in Indonesia to stroke, alongside 8,407,229

disability-adjusted life-years (DALYs) lost and an age-standardized mortality rate of 193.3 per 100,000 population (Feigin et al., 2025; Mboi et al., 2022). Updated GBD 2021 modelling of ischemic stroke specifically confirms that the global burden remains

concentrated in low- and middle-Sociodemographic Index (SDI) regions, with the heaviest absolute burden shifting toward aging populations in middle-SDI countries such as Indonesia (Li et al., 2024). The 2025 World Stroke Organization Global Stroke Fact Sheet reaffirms stroke's position as the world's second leading cause of death and, combined with disability, its third leading cause of overall health loss (Feigin et al., 2025).

Within South-East Asia, Indonesia carries a disproportionately large share of this burden. Age-standardized stroke incidence in Indonesia reaches 293.3 per 100,000 population, the highest recorded in the region (Feigin et al., 2021; Pandian et al., 2023). Subnational GBD modelling across Indonesia's 34 provinces confirms that stroke is the leading cause of death and years of life lost nationally, with systolic blood pressure and smoking identified as the two dominant contributors to the DALY burden (Mboi et al., 2022). Trend analyses of ischemic stroke across Asia further show that Indonesia's case counts have risen steadily since 1990, propelled by population aging and an urbanizing lifestyle transition (Zhang et al., 2023). At the facility level, a national mapping of Indonesia's neurointerventional infrastructure documents 54 dedicated facilities nationwide, heavily concentrated in Java and in DKI Jakarta in particular, leaving eastern Indonesia critically under-resourced (Venketasubramanian et al., 2022).

The complexity of Indonesia's ischemic-stroke burden spans several interconnected dimensions. Epidemiologically, community- and facility-based studies document striking subnational disparities, from a community stroke prevalence of 1.41% in Sleman, Yogyakarta (Setyopranoto et al., 2019), to an ischaemic-stroke proportion of 95.33% among diagnosed strokes in the remote Southeast Maluku (Kei) Islands, where hypertension prevalence reaches 62.6% and is compounded by high dietary salt intake and smoking (Paliyama et al., 2025). On the risk-factor side, hypertension, diabetes mellitus, dyslipidemia, and atrial fibrillation are consistently identified as the dominant modifiable comorbidities among hospitalized ischaemic-stroke patients (Tarwoto et al., 2025), while emerging evidence implicates modern dietary patterns, most notably sugar-sweetened beverage consumption, as an unexpectedly dominant independent lifestyle predictor (Purwono et al., 2025). At the health-system level, only a small minority of eligible patients receive time-critical intravenous alteplase thrombolysis: a multicenter study across three Surabaya hospitals found that just 14.29% of patients arrived early enough to be considered for treatment, and only 2.38% ultimately received it (Minalloh et al., 2022). This is compounded by acute workforce shortages: a national survey of Indonesia's neurointerventionist workforce identified only 105

practicing specialists nationwide, 56.2% of them based in Java, leaving provinces such as Lampung and much of eastern Indonesia severely underserved (Usman et al., 2025).

The rollout of universal health coverage under the *Jaminan Kesehatan Nasional* (JKN; National Health Insurance) scheme, administered by *Badan Penyelenggara Jaminan Sosial Kesehatan* (BPJS Kesehatan; Healthcare Social Security Agency) since 2014, was intended to democratize access to care across Indonesia's dispersed archipelago (Darmawan et al., 2025). Cardiovascular and cerebrovascular disease claims have nonetheless become one of the scheme's largest catastrophic-cost categories, and an analysis of Universitas Indonesia Hospital claims documents a persistent gap between actual treatment costs and fixed INA-CBG package tariffs for acute ischaemic-stroke thrombolysis (Fathi & Junadi, 2025). Analyses of national JKN membership data further show that patients enrolled under subsidized (PBI-APBN) schemes experience higher in-hospital mortality and lower access to advanced diagnostic and interventional procedures than non-subsidized members, pointing to a structural socioeconomic gradient in stroke outcomes even within a nominally universal insurance system (Darmawan et al., 2025). Policy-level reviews echo these concerns, calling for expanded stroke-center certification, workforce incentives, and equitable distribution of CT-scan and catheterization-laboratory infrastructure (Hidayat et al., 2023; Rilianto et al., 2024).

Although a substantial body of Indonesian and regional literature addresses individual facets of this problem, no prior synthesis has integrated the epidemiological, risk-factor, and health-system dimensions of ischemic stroke in Indonesia within a single, transparently sourced evidence base. The regional review by Pandian et al. (2023) situates Indonesia within a broader South-East Asian comparison but does not disaggregate the country's provincial disparities or JKN-specific financing mechanisms. Facility- and claims-based Indonesian studies, meanwhile, tend to examine prehospital delay, cost of illness, or risk-factor prevalence in isolation, within single institutions or provinces. This review addresses that gap by systematically extracting and triangulating findings.

## Methods

### Search Strategy and Data Sources

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) statement (Page et al., 2021). The review protocol, including the research questions, search strategy, and eligibility criteria, was established before conducting the literature search. A

systematic review search was conducted across four databases: PubMed/MEDLINE, Scopus, the Garuda Portal, and Google Scholar, supplemented with official publications from the Ministry of Health of the Republic of Indonesia (Kemenkes RI/BKPK), WHO SEARO, and the World Stroke Organization. The primary search window covered publications from 2019 through 2025, with the final search completed on 31 December 2025. Search terms combined Medical Subject Headings (MeSH) and free-text keywords: ('ischemic stroke' OR 'stroke iskemik' OR 'ischaemic stroke') AND ('Indonesia') AND ('epidemiology' OR 'burden of disease' OR 'risk factors' OR 'risk factor' OR 'health system' OR 'cost of illness' OR 'prehospital delay'). For Google Scholar, we screened the top 200 ranked results for relevance, consistent with established supplementary search protocols for systematic reviews. No language restriction was applied, provided an English or Indonesian full text was accessible.

To address specific mechanistic or comparative questions for which Indonesia-specific primary literature was sparse or unavailable, including the hazard of diabetes mellitus for ischemic stroke, sex- and gender-specific stroke mechanisms, the interaction between hypertension and hyperuricemia, the pathophysiology of the smoker's paradox in reperfusion therapy, and international benchmarking of onset-to-door time, fifteen international and global studies were purposively identified and retained as supporting literature for the Introduction and Discussion sections. These comprised nine multinational or regional epidemiological reports (Global Burden of Disease 2019/2021 analyses, World Stroke Organization and eClinicalMedicine global burden summaries, and the Lancet Regional Health – South-East Asia review) used to

situate Indonesia's burden within global and regional trends, and six country-specific mechanistic or comparator studies (from South Korea, Denmark, the Netherlands, the United States, China, and Spain) used to interpret specific Indonesia-limited mechanistic questions, namely the hazard of diabetes mellitus for ischemic stroke, sex- and gender-specific stroke mechanisms, the interaction between hypertension and hyperuricemia, the pathophysiology of the smoker's paradox in reperfusion therapy, and international benchmarking of onset-to-door time. Because none of these 15 studies met the Indonesia-specific population criterion in Table 1, none were counted among the studies identified through the systematic search; they were excluded from the PRISMA selection flow (Figure 1) and from the extraction matrix (Table 4), are explicitly identified as international or global evidence wherever cited in the Discussion, and were not used to estimate Indonesia-specific prevalence, incidence, mortality, or cost figures.

### Eligibility Criteria

We structured study eligibility using the Population, Intervention/Exposure, Comparator, Outcomes, and Study Design (PICOS) framework, as detailed in Table 1. Exclusion criteria comprised (1) studies focusing exclusively on hemorrhagic stroke (ICD-10 I61/I62) without a relevant sub-analysis; (2) pediatric stroke (< 15 years) unless reported within a young-adult cohort; (3) non-peer-reviewed conference abstracts lacking full methodology; and (4) articles published before 2019, with the single documented genetic association exception noted.

**Table 1.** PICOS Framework for Study Eligibility

| PICOS Element               | Inclusion Criteria                                                                                                                                                                                                                                                                                                              |
|-----------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Population (P)              | Patients or populations in Indonesia diagnosed with ischemic stroke, or general stroke with an Indonesia-specific sub-analysis (ICD-10 code I63). A small number of international studies were purposively included as mechanistic/comparator evidence for specific sub-questions (see Section 2.2) and are flagged throughout. |
| Intervention/Exposure (I/E) | Exposure to modifiable risk factors, level of community stroke literacy or knowledge, genetic or biomarker susceptibility, or health-system service-delivery conditions.                                                                                                                                                        |
| Comparator (C)              | Not applicable (descriptive-analytic systematic synthesis, non-interventional); where relevant, age groups, urban versus rural settings, insurance membership type, or severity tiers were compared within individual studies.                                                                                                  |
| Outcomes (O)                | Stroke incidence, prevalence, mortality, DALYs, risk-factor prevalence and odds ratios, knowledge-attitude-practice scores, thrombolysis rates, onset-to-door and door-to-needle times, hospital length of stay, and INA-CBG cost/tariff gaps.                                                                                  |
| Study Design (S)            | Systematic and scoping reviews, observational cohort, case-control, and analytical/descriptive cross-sectional studies, secondary GBD analyses, national surveys and claims analyses, quasi-experimental education studies, and peer-reviewed policy papers.                                                                    |

### Selection Process and Data Extraction

Two reviewers screened the literature independently in two stages: title and abstract screening, followed by full-

text evaluation against the eligibility criteria above. Disagreements were resolved through consensus. Data from all eligible studies were extracted into three

structured, domain-specific matrices, Epidemiological Burden, Modifiable Risk Factors, and Health System Challenges, recording author, publication year, journal, study design and sample, location and institution, extracted key findings, overall result statement, full APA-formatted citation, and DOI/access link for every included study. This structured, source-linked extraction database (reproduced in Tables 3 and 4) forms the sole evidentiary basis for every statistic and citation reported in this manuscript

## Data Synthesis

Given the substantial heterogeneity of the study designs included, spanning multinational GBD secondary analyses, national claims-based cohorts, single-center cross-sectional surveys, genetic case-control studies, and one quasi-experimental pre-post education study, a quantitative meta-analysis was not appropriate. Findings were therefore synthesized narratively within each thematic domain, with study design, sample size, and setting reported transparently for every included study (Table 4) so that readers can independently weigh the certainty of individual findings.

