



Identifying potential improvement areas in stroke care by comparing Indonesia and Japan

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ABSTRACT

Background: Stroke impacts Asian healthcare systems and economies. Two Asia-Pacific countries, Indonesia and Japan, have different healthcare systems due to ethnic and geographic diversity affecting lifestyles and risk factors. This situation requires the implementation of diverse early intervention strategies. This article aims to identify the differences in stroke care development and the potential that can be developed between Indonesia and Japan.

Summary: In this review, we discussed the epidemiological shift in strokes between two countries, geographic and transportation challenges, a lack of public awareness, and fewer human resources and infrastructure than Japan. Only large cities have stroke centers providing acute reperfusion treatment in Indonesia, which limits access to timely care for stroke patients in rural areas. In addition, Indonesia's national health insurance system is relatively immature and has cost management and service delivery issues, while Japan provides reasonable stroke care services.

Key Messages: There are various aspects in the development of stroke management between the two countries, ranging from epidemiological trends, stroke awareness, pre-hospital care, reperfusion therapy, human resources, infrastructure, financial resources, and stroke prevention strategies. Indonesia could learn valuable lessons from Japan, a country that has substantially progressed in stroke care.

1. Introduction

Stroke, both ischemic and hemorrhagic, is a major cause of mortality and disability in Asia. The Asia-Pacific region, including over 60% of the global population, faces a substantial burden of stroke with 10 million people annually having stroke in 2019 [1,2]. Stroke not only has a significant impact on individual patients and families but also places a substantial burden on healthcare systems and economies. Two Asia-Pacific countries, Indonesia and Japan, share similarities in the burden of disease in several ways, they have made significant strides in healthcare. Nonetheless, there are substantial disparities in their epidemiologic characteristics and stroke care systems [3–5].

Indonesia and Japan differ in certain areas. Although both are Asian

countries, there are some differences in conditions surrounding stroke. Moreover, Indonesia has various ethnic groups and geographic diversity that influence variations in lifestyle factors, as well as the associated risk factors that lead to different approaches to early detection and prevention [6,7]. Despite advances in stroke treatment in recent years, significant gaps in access to and quality of care remain between these countries. Healthcare infrastructure, resource allocation, cultural behaviors, and population health are all factors that contribute to these inequities [3,5].

While Japan has long been recognized as a global leader in healthcare, Indonesia has made significant strides in recent years to improve the quality and accessibility of its healthcare services [7,8]. However, disparities in stroke care remain, with differences in incidence,

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mortality, and functional outcomes. This review aims to compare the condition of stroke care services in Indonesia and Japan, with the goal of identifying potential areas for improvement in both countries.

2. Methods

We used a search strategy based on PubMed and Google Scholar. We also used data made available on the website by the government and medical associations, and other sources, such as books, to increase data accuracy. We restricted our search to only two countries, ensuring that we obtain adequate representation of Indonesia and Japan. Publications retrieved were between January 2000 and June 2025. The search is limited not only to English but also to Indonesian and Japanese. Additionally, studies included internal hospital data for comparisons of information at the National Brain Center Hospital and the National Cerebral and Cardiovascular Center. We screened the abstracts from the search, and all articles on stroke in Indonesia and Japan were selected. This review covered all aspects of studies, including cross-sectional, cohort, case-control, clinical trials, systematic reviews, and narrative reviews. We excluded gray literature, conference abstracts, editorials, and commentaries from our publications. The retrieved publications were categorized into sections on epidemiology, stroke awareness, pre-hospital systems, reperfusion therapy, human resources, infrastructure, insurance, and prevention, which constituted the fundamental components of this review article.

2.1. Epidemiology: shifting between two Asian countries

The incidence trends of stroke in Japan and Indonesia exhibit unique tendencies reflecting varying risk factors and healthcare improvements [9]. Historically, stroke was a leading cause of death in Japan until the 1980 s; however, its incidence and mortality rate have decreased over time mainly because of improved control of hypertension. Stroke is the fourth cause of death in 2023 with 104,518 cases in Japan [10].