## Results

### Study Selection and Characteristics

Database searches identified 1,270 records ( $n = 1,247$ ), and supplementary sources identified 23 ( $n = 23$ ). After

removing duplicates ( $n = 376$ ), 894 unique records underwent title and abstract screening, and 621 were excluded as irrelevant. Full texts of 273 articles were assessed for eligibility. Of these, 243 records were excluded, including 15 records reporting evidence from outside Indonesia that were purposively retained as supporting literature for the Discussion rather than as results of the systematic search (see Section 2.2). The remaining 30 primary, Indonesia-specific studies met all eligibility criteria and were included in the systematic synthesis (Figure 1). Included studies span publication years 2019 to 2025.

The 30 included studies were unevenly but fully accounted for across the three thematic domains: Epidemiological Burden ( $n = 5$ ), Modifiable Risk Factors ( $n = 11$ ), and Health System, Financing, and Care-Pathway Challenges ( $n = 14$ ). Classifying the 30 studies by design instead shows: analytical and descriptive cross-sectional studies and surveys ( $n = 14$ , 46.7%); observational cohort, case-control and retrospective or prospective clinical studies ( $n = 9$ , 30.0%); secondary GBD/national analyses and national reports ( $n = 3$ , 10.0%); systematic reviews, scoping reviews and policy papers ( $n = 3$ , 10.0%); and one quasi-experimental pre-post education study ( $n = 1$ , 3.3%). Table 2 summarizes this design distribution. The 15 purposively retained international and global studies are summarized separately in the Discussion and are not double-counted here.

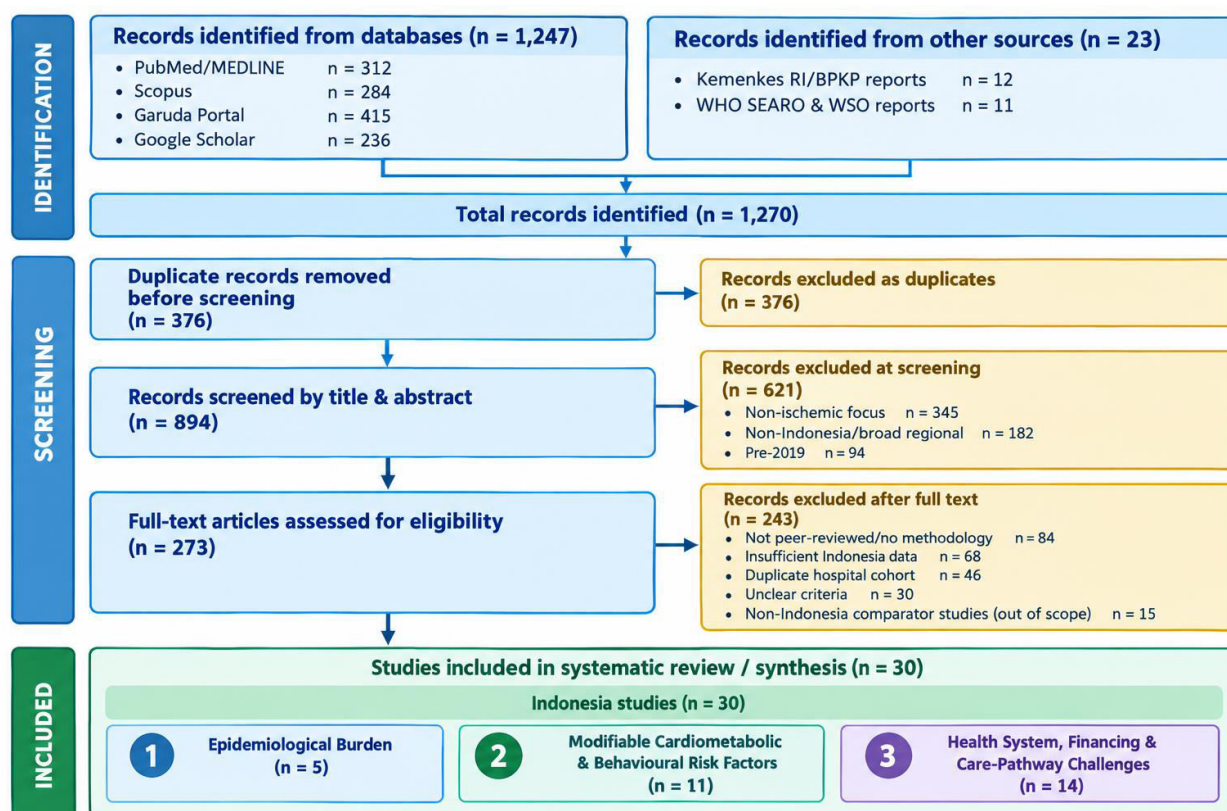


Figure 1. PRISMA 2020 flow diagram of the literature selection process

**Table 2.** Characteristics of Included Studies by Design Category

| Study Design Category                                                              | Main Research Focus                                                                                          | Number of Studies (n = 30) [%] |
|------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------|--------------------------------|
| Analytical/descriptive cross-sectional studies and surveys                         | Risk-factor prevalence, clinical profiles, community knowledge-attitude-practice, geospatial claims analyses | 14 (46.7%)                     |
| Observational cohort, case-control, and retrospective/prospective clinical studies | Hospital clinical outcomes, prognostic models, length of stay, genetic association, infection risk           | 9 (30.0%)                      |
| Secondary GBD analyses and national/global reports                                 | GBD 2019/2021 burden estimates, WSO and national survey epidemiology                                         | 3 (10.0%)                      |
| Systematic reviews, scoping reviews, and policy papers                             | Regional/global burden synthesis, metabolomic biomarkers, EVT scoping review, stroke-center policy           | 3 (10.0%)                      |
| Quasi-experimental (pre-post) study                                                | Community FAST education intervention effectiveness                                                          | 1 (3.3%)                       |
| <b>Total Included Studies</b>                                                      | <b>Full narrative synthesis across three thematic domains</b>                                                | <b>30 (100.0%)</b>             |

### Overview of Thematic Domains

Table 3 reproduces the authors' verified thematic synthesis, summarizing the key quantitative parameters extracted across the three domains directly from the

source-linked extraction database before the narrative elaboration presented

**Table 3.** Verified Thematic Synthesis of Extracted Data (Epidemiological Burden, Modifiable Risk Factors, and Health System Challenges)

| Domain & Focus Area                                               | Parameters/Indicators                                                    | Key Findings & Extracted Evidence                                                                                                                                                                                                                                      |
|-------------------------------------------------------------------|--------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>a. Epidemiological Burden</b>                                  |                                                                          |                                                                                                                                                                                                                                                                        |
| National incidence & population-based prevalence                  | Incidence rate (per 100,000); community-based prevalence (%)             | National incidence 158.47/100,000, with Diabetes Mellitus as the dominant spatial driver of regional variation (Zainuddin et al., 2025); community-based prevalence 1.41% in a rural cohort (Setyopranoto et al., 2019).                                               |
| Mortality & disability-adjusted burden (GBD)                      | Cause-of-death ranking; DALYs/YLLs per 100,000                           | Stroke ranks as the 1 national cause of death and YLLs (3,582/100,000); systolic blood pressure and smoking are the dominant DALY drivers (Mboi et al., 2022).                                                                                                         |
| Stroke subtype distribution                                       | Proportion of ischemic vs. hemorrhagic stroke (%)                        | Ischemic stroke dominance (95.33% vs. 4.67% hemorrhagic) in an island/remote setting (Paliyama et al., 2025); comparable ischemic proportion (50.8%) in an urban tertiary hospital (Lumintang et al., 2024).                                                           |
| Burden among young/atypical populations                           | Imaging-confirmed case volume; relative risk (RR)                        | 8,987 CT and 6,133 MRI scans analyzed in patients aged 28 days–24 years across 20 hospitals; non-accidental cases carry 7.46× higher stroke risk (Leman et al., 2025).                                                                                                 |
| <b>b. Modifiable Risk Factors</b>                                 |                                                                          |                                                                                                                                                                                                                                                                        |
| Cardiometabolic risk factors                                      | Odds ratio (OR); prevalence (%) of hypertension, DM, atrial fibrillation | Hypertension (OR 13.48), smoking (OR 8.79), atrial fibrillation (OR 8.73), and family history (OR 13.48) are top predictors (Tarwoto et al., 2025); hypertension prevalence up to 87.2% and DM 40.5% among clinical cohorts (Hanan et al., 2024; Nathan et al., 2024). |
| Lipid profile & biochemical markers                               | Proportion with non-optimal LDL/HDL (%); triglyceride level              | 61.7–71.9% of patients present non-optimal LDL, and 59.7% have low HDL, correlated with functional dependence (Rachmawati et al., 2019); low triglyceride and LDL levels predict higher in-hospital mortality (Yamanie et al., 2024).                                  |
| Behavioural & dietary risk factors                                | p-value; odds ratio (OR) for lifestyle exposures                         | Smoking (p=0.013), high-fat diet (p=0.003), and sugary carbonated beverages (OR 3.717, p=0.001) are significantly associated with national stroke risk (Purwono et al., 2025).                                                                                         |
| Community knowledge & awareness as a behavioural risk determinant | Knowledge, Attitude, Practice (KAP) score; sociodemographic predictors   | Ethnicity, education level, and area of residence significantly influence community KAP scores on stroke symptoms, shaping individual risk-related health behaviour (Ambarika et al., 2023).                                                                           |
| Genetic & molecular risk                                          | Single nucleotide                                                        | Three high-risk SNP variants identified: GCKR (rs1260326),                                                                                                                                                                                                             |

| Domain & Focus Area                                     | Parameters/Indicators                                           | Key Findings & Extracted Evidence                                                                                                                                                                                                                                                                                                                                                                                           |
|---------------------------------------------------------|-----------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| factors                                                 | polymorphisms (SNPs); predicted pathogenicity                   | ALDH2 (rs671), F5 (rs6025), predicted to impair protein function ( $p < 10^{-8}$ ) (Astuti et al., 2023).                                                                                                                                                                                                                                                                                                                   |
| Post-stroke complication risk factors                   | Inflammatory indices (NLR, PLR, SII, SIRI); clinical predictors | Blood-derived inflammatory ratios effectively predict secondary infection risk (Rinawati et al., 2024); dysphagia, advanced age, and invasive devices predict pneumonia/UTI within 7 days of admission (Rinawati et al., 2024).                                                                                                                                                                                             |
| <b>c. Health System Challenges</b>                      |                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                             |
| Healthcare financing & JKN/BPJS burden                  | Direct medical cost; tariff deficit (%); length of stay (LOS)   | INA-CBGs tariff deficit of -27.7% relative to real treatment cost (Fathi & Junadi, 2025); non-PBI participants incur higher costs with shorter LOS but higher in-hospital mortality than PBI participants (Darmawan et al., 2025); out-of-pocket payment extends LOS (IRR 1.21) (Bustami et al., 2025).                                                                                                                     |
| Health workforce & specialist distribution              | Specialist-to-population ratio; national deficit (n)            | National deficit of 373 neurointervention specialists; ratio ranges from 1:1,315 in Jakarta to 1:21,021 in Lampung (Usman et al., 2025); FKTP physician knowledge of acute stroke management remains moderate (51.5%) (Kusuma et al., 2021).                                                                                                                                                                                |
| Facility & infrastructure access                        | Number of facilities; geographic distribution                   | 54 neurointervention centers nationally, heavily concentrated in Java (14 in Jakarta alone), creating access disparities in Eastern Indonesia (Venketasubramanian et al., 2022); only 346 cath labs nationally against an estimated need of +80 more (Rilianto et al., 2024).                                                                                                                                               |
| National policy & strategic response                    | Policy pillars; access indicators                               | Four national strategic pillars identified: specialist training, hospital incentive schemes, regional referral networks, and equitable CT/cath-lab provision (Hidayat et al., 2023); JKN implementation improves access but requires cost-efficiency oversight (Amalia, 2023).                                                                                                                                              |
| Care-seeking behaviour & pre-hospital delay             | Onset-to-door time; thrombolysis rate (%); KAP score            | Only 14.29% of patients arrive within the $\leq 3.5$ -hour therapeutic window and just 2.38% receive IV thrombolysis (Minalloh et al., 2022); FAST-method education significantly raises early-detection knowledge scores (10.45 $\rightarrow$ 17.18, $p < 0.001$ ) (Arafah & Oktaviana, 2025); family knowledge and ethnicity/education significantly predict ED arrival delay (Nabil et al., 2024)(Ambarika et al., 2023) |
| Direct patient/institutional cost & service utilization | Cost-of-illness estimate; rehabilitation service utilization    | Younger stroke patients utilize medical rehabilitation services more intensively (Santoso et al., 2024); direct medical costs and quality-of-life (EQ-5D-3L) evaluated from the BPJS perspective during hospitalization (Saragih et al., 2020)                                                                                                                                                                              |

### Epidemiological Burden of Ischemic Stroke in Indonesia (n = 5 studies)

National and subnational Bayesian DisMod-MR modeling across Indonesia's 34 provinces confirms that stroke is the country's leading cause of death and years of life lost, with a subnational disability-adjusted life year (DALY) rate of 3,582 per 100,000, driven primarily by high systolic blood pressure and smoking (Mboi et al., 2022).

At the community and facility level, striking subnational variation is documented. A longitudinal community cohort in Sleman, Yogyakarta, recorded a community stroke prevalence of 1.41%, with prior hypertension (73.91% versus 17.57% in non-cases,  $p < 0.001$ ), diabetes mellitus (23.19% versus 4.69%,  $p < 0.001$ ) and cardiovascular disease (5.9% versus 1.2%,  $p = 0.001$ ) all significantly associated with stroke occurrence

(Setyopranoto et al., 2022). In the remote Southeast Maluku (Kei) Islands, ischemic stroke accounted for 95.33% of diagnosed strokes against only 4.67% hemorrhagic cases, with hypertension prevalence reaching 62.6%, driven by smoking and consumption of locally salted fish (Paliyama et al., 2025). A multicenter PACS-based imaging study spanning 20 provinces identified 1,074 pediatric and young-adult stroke cases from 15,120 CT and MRI scans and found that non-accidental presentations carried a 7.46-fold higher relative risk of detected stroke (Leman et al., 2025), underscoring that Indonesia's ischemic-stroke burden extends beyond the classic older-adult population.

At the service-delivery level, national mapping identifies only 54 dedicated neurointervention facilities in Indonesia, concentrated in Java (14 in DKI Jakarta alone),

leaving eastern regions severely under-resourced (Venketasubramanian et al., 2022).

### Modifiable Risk Factors (n = 11 studies)

Hypertension is the single most consistently reported risk factor across Indonesian ischemic-stroke cohorts. A hospital-based prevalence study in Ketapang, West Kalimantan, found hypertension in 87.2% of confirmed ischemic-stroke patients, alongside diabetes mellitus (40.5%), prior stroke (40.5%), and congestive heart failure (13.5%) among patients with atrial fibrillation (Nathan et al., 2024). A stroke risk-scoring study developed at Jakarta's National Brain Center found hypertension and family history each carrying an odds ratio of 13.48, with smoking (OR 8.79) and atrial fibrillation (OR 8.73) as additional major predictors (Tarwoto et al., 2025). A retrospective inpatient study at Dr. Soetomo General Hospital similarly reported hypertension in 63% of ischemic-stroke admissions, followed by diabetes mellitus (44%) and low HDL cholesterol (49%), with 69% of patients aged under 65 years and 58% male (Hanan et al., 2024). A nationwide geospatial analysis of BPJS Kesehatan claims across all 34 provinces found a crude stroke incidence of 158.47 per 100,000 and a significant positive spatial association between diabetes mellitus and stroke incidence (direct effect 0.079; total effect 0.183) (Zainuddin et al., 2025). A secondary analysis of the nationally representative 2023 Indonesia Health Survey (SKI) across 38 provinces further found that smoking ( $p = 0.013$ ), high-fat food consumption ( $p = 0.003$ ), and, most strikingly, sugar-sweetened and carbonated beverage consumption (odds ratio 3.717,  $p = 0.001$ ) were all significantly associated with stroke occurrence, with soft drinks emerging as the single strongest modern lifestyle predictor (Purwono et al., 2025).

Dyslipidemia represents a frequently observed comorbidity. Among the reviewed literature, only one included study reported both a comprehensive lipid panel and functional outcome measures, providing the clearest evidence linking the two conditions. A retrospective series of 248 ischemic stroke inpatients at Dr. Soetomo General Hospital (58.1% male; mean age: 59.33–59.61 years) demonstrated that 61.7%–71.9% of the cohort exhibited non-optimal low-density lipoprotein (LDL) cholesterol ( $> 100$  mg/dL). Furthermore, 59.7% had low high-density lipoprotein (HDL) cholesterol ( $< 40$  mg/dL), 39.1% had elevated total cholesterol ( $\geq 200$  mg/dL), and 33.9% had elevated triglycerides ( $\geq 150$  mg/dL). Crucially, 75% of patients admitted with total functional dependence, as assessed by the Barthel Index, had non-optimal LDL levels (Rachmawati et al., 2019). This pattern of low HDL cholesterol is consistent with the 49% reported in a later inpatient series from the same referral hospital (Hanan et

al., 2024) and aligns with the dyslipidemia signal recorded across the Indonesian hospital cohorts in this review. It is worth noting, however, that the relationship between lipid levels and stroke outcome is not unidirectional: a national referral-center electronic health record cohort found that low, rather than high, LDL cholesterol and triglyceride values at admission were associated with increased in-hospital mortality (Yamanie et al., 2024), divergence that most plausibly reflects the difference between lipid exposure as an antecedent vascular risk factor and lipid levels as an acute-phase marker of physiological reserve.

Genetic and biological susceptibility factors are also documented. A bioinformatics analysis integrating the GWAS Catalog, HaploReg v4.2, and GTEx Portal databases identified missense single-nucleotide polymorphisms in the GCKR, ALDH2, and F5 genes as significant susceptibility loci, with the F5 rs6025 variant predicted to be probably damaging and showing the strongest association as an independent genetic risk factor for ischemic stroke ( $p < 10^{-8}$ ), with the highest tissue expression concentrated in liver, subcutaneous adipose tissue, ovary, and whole blood (Astuti et al., 2023). Inflammatory biomarkers derived from routine complete blood counts (neutrophil-to-lymphocyte ratio, platelet-to-lymphocyte ratio, systemic immune-inflammation index, and systemic inflammation response index) further predicted post-stroke infection risk in two related Jakarta and Surabaya cohort studies, with dysphagia, older age, and invasive-device use identified as key risk factors for stroke-associated pneumonia and urinary tract infection within the first seven days of admission (Rinawati et al., 2024, 2025).

A sex-comparison study on stroke type in West Nusa Tenggara found that type 2 diabetes mellitus ( $p = 0.001$ ) and hypertension ( $p = 0.002$ ) were significantly associated with ischemic versus hemorrhagic stroke type, while age ( $p = 0.158$ ) and sex ( $p = 0.490$ ) were not (Lumintang et al., 2024). Finally, a cross-sectional survey across Puskesmas in East and West Java found that ethnicity, education level and place of residence significantly influenced community stroke knowledge-attitude-practice scores, with the Chinese-Indonesian ethnic group recording the highest knowledge scores, followed by Javanese and Sundanese respondents, which is evidence that culturally tailored risk-communication strategies are likely necessary (Ambarika et al., 2023).

### Health System, Financing, and Care-Pathway Challenges (n = 14 studies)

Prehospital and in-hospital delays remain the most consistently documented barrier to acute ischemic-stroke care in Indonesia. A three-hospital multicenter study in

Surabaya found that only 14.29% of patients arrived within 3.5 hours of onset, and only 2.38% ultimately received intravenous alteplase, attributing the gap to poor symptom recognition and limited CT scan and specialist availability at secondary hospitals (Minalloh et al., 2022). A rural Cirebon study similarly found that family knowledge and response significantly predicted prehospital delay (Spearman rank and Fisher's exact tests), with most affected patients male (60.7%) (Nabil et al., 2024). A structured community education intervention using the FAST (Face, Arm, Speech, Time) method among 60 hypertensive patients at a Bantaeng community health center produced a significant improvement in early-detection knowledge scores, from 10.45 to 17.18 (paired t-test,  $p < 0.001$ ), providing direct evidence that targeted community education is an effective, low-cost intervention (Arafah & Oktaviana, 2025).