According to the observational data from the Hisayama Study, a population-based prospective cohort study that has been conducted in the town of Hisayama, average levels of systolic blood pressure have decreased since 1961. In contrast, the incidence of metabolic risk factors such as obesity, hypercholesterolemia, and diabetes has increased over time [11]. Conversely, Indonesia has exhibited a significant increasing trend and has the highest stroke prevalence in Southeast Asia, attributable to lifestyle factors including hypertension, type 2 diabetes, hypercholesterolemia, coronary heart disease, and smoking. This trend has led to an epidemiological transition from infectious diseases to degenerative diseases [12,13]. In recent years, stroke has become the leading cause of death beyond heart disease and cancer in Indonesia, and the

estimated annual number of new strokes was approximately 500,000 (193.3/100,000 person-years with a population 261 millions) in 2017 [14,15].

The Global Burden Diseases estimated stroke incidents in Japan have remained relatively stable, while in Indonesia they have increased over time (Fig. 1). This indicates that Japan has effectively managed stroke risk factors, particularly hypertension, through comprehensive, complimentary community screening and health education [16]. The average age between in Indonesia and Japan is different. In Japan, the median age of ischemic stroke onset is 74 years, while the average life span is 87.3 years for Japanese females and 81.1 years for Japanese males [8]. In Indonesia, the median age of ischemic stroke patients is younger, approximately 59.2 years. One possible explanation for this difference may be variations in age distribution [17]. Stroke incidence is higher in men than in women. However, Japanese women tend to experience more severe strokes and have worse outcomes at discharge compared to men, possibly due to older age at onset and higher initial stroke severity [18]. There are notable differences between the Indonesian and Japanese healthcare systems in stroke characteristics and services (Table 1).

These disparities affect the healthcare strategies and lifestyle choices that contribute to stroke epidemiology in these countries. Developing countries with large populations, such as Indonesia, where stroke incidence continues to increase, require large-scale, long-term cohort studies. The Stroke and Cardiovascular Disease Control Act was enacted in Japan in December 2018 to make a nationwide approach to reduce the burden of stroke. This policy may provide valuable insights for understanding the stroke burden and developing effective stroke control strategies in Indonesia [24].

2.2. Stroke awareness: campaign and public education

Massive campaigns, primarily through television, social media, and newspapers, have served as major sources of information, but there is still a need for more effective dissemination of knowledge. Public health initiatives in Indonesia are less comprehensive and there is a lack of public education programs, well-developed emergency transport systems, and organized stroke centers. This results in higher stroke fatality and mortality rates [25].

While Japan has made significant progress in stroke awareness and management through research and public health initiatives, challenges remain in effectively educating the public and ensuring equitable access to healthcare. In contrast, Indonesia faces more fundamental challenges related to healthcare infrastructure and public education, which contribute to lower stroke awareness and higher mortality rates [24,26]. Both countries could benefit from enhanced public education campaigns

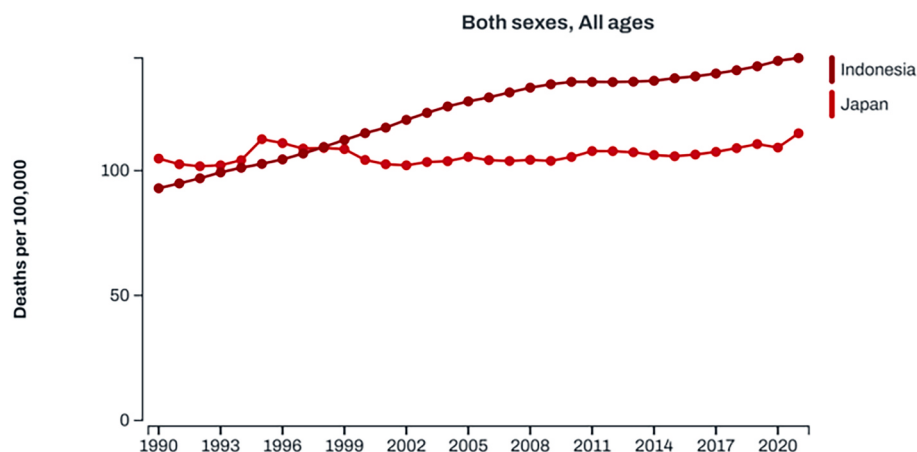


Fig. 1. Comparison of stroke death in both sexes and all ages between Indonesia and Japan (IHME's Guide to GBD Health Data). Cited: <https://vizhub.healthdata.org/> [19].