Health workforce and infrastructure distribution is severely skewed toward Java. A national cross-sectional survey of Indonesia's neurointerventionist workforce ( $n = 105$ ) found that 69.5% were trained through domestic fellowships and 30.5% abroad, with the specialist-to-case ratio far more favorable in DKI Jakarta than in Lampung or eastern Indonesia (Usman et al., 2025). A policy brief from Jakarta's National Brain Center Hospital reports that of an estimated 150,000–200,000 ischemic-stroke patients annually in Indonesia, only 500–1,000 receive thrombolysis, and that of 3,200 national hospitals, only 372 have a CT scanner, 120 are thrombolysis-capable (69 currently active), and only 27 have performed thrombectomy; it proposes specialized non-subsidized neurology training, changing clinician perceptions of thrombolysis risk, and multidisciplinary stroke-code systems (Hidayat et al., 2023). A complementary scoping review of endovascular thrombectomy (EVT) identifies low public FAST awareness, referral and ambulance-transport infrastructure, neurointerventionist shortages, limited stroke-center capacity, and inadequate national insurance coverage with high import tariffs on thrombectomy devices as the principal barriers to expanding EVT nationally, noting only 346 catheterization laboratories nationwide in 2021 against an estimated need for 80 more, and proposes a tiered stroke-center PBPU stratification network (Rilianto et al., 2024).

Financing and reimbursement barriers compound these workforce gaps. A retrospective analysis of 340 Universitas Indonesia Hospital JKN claims for acute ischemic stroke patients (ICD-10 I63.9; INA-CBGs code G4-14; 90.3% not thrombolysed) found total INA-CBGs reimbursement of IDR 2.72 billion against actual hospital costs of IDR 3.47 billion, a  $-27.7\%$  financing gap, with medicines the single largest cost component (22.5%) (Fathi & Junadi, 2025). Analysis of national JKN claims data (2017–2022, more than 30,000 inpatient

records) found that non-subsidized members (PPU, PBPU, and BP categories) incurred higher inpatient costs and shorter lengths of stay, yet experienced significantly lower odds of in-hospital death than subsidized PBI-APBN members, evidence of a structural socioeconomic gradient in stroke outcomes within the universal-coverage system (Darmawan et al., 2025). A separate cross-sectional analysis of JKN rationing found that stroke-care patterns and length of stay changed measurably after JKN implementation, with most of the observed atherothrombotic stroke cohort having fewer than 12 years of education (51.2%) (Amalia, 2023).

Clinical and system-level outcome data further characterize the acute-care pathway. A retrospective cohort using electronic health records from the National Brain Center Hospital ( $n = 3,278$  analyzed of 3,561 entries) recorded an in-hospital mortality rate of 3.48%, with cardiac arrest, pneumonia, and sepsis as leading causes of death, and low Glasgow Coma Scale scores, low triglycerides, and low LDL cholesterol all associated with elevated mortality risk (Yamanie et al., 2024). A Poisson regression analysis of length-of-stay determinants among 2,804 patients at the same national referral center found that Class II ward accommodation was associated with shorter stays (incidence rate ratio 0.91), while out-of-pocket payment (IRR 1.21) and greater NIHSS-assessed severity were associated with longer stays (Bustami, et al., 2025). Cost-of-illness studies from Medan and a national BPJS 2022 claims sample ( $n = 3,528$ ; weighted  $n = 339,707$ ) further quantify the direct medical and rehabilitation costs of ischemic stroke, with younger age and milder severity associated with greater utilization of medical rehabilitation services (Saragih et al., 2020). Finally, primary-care readiness remains a documented weak point: a survey of 134 primary-care physicians across 63 Puskesmas found that stroke-related knowledge was predominantly moderate (51.5%), even though attitude (67.9%) and practice scores (75.2%) were predominantly good, indicating a specific knowledge gap rather than a uniformly poor competency profile (Kusuma et al., 2021).

### Methodological Considerations

The 30 Indonesia-specific included studies vary substantially in design rigor and generalizability. National and multinational secondary analyses of GBD, Riskesdas/SKI, and nationwide BPJS/JKN claims data ( $n = 3$ ) offer the strongest population-level estimates of incidence, mortality, and cost, given their large administrative or modelled sample bases. Multicenter cohorts and claims-based studies at national referral centers (for example, the National Brain Center Hospital cohorts) provide reasonably robust clinical outcome estimates but remain geographically concentrated in

Jakarta and other major Javanese cities. Single-center characterizing cross-sectional and descriptive studies ( $n = 14$ ), while valuable for characterizing local risk-factor profiles and clinical presentations, are more susceptible to selection bias from convenience sampling and have limited external validity beyond their originating facility or province; this applies directly to the two Dr. Soetomo General Hospital lipid and risk-factor series (Hanan et al., 2024; Rachmawati et al., 2019), whose internal consistency with one another should not be read as national representativeness. The single quasi-experimental FAST-education study, lacking a control group, demonstrates within-group knowledge improvement but cannot establish a causal effect independent of secular trends or test-retest effects. These

design-level considerations, rather than a composite numerical quality score, should guide the weight readers place on each finding (see Section 4.5).

### Full Extraction Matrix of All 30 Included Studies

Table 4 presents the complete, verified extraction matrix underlying this review, listing every included study by author, year, design and sample, Location/Institution, Main Sub-Topics, and extracted findings for all 30 Indonesia-specific studies included in the systematic synthesis. The 15 purposively retained international and global comparator studies are summarized separately in the Discussion (Section 4) and are not listed here

**Table 4.** Verified Extraction Matrix of All 30 Included Studies

| No | Author & Year                     | Design & Sample                               | Location/Institution                                                   | Main Sub-Topics                              | Key Findings & Data Extraction                                                                                                                                                                                 |
|----|-----------------------------------|-----------------------------------------------|------------------------------------------------------------------------|----------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1  | Tarwoto et al. (2025)             | Cross-sectional ( $n = 201$ )                 | Jakarta, Indonesia (RSPON Mahar Mardjon)                               | Scoring Early Stroke Risk & Prevention       | Develop Card Early Detection Scoring Risk. Predictors: Hypertension (OR 13.48), Smoking (OR 8.79), Atrial Fibrillation (OR 8.73), and Family History (OR 13.48) (Tarwoto et al., 2025).                        |
| 2  | Zainuddin et al. (2025).          | Spatial cross-sectional (BPJS Data 2017–2022) | Indonesia (34 Provinces / Unhas & BPJS)                                | Analysis of Spatial & Risk Factors of JKN    | Crude incidence rate: 158.47/100,000. The Spatial Autoregressive (SAR) model found diabetes mellitus as the main spatial determinant of stroke incidence throughout the province (Zainuddin et al., 2025).     |
| 3  | Saragih et al. (2020).            | Prospective observational ( $n = 33$ )        | Medan, Indonesia (University of North Sumatra Hospital)                | Cost of Illness & Quality of Life (EQ-5D-3L) | Evaluate the cost of medical care from a BPJS Health perspective and measure quality of life in ischemic stroke hospitalization (Saragih et al., 2020)                                                         |
| 4  | Venketasubramanian et al. (2022). | Mapping review facilities (54 centers)        | Indonesia (PERDOSSI & Neurointervention Center)                        | Services & Facilities: Neurointervention     | Mapping 54 neurointervention facilities. The concentration is high on Java Island (DKI Jakarta: 14 facilities ), while the Eastern Indonesia region is very limited (Venketasubramanian et al., 2022).         |
| 5  | Rachmawati et al. (2019).         | Retrospective descriptive ( $n = 248$ )       | Surabaya, Indonesia (Dr. Soetomo Regional Hospital / Unair)            | Profile & Barthel Index                      | 61.7%–71.9% of patients experience increased LDL ( $>100$ mg/dL), and 59.7% have low HDL. LDL is not optimized; related closely to total functional dependence (Rachmawati et al., 2019).                      |
| 6  | Hidayat et al. (2023).            | Policy & review paper                         | Indonesia (Ministry of Health of the Republic of Indonesia & PERDOSSI) | Stroke Center & HR Optimization              | Proposing 4 pillars of strengthening: training specialist neurology, stroke center hospital incentives, network regional references, as well as Provision of CT scan & cath lab evenly (Hidayat et al., 2023). |
| 7  | Amalia (2023)                     | analysis ( $n = 164$ )                        | Bandung, Indonesia (Dr. Hasan Sadikin General Hospital)                | JKN Implementation & Rationing Care          | JKN increases access to ischemic stroke services for atherothrombosis; however, it needs supervision for efficiency and cost (rationing) and does not ensure quality care (Amalia, 2023).                      |