Table 1
Stroke epidemiology, resources, and care between Indonesia and Japan [10,15,20–22].

Characteristics	Indonesia	Japan
Demography and Epidemiology		
Number of Population	277 million (2024)	124 million (2024)
Estimated number of stroke patients	≈500,000 (2017)	≈220,000 (2017)
Rank among causes of death	1st	4th
Number of stroke deaths among all causes	357,183 or 21.12% (2020)	121,823 or 11.03% (2020)
Stroke Awareness		
Stroke awareness system	Limited	Widely available
LVO detection	Limited	Widely available
Pre-Hospital Care		
Emergency medical service	Developing	Well established
Patient transportation	Mostly without an ambulance	Well-organized collaboration between the hospital and ambulance (fire department)
Infrastructures		
Number of Hospitals	3,216 (2024)	8,068 (2024)
Number of Beds	384,200 (2022)	1,479,728 (2024)
Primary Stroke Centers	239 (2024)	957 (2024)
Comprehensive Stroke Centers	85 (2024)	296 (2024)
Number of MRI units (per million population)	1.11 (2023)	57.39 (2023)
Human Resources		
Number of Neurologists	2,732 (2024)	6,409 (2024)
Number of Neurosurgeons	465 (2024)	5,407 (2024)
Number of neurointerventionists [#]	274 (2024)	2,254 (2024)
National/universal Insurance*	Partially funded	Fully funded
Stroke prevention	Less controlled	Reasonably controlled

References: [16,20–23]; Annual reports from government, 2023.
[#] Neurointerventionists come from neurologists, neurosurgeons, or neuroradiologists.
^{*} For EVT coverage.

and improvements in healthcare systems to better address the burden of stroke.

The Japan Stroke Association was founded in 2005 to contribute to stroke prevention by disseminating accurate knowledge about stroke and raising public awareness. In addition, the association aims to provide information to stroke survivors and their families and to enhance support for patient independence, thereby reducing anxiety and disability and improving quality of life [27]. The association also played an important role in advocating for the enactment of the Stroke and Cardiovascular Disease Control Act in 2018. In accordance with the national government’s plan for stroke control, each prefecture is required to develop a prefectural action plan. Both national and prefectural plans are reviewed at least every six years. This nationwide approach is expected to contribute to reducing the stroke burden and to prolonging healthy life expectancy [24]. The national strategy includes eight fundamental measures: (1) educating citizens on prevention and appropriate initial responses; (2) enhancing local emergency transportation and medical systems; (3) upgrading local facilities; (4) improving the quality of life for patients; (5) refining the coordination among relevant professionals; (6) cultivating human resources; (7) advancing information collection and consultation support systems for patients; and (8) promoting research initiatives [28].

Furthermore, stroke education for younger generations in Japan has gained increasing attention through innovative programs designed to improve awareness and understanding of stroke prevention and recognition. These initiatives have demonstrated significant improvements in stroke-related knowledge among junior high school students and their families, contributing to better health outcomes [29]. The Tochigi Project, a public education campaign on stroke knowledge conducted in collaboration with the local government of Tochigi Prefecture between

September 2012 and July 2013, found that manga-based lessons improved students’ knowledge of stroke. Importantly, this knowledge was subsequently communicated to their parents, potentially leading to faster stroke recognition and response times [30,31]. Japan also implemented school-based stroke education during the coronavirus disease 2019 pandemic [32]. In contrast, Indonesia could introduce novel educational methods, significantly enhancing awareness and fast recognition of stroke symptoms among parents.

2.3. Pre-hospital system: transportation, paramedics, and early detection

The prehospital systems for acute stroke management in Japan and Indonesia exhibit significant differences, primarily due to variations in infrastructure, technological integration, and healthcare policies. Japan’s system is characterized by advanced technological applications and well-structured emergency medical services, while Indonesia’s system is still developing, with ongoing efforts on improving human resources, education, and infrastructure [28,33,34]. These differences reflect broader disparities in healthcare capabilities and resources between the two countries.