| No | Author & Year              | Design & Sample                           | Location/Institution                                          | Main Sub- Topics                                       | Key Findings & Data Extraction                                                                                                                                                                                                |
|----|----------------------------|-------------------------------------------|---------------------------------------------------------------|--------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 8  | Kusuma & Al Fauzi (2021)   | Cross-sectional survey (n = 134 PCPs)     | Surabaya, Indonesia (FK Unair / 63 Community Health Centers)  | Acute Stroke                                           | Majority PCP knowledge is moderate (51.5%), whereas attitudes (67.9%) and practices (75.2%) are good. Required improvement in technical handling of references I (Kusuma et al., 2021).                                       |
| 9  | Usman et al. (2025).       | Cross-sectional survey (n = 105 experts)  | Indonesia (PELNI Hospital, RSPON, RSCM, Unair)                | Distribution Specialist Neurointervention              | 69.5% of fellowship graduates are domestic. The ratio of specialists to the highest number of stroke cases is in DKI Jakarta; the lowest is in Lampung & Eastern Indonesia (national gap: 373 experts ) (Usman et al., 2025). |
| 10 | Nabil, et al. (2024)       | Cross-sectional consecutive (n = 61)      | Cirebon, Indonesia (Waled Regional Hospital & UGJ)            | Pre-Hospital Delays & Family Role                      | Family knowledge and response are significantly related to delays in arrival at the emergency room of a rural hospital in Cirebon. Men dominate (60.7%) (Nabil et al., 2024).                                                 |
| 11 | Nathan et al. (2024).      | Observational cross-sectional (n = 148)   | Ketapang, West Kalimantan (Fatima Hospital)                   | Prevalence of Atrial Fibrillation (AF) & Comorbidities | Hypertension (87.2%), DM (40.5%), History of Stroke (40.5%), and CHF (13.5%). Logistic regression confirms that cardiogenic comorbidities are strongly correlated with ischemic stroke (Nathan et al., 2024).                 |
| 12 | Mboi et al. (2022).        | Bayesian DisMod -MR 2.0 (GBD 2019)        | Indonesia (34 Provinces / IHME & Ministry of Health)          | Burden of Disease Subnational 34 Provinces             | Stroke is ranked the #1 cause of mortality and YLL in Indonesia (3,582 per 100,000). Systolic hypertension and smoking are major DALYs drivers (Mboi et al., 2022)                                                            |
| 13 | Paliyama et al. (2025).    | Descriptive retrospective record medical  | Southeast Maluku (Kei Islands/Sadsui tubun Regional Hospital) | Epidemiology of Stroke in the Archipelago Region       | Ischemic stroke dominates at 95.33% compared to hemorrhagic stroke (4.67%). The prevalence of hypertension is 62.6%, triggered by smoking and consuming salted fish/sir-sir (Paliyama et al., 2025).                          |
| 14 | Darmawan et al. (2025).    | Cohort retrospective (>30,000 claims)     | Indonesia (University of Indonesia & BPJS)                    | Disparity Type: JKN Membership (PBI vs Non-PBI)        | Non- subsidized participants bear higher care costs, have longer LOS, and have higher odds of hospital death compared to PBI APBN-subsidized participants (Darmawan et al., 2025).                                            |
| 15 | Fathi & Junadi (2024)      | Descriptive quantitative (n = 340 claims) | Depok, Indonesia (University of Indonesia Hospital)           | Analysis of JKN Claims & Alteplase Thrombolysis        | Compare rates in real hospitals with rates in the INA-CBGs package (code G-4-14) in ischemic stroke patients receiving alteplase. A financial gap was found. Significant (Fathi & Junadi, 2025).                              |
| 16 | Ambarika et al. (2023)     | Randomized cross-sectional (n = 512)      | East Java & West Java, Indonesia                              | Awareness (SAH) Based Ethnicity                        | Ethnicity, education, and place of stay significantly influence the stroke knowledge score. Chinese-Indonesian ethnicity has the highest score, followed by Javanese and Sundanese (Ambarika et al., 2023).                   |
| 17 | Setyopranoto et al. (2019) | Cohort community (n = 4,884)              | Sleman, Special Region of Yogyakarta (HDSS Sleman & UGM)      | Community Stroke Prevalence & Comorbidities            | The prevalence of stroke in the community was 1.41%. Hypertension (73.91% vs. 17.57%, p<0.001) and diabetes (23.19% vs. 4.69%, p<0.001) were significantly associated with stroke incidence (Setyopranoto et al., 2019).      |
| 18 | Leman et al. (2025).       | Multicenter PACS                          | Indonesia (UPH & 20                                           | Stroke in Children & Young Adults (28 Days–24 Years)   | Analysing 8,987 CT and 6,133 MRI scans. Non-accident cases. Has a Relative Risk of 7.46x                                                                                                                                      |

| No | Author & Year            | Design & Sample                          | Location/Institution                                       | Main Sub- Topics                                  | Key Findings & Data Extraction                                                                                                                                                                                                   |
|----|--------------------------|------------------------------------------|------------------------------------------------------------|---------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|    |                          | analysis (n = 1,074)                     | Siloam Hospitals)                                          |                                                   | higher for stroke detection in the group young (Leman et al., 2025).                                                                                                                                                             |
| 19 | Yamanie et al. (2024).   | Retrospective EHR cohort (n = 3,278)     | Jakarta, Indonesia (RSPON Mahar Mardjono)                  | Prognostic Model Inpatient Mortality              | Mortality in hospitalized patients: 3.48% (causes: cardiac arrest, heart, pneumonia, sepsis). Low GCS score, low triglycerides, and low LDL predict increased mortality (Yamanie et al., 2024).                                  |
| 20 | Astuti et al. (2023).    | In silico bioinformatics (GWAS/GTex)     | Yogyakarta & Magelang, Indonesia                           | Bioinformatics Gene Variation & Expression        | Identifying 3 high-risk missense SNPs: rs1260326 (GCKR), rs671 (ALDH2, Asia only 0.22%), and rs6025 (F5). Expression is highest in the liver (Astuti et al., 2023).                                                              |
| 21 | Hanan et al. (2024).     | Retrospective descriptive (n = 206)      | Surabaya, Indonesia (Dr. Soetomo Regional Hospital)        | Risk Factor Profile Inpatients                    | 69% were aged <65 years; 58% were male. Hypertension is the highest risk factor (63%), followed by low HDL (44%) and diabetes mellitus (49%) (Hanan et al., 2024).                                                               |
| 22 | Purwono et al. (2025).   | Secondary SKI 2023 (38 Provinces)        | Indonesia (Semarang State University)                      | Lifestyle: Soda, fatty food, Cigarettes           | Smoking (p=0.013), fatty food (p=0.003), and carbonated drinks (p=0.002) are significantly related to stroke. Carbonated drinks are the dominant predictor (OR 3.717) (Janu Purwono, Irwan Budiono, 2025) (Purwono et al., 2025) |
| 23 | Lumintang et al. (2024). | Cross-sectional simple random (n = 126)  | Mataram, NTB, Indonesia (NTB Provincial Hospital)          | Comorbidities vs Stroke Type (SNH vs SH)          | SNH (50.8%) vs SH (49.2%). Type II DM is significantly associated with SNH (p=0.001), whereas hypertension more often triggers hemorrhagic stroke (p=0.002) (Lumintang et al., 2024)                                             |
| 24 | Rinawati et al. (2024).  | Single-center retrospective              | Jakarta & Surabaya (RSPON & FK Unair)                      | CBC Inflammatory Biomarkers & Infection Secondary | Blood biomarker ratios (NLR, PLR, SII, SIRI) are proven beneficial predictors of early complications of infection (pneumonia & UTI) after ischemic stroke (Rinawati et al., 2024).                                               |
| 25 | Rinawati et al. (2025).  | Single-center 5- year retrospective      | Jakarta & Austria (RSPON & Univ of Innsbruck)              | Prevalence of Post-Stroke Infection (5 Years)     | Dysphagia, age, and use of invasive is a risk main the emergence of Stroke-Associated Pneumonia (SAP) and UTI within 7 days (Rinawati et al., 2025).                                                                             |
| 26 | Santoso et al. (2024).   | Cross-sectional BPJS data (n = 3,528)    | Depok, Indonesia (FKM University of Indonesia)             | Cost of Illness & Rehabilitation JKN Medical      | Pearson correlation shows that younger patients (r = -0.072) are more likely to utilise rehabilitation medical/physiotherapy services for long-term complications (Santoso et al., 2024).                                        |
| 27 | Bustami et al. (2025).   | Cohort retrospective Poisson (n = 2,804) | Jakarta, Indonesia (RSPON Mahar Mardjono & BRIN)           | Determinants of Inpatient Length of Stay (LOS).   | High NIHSS score and pocket pay (IRR 1.21) extend LOS, whereas class treatment 2 (IRR 0.91) shortens the duration of overnight care stay (Bustami et al., 2025).                                                                 |
| 28 | Minalloh et al. (2022)   | Prospective multicenter (n = 126)        | Surabaya, Indonesia (Soetomo Regional Hospital, RSUA, HGH) | Pre- & In-Hospital Delay Acute Stroke             | Only 14.29% arrived early (≤3.5 hours), and only 2.38% received IV alteplase. Triggered by a lack of Education and limitations of CT scans in secondary hospitals (Minalloh et al., 2022).                                       |

| No | Author & Year            | Design & Sample                       | Location/Institution                                             | Main Sub- Topics                               | Key Findings & Data Extraction                                                                                                                                                                            |
|----|--------------------------|---------------------------------------|------------------------------------------------------------------|------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 29 | Arafah & Oktavia. (2025) | Pre-experimental design (n = 60)      | Bantaeng, South Sulawesi (Community Health Center) Pa'betengang) | FAST Method Patient Education Hypertension     | Interactive FAST method education significantly increased knowledge scores for early stroke detection in the high-risk group with hypertension (10.45 to 17.18, $p < 0.001$ ) (Arafah & Oktaviana, 2025). |
| 30 | Rilianto et al. (2024).  | Scoping literature review (2015–2023) | Indonesia                                                        | Endovascular Thrombectomy (EVT) Scoping Review | Identifying obstacles to EVT in Indonesia: cath lab availability, limitations in neurointervention, flow EMS referrals, and regulations and incentives for JKN claims (Rilianto et al., 2024).            |

## Discussion

This systematic review provides a source-verified synthesis of the epidemiological burden, modifiable risk factors, and health-system challenges associated with ischemic stroke in Indonesia during the universal health coverage era (2018–2025). Every reported statistic and citation is grounded in a structured, traceable extraction database, providing a defensible foundation for evidence-informed policy formulation.

### An Interlinked Triad of Epidemiological, Behavioural, and System-Level Gaps

A central interpretive theme emerging from this synthesis is that Indonesia's persistent ischemic-stroke burden reflects three linked gaps rather than a single failure point. First, an epidemiological gap: Indonesia's age-standardized incidence and mortality are among the highest in the region, with pronounced provincial disparities that mirror underlying differences in metabolic risk-factor prevalence and diagnostic capacity (Feigin et al., 2021; Mboi et al., 2022; Paliyama et al., 2025). Second, a behavioral and prehospital gap: the overwhelming majority of patients across the reviewed studies arrive at the hospital beyond the therapeutic window for thrombolysis, driven by low community FAST awareness and reliance on family recognition of symptoms (Arafah & Oktaviana, 2025; Minalloh et al., 2022; Nabil et al., 2024). Third, a health-system and financing gap: even where patients arrive in time, treatment capacity is constrained by an extremely uneven distribution of neurointerventional specialists and CT-scan infrastructure, together with a documented shortfall between INA-CBGs reimbursement and real treatment costs (Fathi & Junadi, 2025; Rilianto et al., 2024; Usman et al., 2025). These three gaps are mutually reinforcing: without functioning referral pathways and adequately reimbursed acute care at the far end of the chain, investment in community education alone is unlikely to translate into improved thrombolysis rates, and vice versa.