In Indonesia, an insufficient number of ambulances are equipped for stroke care, and geographical barriers limit the timely treatment of patients with suspected strokes, especially in remote and underserved regions. Ambulance costs in Indonesia vary, depending on the type of service, distance traveled, and facilities used; meanwhile, in Japan, ambulance and fire services (which include transportation to stroke centers) are free. Delays in reaching a capable thrombectomy hospital are caused by a lack of ambulances, which reduces the effectiveness of the treatment [35]. Funding in emergency medical services is crucial, especially in rural regions. This requires a sufficient number of well-equipped ambulances and the training of emergency healthcare providers to manage stroke patients. Training such as prehospital stroke life support enhances the pre-hospital treatment of stroke victims by facilitating a more efficient, organized, and systematic process [36]. Collaborations among government agencies and healthcare institutions, as well as non-profit organizations, might boost the current infrastructure and address shortcomings in stroke care accessibility.

Japan has employed a multifaceted approach to identify large-vessel occlusion (LVO), a critical condition in acute ischemic stroke management. The identification process involves paramedic education through prehospital stroke life support, prehospital screening scales, advanced imaging techniques, and automated detection software, each contributing to timely and accurate diagnosis. In recent years, the Japan Stroke Society introduced the LVO scale, which consists of 6 items: irregular pulse beat, eye deviation, hemineglect, aphasia, facial droop, and arm weakness (Fig. 2). A score of 2 or more indicates an LVO stroke requiring transfer to a thrombectomy center [37]. The LVO scale can facilitate early detection of suspected strokes with LVO, allowing patients with suspected LVO to be transferred to the nearest thrombectomy center [38].

In Indonesia, screening for stroke detection generally uses face, arm, speech, and time, but its implementation has not yet been widespread, and awareness of identifying LVO remains limited. Consequently, ischemic patients are being underdiagnosed and undertreated. However, a few regions have begun to use cortical symptoms such as visual, aphasia, neglect for screening of LVO [28]. It is necessary to advocate for an appropriate and feasible scale, not only for early stroke detection but also for identifying LVO.

2.4. Reperfusion therapy era: intravenous thrombolysis and endovascular thrombectomy

The history of thrombolysis for ischemic stroke is marked by significant advancements and challenges over the past several decades worldwide. The efficacy and safety of thrombolysis have been extensively studied, revealing its benefits across various patient