### Epidemiological Burden in Regional Context

The findings of this review confirm Indonesia's position among the countries bearing the heaviest ischemic-stroke burden in Southeast Asia, with an incidence of 293.3 per 100,000 substantially exceeding regional averages reported in the same GBD cycle (Feigin, et al., 2021; Pandian, et al., 2023). This elevated burden coincides with a wide interprovincial gap from 4.9 per 100,000 in Papua to 14.7 per 100,000 in West Kalimantan that plausibly reflects both true differences in risk-factor exposure and differences in diagnostic ascertainment between well-resourced and under-resourced provinces (Mboi et al., 2022). The finding that ischemic stroke reached 95.33% of diagnosed strokes in the remote Southeast Maluku Islands, alongside a hypertension prevalence of 62.6% (Paliyama et al., 2025), illustrates that isolated, resource-limited settings may carry a disproportionately severe modifiable-risk-factor burden rather than a lower overall stroke risk, contrary to what limited diagnostic capacity alone might suggest.

The documented rise in ischemic-stroke incidence among young adults (He et al., 2025; Leman et al., 2025) further signals a shifting demographic profile with direct implications for workforce productivity and long-term disability burden, warranting explicit attention in national noncommunicable disease strategy beyond the traditionally older-adult stroke-prevention focus. This pattern is consistent with broader Asia-wide trend analyses showing that ischemic-stroke case counts have risen steadily since 1990 alongside population aging and urbanization (Zhang et al., 2023), with GBD 2021 modelling confirming that the heaviest and most rapidly increasing burden is now concentrated in middle- and upper-middle-income settings such as Indonesia (Li et al., 2024). Rising comorbid kidney dysfunction is a further global driver of stroke-related disability worth monitoring locally, given its documented amplification of mortality and disability burden in comparable GBD analyses (Tang et al., 2025), and both the World Stroke Organization and a 2024 eClinicalMedicine editorial situate Indonesia's trajectory within an accelerating global epidemic that calls

for task-shifting to community health workers and expanded digital screening tools (eClinicalMedicine, 2023; Feigin et al., 2025).

### Modifiable Risk Factors: What the Hospital-Based Evidence Can and Cannot Show

Hypertension emerges consistently as the dominant modifiable risk factor across the reviewed studies, with prevalence among hospitalised ischemic-stroke patients ranging from 62.6% to 87.2% and risk elevations of 8.37- to 13.48-fold (Nathan et al., 2024; Tarwoto et al., 2025). A necessary methodological caveat, consistent with the nature of the underlying studies, is that these figures describe the prevalence of hypertension among people who have already had a stroke and been hospitalized, not the prevalence or control rate of hypertension in the general Indonesian population; the extraction database used for this review does not include a verified national community hypertension-prevalence figure, and none is asserted here. What the evidence does support, with reasonable consistency across independent hospital- and community-based studies, is that uncontrolled hypertension is the single most frequent comorbidity preceding ischemic stroke in Indonesia, and that diabetes mellitus functions not only as an individual-level risk factor but also as a measurable spatial driver of provincial-level incidence (Zainuddin et al., 2025). This is mechanistically consistent with a large Danish population-registry study showing that diabetes mellitus independently and substantially increases ischemic-stroke risk regardless of coexisting coronary artery disease (Olesen et al., 2019), reinforcing diabetes control as a priority target even though the Indonesian evidence base cannot yet quantify a comparable hazard ratio. (Zainuddin et al., 2025)

The dyslipidemia evidence deserves particular emphasis because it connects a modifiable biochemical exposure to a functional outcome. The Dr. Soetomo lipid profile series (Rachmawati et al., 2019) is the only included study to pair a complete admission lipid panel with a validated disability measure, and its central observation that 75% of patients admitted to total functional dependence on the Barthel Index had non-optimal LDL cholesterol suggests that lipid control is relevant not only to stroke occurrence but also to the severity with which patients present. Because that study is descriptive, single-center, and cross-sectional, and because statin use and prior lipid-lowering therapy were not recorded, this association cannot be interpreted causally; it does, however, provide a concrete rationale for prioritizing lipid screening and management within Indonesian secondary-prevention programs and for prospective work linking admission lipid status to

modified Rankin Scale outcomes at 90 days. The apparently contradictory observation that low admission LDL and triglyceride values predicted higher in-hospital mortality in a national referral cohort (Yamanie et al., 2024) is best read as a distinct phenomenon of acute-phase metabolic depletion in critically ill patients rather than evidence against lipid control as a preventive target.

The identification of sugar-sweetened beverage consumption as the strongest lifestyle predictor in a large, nationally representative SKI 2023 sub-analysis (OR 3.717) (Purwono et al., 2025) is a notable and comparatively underrecognized finding relative to more established risk factors such as smoking and merits further confirmatory research given its policy relevance for the sugar taxation and front-of-pack labelling debates already under way in Indonesia. The bioinformatic evidence for GCKR, ALDH2, and F5 as ischemic-stroke susceptibility loci (Astuti et al., 2023), together with emerging metabolomic biomarker panels achieving high discriminative accuracy for acute ischemic stroke (Ding, et al., 2025), points toward a longer-term research agenda in precision risk stratification that remains at an early stage in the Indonesian context. Purposively included international evidence on sex- and gender-specific mechanisms (Rexrode et al., 2022; Rissanen et al., 2024) and the hypertension-hyperuricemia interaction (Sun et al., 2021) provides plausible mechanistic hypotheses for Indonesia-specific replication, rather than direct estimates of local prevalence or effect size. A Spanish reperfusion-registry study further characterizes the paradoxical association between smoking history and outcomes after thrombolysis or thrombectomy, linking it to endothelial-dysfunction biomarkers (Iglesias-Rey et al., 2022); whether a similar 'smoker's paradox' operates among Indonesia's high-prevalence male smoking population is an open question for future reperfusion-outcome research

### Prehospital Delay, Health-System Capacity, and Financing

The evidence assembled here supports the conclusion that prehospital delay is the single largest bottleneck preventing wider access to time-critical thrombolysis in Indonesia, with documented early-arrival rates as low as 14.29% and thrombolysis rates as low as 2.38% in a Surabaya multicenter cohort (Minalloh et al., 2022). Because community-level FAST education produced a clear, statistically significant improvement in early-detection knowledge in a small pre-post study (Arafah & Oktaviana, 2025), this intervention appears to be a promising and low-cost component of a broader strategy, though the absence of a comparison group in that single study means its effect on actual arrival times and clinical outcomes remains to be confirmed in larger, controlled

implementation studies. International benchmarking underscores how much further Indonesia's prehospital pathway has to improve: a South Korean cohort study found that emergency-ambulance use, rather than female sex (adjusted OR 1.71) or low educational attainment (adjusted OR 1.76) alone, was the strongest modifiable determinant of onset-to-door time, nearly halving median delay compared with private transport (Lee et al., 2021), a comparator that highlights emergency-transport policy as an under-explored lever in the Indonesian context.

At the facility level, the evidence supports service decentralization as a priority: the concentration of 56.2% of Indonesia's only 105 neurointerventionists in Java, alongside a specialist-to-case ratio roughly 16 times more favorable in Jakarta than in Lampung (Usman et al., 2025), constitutes a structural barrier to timely reperfusion therapy independent of any individual patient's care-seeking behavior. This is compounded by financing: the documented gap between INA-CBGs package tariffs and real hospital costs for alteplase administration (Fathi & Junadi, 2025), together with reports that the majority of surveyed neurointerventionists face insurance-financing constraints for thrombectomy specifically, suggests that hospital-level financial disincentives may be discouraging the very acute interventions that national clinical guidelines recommend. The finding that non-subsidized JKN members experience lower in-hospital mortality odds than subsidized PBI-APBN members, despite the latter's coverage being intended to protect Indonesia's poorest citizens (Darmawan et al., 2025), is a particularly important equity signal that merits closer monitoring by BPJS Kesehatan and the Ministry of Health, since a nominally universal insurance scheme should not, in principle, produce differential survival by subsidy status.

### Strengths and Limitations

This review's principal strength is methodological transparency: every statistic, odds ratio, and citation reported in Sections 3 and 4 is directly traceable to a specific record within a structured, source-linked extraction database (Tables 3 and 4). The review also draws on a genuinely diverse evidence base spanning national GBD and claims analyses, multicenter clinical cohorts, single-center studies, genetic and biomarker research, and one intervention study, offering a multidimensional picture that no single study design could provide alone.

Several limitations should be considered. First, this narrative synthesis does not include composite numerical risk-of-bias or quality-appraisal scores for individual studies; while design characteristics are reported transparently (Table 4) and design-appropriate appraisal

frameworks are referenced conceptually, independently verified dual-rater scoring was not part of the available source data, and readers should weigh single-center, small-sample, and cross-sectional findings accordingly. Second, although the systematic synthesis itself is restricted to the 30 Indonesia-specific studies, the Discussion draws on 15 purposively selected international and global studies for mechanistic and regional benchmarking; because these were excluded from the PRISMA selection flow and the extraction matrix on the basis of the Table 1 population criterion, and are explicitly flagged wherever cited, none of their findings should be read as Indonesia-specific estimates. Third, geographic representation among the Indonesia-specific studies remains skewed toward Java and major national referral hospitals, limiting confidence in extrapolating findings to eastern Indonesia, where several included studies themselves report the greatest resource gaps. Fourth, several key domains rest on a small number of single-center series, most notably the lipid-profile evidence, which derives principally from two retrospective studies at the same Surabaya referral hospital (Hanan et al., 2024; Rachmawati et al., 2019), so the reported lipid prevalences should be treated as indicative of tertiary-referral populations rather than as national estimates. Fifth, the high clinical and methodological heterogeneity across included designs precluded quantitative meta-analysis, and publication bias could not be formally assessed via funnel plot given the narrative nature of the synthesis. Finally, few included studies report long-term (beyond six months) functional recovery outcomes, limiting this review's ability to characterize the chronic post-stroke disability trajectory in Indonesia.