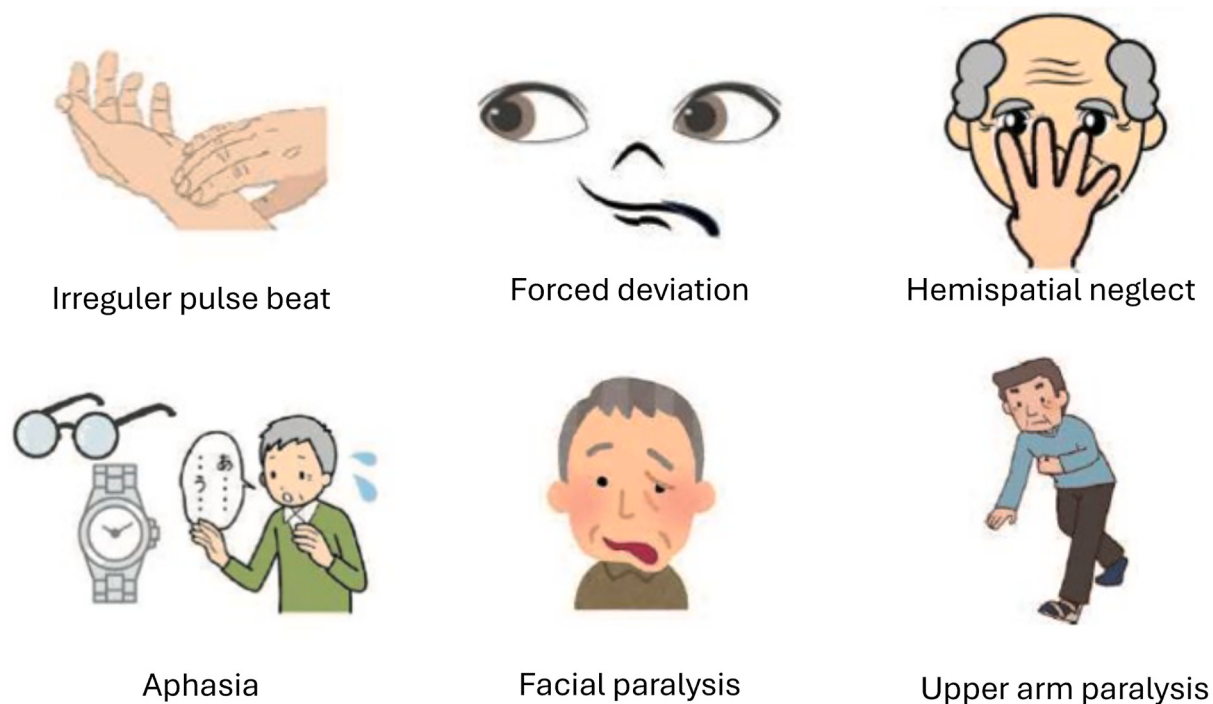


Fig. 2. The LVO scale for identifying LVO stroke in prehospital (Japanese Stroke Society) [37].

demographics, including patients with minor stroke [39]. Japan employs a low-dose alteplase regimen (0.6 mg/kg) for thrombolysis, which was approved in 2005 following the Japan Alteplase Clinical Trial [40]. The risk of symptomatic intracranial hemorrhage (ICH) may be higher in East Asian populations, including those in Japan and Indonesia, possibly due to the higher incidence of hemorrhagic stroke in these populations [13,15,41,42]. The lower dose of tPA used in Japan reflects a tailored strategy to balance efficacy and safety, particularly in older populations. Post-marketing surveillance in Japan has demonstrated that approximately 33% of patients achieve favorable outcomes (modified Rankin Scale scores of 0–1), with a symptomatic ICH rate of 4.5% [43].

In Indonesia, thrombolysis therapy was first introduced in 2014 at Cipto Mangunkusumo General Hospital. Interestingly, according to the national stroke guideline, the recommended dose ranges from 0.6 mg/kg to 0.9 mg/kg at the physician's discretion [44]. There is an increase in stroke centers in large cities that are capable of performing thrombolysis and thrombectomy every year. Currently, the National Brain Center Hospital in Jakarta is the only advanced stroke center in Indonesia accredited by the World Stroke Organization, providing 24/7 services with 279 beds.

The comparison of thrombectomy practices between Japan and Indonesia reveals significant differences in healthcare infrastructure, accessibility, and outcomes. Japan has made substantial advancements in EVT for LVO stroke, supported by robust clinical trials and healthcare systems. Japan has conducted important clinical trials, such as the RESCUE-Japan LIMIT, which demonstrated the effectiveness of EVT in patients with large core ischemic stroke [45]. Japan's healthcare system supports widespread access to thrombectomy, with a network of hospitals capable of performing EVT. In contrast, Indonesia faces numerous challenges in implementing thrombectomy due to a lack of public awareness, inadequate infrastructure, and limited human resources. Most stroke centers capable of performing thrombectomy are located on the island of Java [28]. EVT has been shown to be cost-effective in ischemic stroke patients even with a large core in Japan. Therefore, Indonesia should consider expanding the implementation of this effective treatment [46].

2.5. Human resources: the number and distribution of health worker

Improving human resources for stroke care in Indonesia involves addressing several critical factors, including residency training, physician distribution, and quality of healthcare professionals (see Table 1). Currently, the number of specialists, such as neurologists, neurosurgeons, and stroke nurses, remains limited in Indonesia. In addition to the issue of quantity, the distribution of doctors is uneven, with many concentrated in major cities, particularly on the island of Java. The number of neurointerventionists is also relatively low, resulting in patients with LVO not receiving appropriate treatment.

Japan has long implemented a university-, national center- or hospital-based residency system for quite a long time that is well-established. There are approximately 300 accredited training programs in neurology in Japan. In 2004, Ministry of Health, Labor and Welfare of Japan mandated 2 years of postgraduate medical training in primary care medicine before entering their specialty of choice to enhance knowledge of general medicine [47]. Trainees receive a base salary determined by their years of experience. Japan, despite having a population half that of Indonesia, has twice as many neurologists and nearly ten times as many neurosurgeons (Table 1).

Currently, the number of neurologists, neurosurgeons, and neurointerventionists trained each year in Indonesia has increased. The available centers remain insufficient to produce neurologists at a ratio that meets the needs of the Indonesian population, with only 15 university-based centers and 1 hospital-based residency program. Several steps are required by the government to increase the number of specialist doctors and promote a more equitable distribution of physicians, particularly in regions outside Java Island.

Other healthcare professionals, such as nurses, also play an important role in improving stroke outcomes. In Japan, since 2006, the number of stroke care units (SCUs) in hospitals has increased, and to ensure high-quality nursing practice, the patient-to-nurse ratio in SCUs is typically three patients per nurse or fewer [48]. Currently, Indonesia has a surplus of nurses which could be utilized to improve the nurse-to-patient ratio, aiming to achieve an optimal ratio that meets international standards [49]. In addition, Indonesia needs to increase both the number

and the equitable distribution of physicians and paramedics, particularly for the acute phase of stroke care, by expanding the number of training centers.

2.6. Infrastructure capacities: increasing stroke centers

The healthcare infrastructure for stroke care in Indonesia is less developed than that of Japan, with an insufficient number of stroke neurologists and limited availability of diagnostic tools such as computed tomography (CT), magnetic resonance imaging (MRI), and cath labs. The limited number of dedicated stroke centers means that reperfusion therapies are mainly accessible in major metropolitan areas such as Jakarta, Surabaya, and Medan. Consequently, adequate ambulance resources, both in number and quality, are essential to enable timely access to stroke centers across long distances, particularly in the context of heavy traffic congestion in major cities. Currently, the Indonesian Ministry of Health is planning to increase stroke care through a national hospital stratification program [23]. Indonesia has 239 primary stroke centers capable of providing intravenous thrombolysis, whereas the number of neurointerventional facilities (EVT centers) is only 85 as of 2024, most of which are located on the island of Java [23]. A comparison of major stroke centers in Indonesia and Japan is presented in Table 2.

Access to stroke centers providing EVT is particularly limited in remote regions of developing countries due to insufficient transportation infrastructure and geographical barriers. The lack of robust referral procedures and the shortage of ambulances capable of transporting patients with strokes limit timely access to treatment. Collectively, these factors contribute to delayed treatment and reduced utilization of thrombectomy services in underserved regions. Therefore, the government should optimize healthcare financing and ensure equitable distributions of resources to reduce disparities between urban and rural areas [28,50].

The Japan Stroke Society, an academic society for contributing to the prevention, treatment, management, and stroke research, launched the certification system of the primary stroke center (n = 957 in 2023) in 2020 and the core primary stroke center (n = 296 in 2023), which provide 24/7 EVT capability in 2021 nationwide to strengthen emergency stroke transport and care system [51]. The presence of core primary stroke centers and a well-organized emergency medical service system facilitates timely treatment. Japan has developed a helicopter

transportation system for patients in remote islands who require mechanical thrombectomy [33,34]. Indonesia needs to further increase the number of stroke centers and ensure their equitable distribution, not only by expanding capacity but also by providing adequate equipment and sufficient healthcare personnel. In addition, clear systems should be established to enable efficient integration and communication between stroke centers, prehospital services, and referring hospitals.

2.7. Insurance in health system: financial challenges

The differences in healthcare systems and insurance models in each country shape the disparities in medical insurance coverage between Indonesia and Japan. These differences affect the accessibility, quality, and financial sustainability of stroke care in both countries. Japan has a well-developed universal health insurance system that covers a wide range of medical treatments, including stroke care. On the other hand, Indonesia's national health insurance program is still in its early stages and has trouble managing costs and providing services.

For decades, Japan has maintained a universal health insurance system that covers the entire population and supports comprehensive stroke care. The national health insurance system and the long-term care insurance system also cover rehabilitation therapy for patients with both acute and chronic stroke [52]. In addition, the Japan Stroke Society guidelines emphasize acute treatment, rehabilitation, and preventive strategies, reflecting advances in stroke care following the enactment of the Basic Act on Stroke and Cardiovascular Disease [53].