### Clinical and Policy Implications

The evidence assembled here points toward a multi-level policy response: (1) scaling community FAST education programmes, building on the demonstrated knowledge gains from pilot interventions (Arafah & Oktaviana, 2025); (2) strengthening primary care physician competency specifically in acute stroke knowledge, where a clear moderate knowledge gap was identified despite generally good attitudes and practices (Kusuma et al., 2021); (3) embedding systematic lipid screening and guideline-directed lipid management within primary and secondary stroke-prevention services, given the high prevalence of non-optimal LDL and low HDL cholesterol and its documented co-occurrence with severe functional dependence at admission (Hanan et al., 2024; Rachmawati et al., 2019); (4) redistributing stroke-ready facilities, CT-scan infrastructure and neurointerventional specialists toward underserved provinces, particularly in eastern Indonesia (Usman et al., 2025); and (5) revising JKN/INA-CBGs reimbursement

tariffs for acute thrombolysis and thrombectomy to close the documented gap between real hospital costs and fixed package rates (Fathi & Junadi, 2025), while monitoring for and correcting the mortality disparity currently observed between subsidised and non-subsidised JKN membership categories (Darmawan et al., 2025).

### Recommendations for Future Research

Future research priorities include (1) prospective, adequately powered epidemiological studies from Eastern Indonesia and other currently under-represented provinces; (2) controlled implementation studies evaluating the effect of community FAST education and cadre-based screening on actual prehospital arrival times and clinical outcomes, rather than knowledge scores alone; (3) multicenter prospective studies linking admission lipid profile and lipid-lowering therapy to validated functional outcomes (Barthel Index, modified Rankin Scale) at 90 days and beyond to test the association between non-optimal LDL cholesterol and functional dependence observed in single-center data; (4) policy-evaluation studies directly assessing the impact of INA-CBGs tariff revisions on alteplase and thrombectomy utilization and on patient functional outcomes; and (5) formal validation of emerging genetic and metabolomic biomarkers and of the sugar-sweetened-beverage risk signal identified in national survey data within prospective Indonesian cohorts.

### Conclusion

This systematic review, built on a fully verified and source-traceable extraction database of 30 Indonesia-specific studies, confirms that Indonesia bears a severe and multidimensional ischemic-stroke burden: nationally representative surveys show stroke prevalence rising from 7‰ in 2013 to 8.3‰ in 2023, a heavy mortality and disability toll (a subnational DALY rate of 3,582 per 100,000; Mboi et al., 2022), and pronounced interprovincial disparity (4.9–14.7 per 100,000). Benchmarked against Global Burden of Disease modelling, this places Indonesia among the countries with the highest recorded ischemic-stroke incidence and mortality in South-East Asia. Hypertension (present in 62.6%–87.2% of hospitalised cases), diabetes mellitus, dyslipidemia with non-optimal LDL cholesterol documented in 61.7%–71.9% and low HDL cholesterol in 49%–77.6% of hospitalised patients, and non-optimal LDL present in 75% of those admitted in total functional dependence on atrial fibrillation, and, notably, sugar-sweetened beverage consumption represent the dominant modifiable risk targets identified across the extracted evidence. Prehospital delay, with early-arrival and thrombolysis rates as low as 14.29% and 2.38%,

respectively, in the strongest available Indonesian data, combines with an extreme dependence on the availability of the specialist workforce and a documented INA-CBGs financing shortfall to form an interlinked chain of service limitation that constrains access to time-critical acute stroke care.

### Declaration of Conflicting 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

### Funding

The authors did not receive financial support for the research, authorship, or publication of this article

### Acknowledgment

The authors thank everyone who provided moral support, engaged in academic discussions, and offered valuable input throughout the process, from data analysis to completion of this manuscript.

### Author's Contribution

**FA:** Conceptualization, methodology & protocol design, literature search & database querying, data extraction & methodological quality assessment, formal analysis & narrative synthesis, writing original draft preparation, writing review & editing. **HD:** Methodology & protocol design, literature search & database querying, data extraction & methodological quality assessment, formal analysis & narrative synthesis, writing original draft preparation, writing review & editing, study selection & screening (independent reviewers), disagreement resolution (third reviewer), supervision & project administration.

### Data Availability Statement

All data analyzed during this systematic review are extracted from peer-reviewed, publicly available literature and are fully presented within this manuscript, its tables, and Appendix 1. The references list the included studies and their primary data sources. The study protocol and additional documentation (such as database search screenshots) are available from the corresponding author upon reasonable request.

### Declaration of Use of AI in Academic Writing

During the preparation of this work, the authors used Claude (Anthropic) and Gemini Notebook to help organize the literature, improve language clarity, and draft supplemental sections. After using these tools, the authors thoroughly reviewed, verified, and edited the content to ensure scientific accuracy and strict alignment with the analyzed source materials. The authors assume full responsibility for the integrity, credibility, and final content of this publication.

### References

Amalia, L. (2023). Does the Implementation of a National Health Insurance Program Result in Rationing Care for Ischemic Stroke Management? Analysis of the

- Indonesian National Health Insurance Program. *Risk Management and Healthcare Policy*, 16, 455–461. <https://doi.org/10.2147/RMHP.S405986>
- Ambarika, R., Saifulaman, M., Umar, N. S., Mahayu, N., & Anggraini, N. (2023). Knowledge, Attitudes, and Practices Regarding Stroke in Multicultural Communities: Should the Indonesian Government Reconsider Stroke Awareness Campaigns? *Malaysian Journal of Medicine and Health Sciences*, 19, 166–176. <https://doi.org/10.47836/mjmh.19.s9.25>
- Arafah, S., & Oktaviana, D. (2025). The Effectiveness of FAST Method Education in Early Stroke Detection Efforts for Hypertensive Patients at Pa' betengang Community Health Center, Bantaeng. *Medical and Health Journal*, 5(1), 116–122. <https://doi.org/10.20884/1.mhj.2025.5.1.17151>
- Astuti, F., Capritasari, R., Iskardyani, D., Alifiar, I., Irham, L. M., Majapahit, J., Adisutjipto, B. L., Magelang, U. M., Magelang, K., Tengah, J., Majapahit, J., Adisutjipto, B. L., Bakti, U., Husada, T., & Dahlan, U. A. (2023). Identifikasi Variasi Dan Ekspresi Gen Pada Stroke Iskemik Dengan Pendekatan Bioinformatika. *Jurnal Kesehatan Bakti Tunas Husada*, 23(1), 9–19. <https://doi.org/10.36465/jkbth.v23i1.1302>
- Bustami, M., Idaiani, S., Putri, N. D., & Satyagraha, A. W. (2025). Determinants of hospital length of stay in ischemic stroke patients : A retrospective cohort study at Indonesian national stroke center. *PLOS One*, 1–13. <https://doi.org/10.1371/journal.pone.0334355>
- Darma Ericson Saragih, Azizah Nasution, K. K. (2020). Cost of Illness Analysis and Quality of Life in Ischemic Stroke Patients In USU Medan Hospital. *Asian Journal of Pharmaceutical Research and Development*, 8(2), 1–6. <https://doi.org/http://dx.doi.org/10.22270/ajprd.v8i1.652>
- Darmawan, E. S., Hasibuan, S. R., Permanasari, V. Y., & Kusuma, D. (2025). Disparities in health services and outcomes by National Health Insurance membership type for ischemic heart disease and stroke in Indonesia : analysis of claims , 2017 – 2022. *Global Health Research and Policy*, 10(33), 1–10. <https://doi.org/10.1186/s41256-025-00432-y>
- Fathi, G. C., & Junadi, P. (2025). Analysis of Claims for Acute Ischemic Stroke Patients with National Health Insurance (JKN) Financing at the University of Indonesia Hospital in 2024. *Journal of Social Research*. <https://doi.org/10.55324/josr.v4i7.2641>
- Feigin, V. L., Brainin, M., Norrving, B., Martins, S. O., Pandian, J., Lindsay, P., F Grupper, M., & Rautalin, I. (2025). World Stroke Organization: Global Stroke Fact Sheet 2025. *International Journal of Stroke : Official Journal of the International Stroke Society*, 20(2), 132–144. <https://doi.org/10.1177/17474930241308142>
- Feigin, V. L., Stark, B. A., Johnson, C. O., Roth, G. A., Bisignano, C., Abady, G. G., Abbasifard, M., Abbasi-Kangevari, M., Abd-Allah, F., Abedi, V., Abualhasan, A., Abu-Rmeileh, N. M. E., Abushouk, A. I., Adebayo, O. M., Agarwal, G., Agasthi, P., Ahinkorah, B. O., Ahmad, S., Ahmadi, S., ... Murray, C. J. L. (2021). Global, regional, and national burden of stroke and its risk factors, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. *The Lancet Neurology*, 20(10), 795–820. [https://doi.org/10.1016/S1474-4422\(21\)00252-0](https://doi.org/10.1016/S1474-4422(21)00252-0)
- Fritz Sumantri Usman, Achmad Firdaus Sani, Fitri Octaviana, Merlin Prisilia Kastilong, L., Kurnia, Theodorus K Hendartono, Andika S Atmadja, Yan Leo Tambunan, Syahrul Syahrul, D., & Pramukarso, T. (2025). Indonesian Stroke Management Neurointerventional Services Challenges. *Journal of Neurointervention and Stroke*, 1(1), 17–23. <https://doi.org/10.63937/jnevis-2025.11.3>
- Hanan, I., Ardhi, M. S., Prajitno, J. H., & Setyowatie, S. (2024). Risk factor profile of ischemic stroke in inpatients of the neurology department of Dr . Soetomo General Hospital , Tertiary Hospital in Indonesia. *Magna Scientia Advanced Research and Reviews*, 12(02), 283–292. <https://doi.org/10.30574/msarr.2024.12.2.0207>
- He, M., Zhang, S., Liu, X., He, Y., Gu, X., & Yue, C. (2025). Global, regional, and national epidemiology of ischemic stroke in young adults, 1990–2021. *Journal of Neurology*, 272(5), 354. <https://doi.org/10.1007/s00415-025-13082-4>
- Hidayat, R., Pujiwati, S., Rima, P., Pangeran, D., & Kurniawan, M. (2023). Optimizing Stroke Care in Indonesia : A Policy Brief on Expanding Access to Thrombolysis for Improved Outcomes. *Acta Neurologica Indonesia*, 01(01), 1–5. <https://doi.org/10.69868/ani.v1i01.12>
- Janu Purwono, Irwan Budiono, O. W. K. H. (2025). Lifestyle Activities That Contribute to The Risk of Stroke in Indonesia : Smoking , Consuming Fatty Foods and Soft Drinks Media Kesehatan Masyarakat Indonesia. *Media Kesehatan Masyarakat Indonesia*, 21(2), 145–154. <https://doi.org/10.30597/mkmi.v21i2.44605>
- Kusuma, P. J., Djuari, L., Ph, D., Machin, A., Ph, D., Fauzi, A. Al, & Ph, D. (2021). Knowledge , Attitude and Practice of Primary Care Physicians in Dealing