Indonesia's national health insurance program was introduced in 2013 to provide social protection, including coverage for stroke patients. However, economic constraints continue to affect the program, particularly in aligning hospital tariffs with the actual costs of stroke care, which leads to discrepancies in funding and service provision [54]. The Indonesia case-based groups (INA-CBGs) payment system places financial pressure on healthcare facilities and may affect the quality of stroke care delivered. The cost of stroke treatment and medical equipment accounts for approximately 27%–45% of total direct medical costs. The INA-CBGs system often results in substantial cost discrepancies, as actual treatment costs frequently exceed reimbursement rates, significantly affecting hospital finances [55]. In 2023, the cost of thrombolysis therapy was fully covered by the government as a national stroke program; however claims for thrombectomy procedures and other intervention treatment only covered less than half of the actual costs [56]. Indonesia needs to seek other innovative efforts so that stroke patients can still receive appropriate treatment that requires intervention like thrombectomy.

2.8. Stroke prevention strategies

2.8.1. Secondary prevention

Stroke prevention strategies in Japan and Indonesia differ significantly because of variations in education systems, healthcare infrastructure, population demographics, and prevalent risk factors. Japan, with its advanced healthcare system, emphasizes public education, lifestyle modification, pharmacological interventions, and comprehensive clinical guidelines developed by the Ministry of Health, Labour, and Welfare, local governments, the Japan Stroke Society, and the Japan Stroke Association. In contrast, Indonesia focuses more on community-based health promotion and improvements in healthcare infrastructure. These differences reflect the distinct challenges and resources available in each country. Regarding secondary prevention guidelines, the use of antiplatelet agents such as aspirin, clopidogrel, and cilostazol is generally similar in both Indonesian and Japanese populations [44,53,57,58]. However, more studies are needed on the use of antithrombotics in ischemic stroke related to efficacy and safety in a more diverse Indonesian population.

Table 2
Comparison of stroke care between NBC Hospital and NCV Hospital.

Characteristics	NBC Hospital	NCVC Hospital
Founded year	2014	1977
Location	East Jakarta, Jakarta	Suita, Osaka
Specialization	Neurological diseases	Cerebrovascular and cardiovascular diseases
Thrombolysis (2024)		
Rate	7.2%	12.7%
Dosages	0.6–0.9 mg/kg	0.6 mg/kg
Door-to-needle times	37 min (median)	38 min (median)
Thrombectomy (2024)		
Rate	1.35%	18.7%
Number of operators	4	10
Door-to-puncture times	210 min (median)	49 min (median)
SCU beds	18	18
NCU beds	13	10
CT scans	2 units	3 units
MRI scans	1 units	4 units
Cath labs	2 (dedicated for stroke)	9 (sharing with cardiology)
Operating rooms for neurosurgery	5	2

*Rate of thrombolysis and thrombectomy: number of procedures by total number of ischemic stroke admissions.

2.8.2. Primary prevention

Indonesia needs to strengthen primary prevention efforts by intensifying the management of modifiable risk factors through community-based health promotion programs that encourage healthy lifestyles and address prevalent conditions such as hypertension, diabetes, dyslipidemia, and physical inactivity [7,13,59]. Japan has successfully reduced the burden of stroke and cardiovascular diseases by controlling major risk factors, particularly hypertension. The government has promoted reductions in dietary salt intake since the 1950s, which has led to a substantial decline in stroke and cardiovascular mortality [60,61]. The Japanese Society of Hypertension recommends limiting daily salt consumption to less than 6 g and promotes low-sodium dietary products [62]. Furthermore, in 2008, Japan launched a comprehensive national health checkup program known as the specific health checkup, aimed at the main prevention of obesity-related disorders. These checkups assess risk factors like waist circumference, body mass index, blood pressure, blood sugar, and cholesterol levels among adults aged 40–74 [63]. Indonesia needs to implement strong, intensive, and sustainable primary prevention programs, as preventive strategies are generally less costly than high-cost curative treatments.

3. Conclusion

Advances in stroke care in Japan began a few decades ago. The government, institutions, and medical associations collaborate and are strongly committed to combating stroke. Additionally, a scientific approach underpins stroke management, encompassing fundamental research, population-based studies, and clinical trials. All efforts begin with small and consistent steps. Indonesia can gain useful insight from Japan, a country in Asia that has made significant improvements to stroke care across all areas.