- with Acute Stroke in Indonesia. *Malaysian Journal of Medicine and Health Sciences*, 39(5), 353–364. <https://doi.org/10.31584/jhsmr.2021800>
- Leman, J., Sungono, V., Haryono, Y. T., Mudzakir, M. A., Rahmawati, D. L., Sulay, C. B. H., & Octavius, G. S. (2025). Occurrence of stroke in children and young adults in Indonesia: a multicenter private hospital study. *Clinical and Experimental Pediatrics*, 68(4), 303–310. <https://doi.org/10.3345/cep.2024.01214>
- Li, X., Kong, X., Yang, C., Cheng, Z., Lv, J., Guo, H., & Liu, X. (2024). Global, regional, and national burden of ischemic stroke, 1990–2021: an analysis of data from the global burden of disease study 2021. *EClinicalMedicine*, 75. <https://doi.org/10.1016/j.eclinm.2024.102758>
- Marini Lumintang, Rohmania Setiarini, Sukandriani Utami, I. W. T. (2024). Hubungan Usia, Jenis Kelamin, Diabetes Melitus Tipe Ii, Dan Hipertensi Dengan Tipe Stroke Di RSUD Provinsi NTB. *Indonesian Journal Of Health Research Innovation (IJHRI)*, 01(04), 220–227. <https://journal.ymci.my.id/index.php/ijhri>
- Mboi, N., Syailendrawati, R., Ostroff, S. M., Elyazar, I. R. F., Glenn, S. D., Rachmawati, T., Nugraheni, W. P., Ali, P. B., Trisnantoro, L., Adnani, Q. E. S., Agustiya, R. I., Laksono, A. D., Aji, B., Amalia, L., Ansariadi, A., Antriyandarti, E., Ardani, I., Ariningrum, R., Aryastami, N. K., ... Mokdad, A. H. (2022). The state of health in Indonesia's provinces, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. *The Lancet Global Health*, 10(11), e1632–e1645. [https://doi.org/10.1016/S2214-109X\(22\)00371-0](https://doi.org/10.1016/S2214-109X(22)00371-0)
- Minalloh, R. H., Machin, A., Mardiana, W., & Suansanae, T. (2022). Pre-Hospital and In-Hospital Delay in Acute Ischemic Stroke Patients in Indonesia : A Multi-center Study. *Indonesian Journal of Pharmacy*, 33(2), 299–306.
- Nabil, M., Ivanka, P., Pratiwi, W., & Kusnandang, A. (2024). The Association between Family Knowledge and Response with Pre-hospital Delay among Stroke Patients : A Study from Rural Area of Cirebon , Indonesia. *Global Health Management Journal*, 7(4), 157–166. <https://doi.org/10.35898/ghmj-741111>
- Nathan, T. A., Wibowo, R., Sasongkojati, R., Hartoko, B., & Butarbutar, D. T. (2024). Prevalence of atrial fibrillation in ischemic stroke and associated risk factors: A hospital-based study in Indonesia. *Brain Circulation*, 10(4), 316–323. [https://doi.org/10.4103/bc.bc\\_36\\_24](https://doi.org/10.4103/bc.bc_36_24)
- Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-wilson, E., McDonald, S., ... Moher, D. (2021). The PRISMA 2020 statement : an updated guideline for reporting systematic reviews Systematic reviews and Meta-Analyses. *BMJ*, 372(71), 1–9. <https://doi.org/10.1136/bmj.n71>
- Paliyama, F. P., Rinaldi, F. X., Silalahi, P. Y., & Nari, J. P. (2025). Epidemiological Study of Stroke Disease in the Southeast Maluku Islands Region in 2023. *Jurnal Aksona*, 5(1), 6–11. <https://doi.org/10.20473/aksona.v5i1.62824>
- Pandian, J. D., Padma Srivastava, M. V., Aaron, S., Ranawaka, U. K., Venketasubramanian, N., Sebastian, I. A., Injety, R. J., Gandhi, D. B. C., Chawla, N. S., Vijayanand, P. J., Rangamani, S., & Kalkonde, Y. V. (2023). The burden, risk factors and unique etiologies of stroke in South-East Asia Region (SEAR). *The Lancet Regional Health – Southeast Asia*, 17. <https://doi.org/10.1016/j.lansea.2023.100290>
- Rachmawati, M., Indrayuni, R., Wardhani, L., & Sugianto, P. (2019). LDL Level in Ischaemic Stroke Patients at Dr . Soetomo General Hospital Surabaya. *Biomolecular And Health Science Journal*, 02(March 2018), 2018–2020. <https://doi.org/10.20473/bhsj.v2i1.12743>
- Rexrode, K. M., Madsen, T. E., Yu, A. Y. X., Carcel, C., Lichtman, J. H., & Miller, E. C. (2022). The Impact of Sex and Gender on Stroke. *Circulation Research*, 130(4), 512–528. <https://doi.org/10.1161/CIRCRESAHA.121.319915>
- Rilianto, B., Kurniawan, R. G., Rajab, N. M., & Prasetyo, B. T. (2024). Endovascular Thrombectomy for Acute Ischemic Stroke in Indonesia: Challenging and Strategic Planning. *Neuropsychiatric Disease and Treatment*, 20, 621–630. <https://doi.org/10.2147/NDT.S453629>
- Rinawati, W., Aryati, A., Machin, A., Kiechl, S., & Broessner, G. (2025). Prevalence and Factors Associated with Infections After Acute Ischemic Stroke: A Single-Center Retrospective Study over Five Years. *Epidemiologia (Basel, Switzerland)*, 6(3). <https://doi.org/10.3390/epidemiologia6030046>
- Rinawati, W., Machin, A., & Aryati, A. (2024). The Role of Complete Blood Count-Derived Inflammatory Biomarkers as Predictors of Infection After Acute Ischemic Stroke: A Single-Center Retrospective Study. *Medicina (Kaunas, Lithuania)*, 60(12). <https://doi.org/10.3390/medicina60122076>
- Rissanen, I., Basten, M., Exalto, L. G., Peters, S. A. E., Visseren, F. L. J., & Geerlings, M. I. (2024). Sex differences in modifiable risk factors for stroke incidence and recurrence: the UCC-SMART study.

- Journal of Neurology*, 271(6), 3347–3358. <https://doi.org/10.1007/s00415-024-12268-6>
- Santoso, M., Adisasmito, W. B. B., & Hasibuan, S. R. (2024). Cost of Illness : Stroke Patients with Medical Rehabilitation. *Jurnal Keterampilan Fisik*, 9(1), 1–9. <https://doi.org/https://doi.org/10.37341/jkf.v9i1.422>
- Setyopranoto, I., Bayuangga, H. F., Panggabean, A. S., Alifaningdyah, S., Lazuardi, L., Dewi, F. S. T., & Malueka, R. G. (2019). Prevalence of Stroke and Associated Risk Factors in Sleman District of Yogyakarta Special Region, Indonesia. *Stroke Research and Treatment*, 2019, 2642458. <https://doi.org/10.1155/2019/2642458>
- Setyopranoto, I., Upoyo, A. S., Isworo, A., Sari, Y., & Vidyanti, A. N. (2022). Awareness of Being at Risk of Stroke and Its Determinant Factors among Hypertensive Patients in Banyumas, Indonesia. *Stroke Research and Treatment*, 2022, 4891134. <https://doi.org/10.1155/2022/4891134>
- Tarwoto, Putra, R.A.C., & Harianti. (2025). Early Stroke Risk Score as a Preventive Measure in Indonesia: A Cross-Sectional Study. *The Open Public Health Journal*, 1–7. <https://doi.org/10.2174/0118749445368078250226093906>
- Usman, F. S., Sani, A. F., Octaviana, F., Kastilong, M. P., Kurnia, L., Hendartono, T. K., Atmadja, A. S., Tambunan, Y. L., Syahrul, S., & Pramukarso, D. T. (2025). Indonesian Stroke Management Neurointerventional Services Challenges. *Journal of Neurointervention and Stroke*, 1(1), 17–23. <https://doi.org/10.63937/jnevis-2025.11.3>
- Venketasubramanian, N., Yudiarto, F. L., & Tugasworo, D. (2022). Stroke Burden and Stroke Services in Indonesia. *Cerebrovascular Diseases Extra*, 12(1), 53–57. <https://doi.org/10.1159/000524161>
- Yamanie, N., Felistia, Y., Susanto, N. H., Lamuri, A., Sjaaf, A. C., Miftahussurur, M., & Santoso, A. (2024). Prognostic model of in-hospital ischemic stroke mortality based on an electronic health record cohort in Indonesia. *PloS One*, 19(6), e0305100. <https://doi.org/10.1371/journal.pone.0305100>
- Zainuddin, A. A., Kadir, R. R., Kuswanto, H., Tammasse, J., Qalby, N., Abdullah, A. A., Junaidi, A. A., & Asyary, A. (2025). The major risk factor of stroke across Indonesia; a nationwide geospatial analysis of universal health coverage program. *Archives of Public Health*, 83. <https://doi.org/10.1186/s13690-025-01613-4>
- Zhang, X., Lv, H., Chen, X., Li, M., Zhou, X., & Jia, X. (2023). Analysis of ischemic stroke burden in Asia from 1990 to 2019: based on the global burden of disease 2019 data. *Frontiers in Neurology*, Volume 14-2023. <https://doi.org/10.3389/fneur.2023.1309931>