CRedit authorship contribution statement

Beny Rilianto: Writing – review & editing, Writing – original draft, Software, Resources, Project administration, Investigation, Conceptualization. **Tomohide Yoshie:** Supervision, Resources, Formal analysis, Data curation, Conceptualization. **Sohei Yoshimura:** Validation, Supervision, Data curation. **Masayuki Shiozawa:** Resources, Project administration, Data curation, Conceptualization. **Ita Muharram Sari:** Validation, Supervision, Formal analysis, Data curation, Conceptualization. **Reza Arpandy:** Validation, Supervision, Data curation. **Syahrul:** . **Adin Nulkhasanah:** Validation, Data curation. **Mursyid Bustami:** Validation, Supervision, Conceptualization. **Manabu Inoue:** Supervision, Investigation, Formal analysis, Conceptualization. **Kazunori Toyoda:** Supervision. **Masatoshi Koga:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Funding acquisition, Data curation, Conceptualization.

Declaration of competing 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.

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References

- [1] Ferrari AJ, Santomauro DF, Aali A, Abate YH, Abbafati C, Abbastabar H, et al. Global incidence, prevalence, years lived with disability (YLDs), disability-adjusted life-years (DALYs), and healthy life expectancy (HALE) for 371 diseases and injuries in 204 countries and territories and 811 subnational locations, 1990–2021:

- a systematic analysis for the Global Burden of Disease Study 2021. *Lancet* 2024; 403(10440):2133–61. [https://doi.org/10.1016/S0140-6736\(24\)00757-8](https://doi.org/10.1016/S0140-6736(24)00757-8).
- [2] Wang H, Lin J, Zhao F, Zhang X, Wang L, Zhang C, et al. Burden of intracerebral hemorrhage in Asia from 1990 to 2030: a population-based study. *Neuroepidemiology* 2025;22:1–20. <https://doi.org/10.1159/000543638>.
- [3] Tan KS, Pandian JD, Liu L, Toyoda K, Leung TWH, Uchiyama S, et al. Stroke in Asia. *Cerebrovasc Dis Extra* 2024;26. <https://doi.org/10.1159/000538928>.
- [4] Venketasubramanian N. Stroke epidemiology in Asia. *Cerebrovasc Dis Extra* 2025; 15(1):81–92. <https://doi.org/10.1159/000543399>.
- [5] Sebastian IA, Gandhi DBC, Sylaja PN, Paudel R, Kalkonde YV, Yangchen Y, et al. Stroke systems of care in South-East Asia Region (SEAR): commonalities and diversities. *Lancet Reg Health - Southeast Asia* 2023;17:100289. <https://doi.org/10.1016/j.lansea.2023.100289>.
- [6] Toyoda K, Koga M, Hayakawa M, Yamagami H. Acute reperfusion therapy and stroke care in Asia after successful endovascular trials. *Stroke* 2015;46(6):1474–81. <https://doi.org/10.1161/STROKEAHA.115.008781>.
- [7] Venketasubramanian N, Yudiarto FL, Tugaworo D. Stroke burden and stroke services in Indonesia. *Cerebrovasc Dis Extra* 2022;12(1):53–7. <https://doi.org/10.1159/000524161>.
- [8] Toyoda K, Inoue M, Koga M. Small but steady steps in stroke medicine in Japan. *J Am Heart Assoc* 2019;8(16):e013306. <https://doi.org/10.1161/JAHA.119.013306>.
- [9] Roth GA, Mensah GA, Johnson CO, Addolorato G, Ammirati E, Baddour LM, et al. Global burden of cardiovascular diseases and risk factors, 1990–2019. *J Am Coll Cardiol* 2020;76(25):2982–3021. <https://doi.org/10.1016/j.jacc.2020.11.010>.
- [10] Health Insurance Bureau, Ministry of Health, Labour and Welfare of Japan. The Major Changes in the Revision of Medical Service Fee. Available online: <https://www.mhlw.go.jp/toukei/saikin/hw/jinkou/geppo/nengai23/dl/h10.pdf> (Accessed on 28 March 2025).
- [11] Hata J, Ninomiya T. Epidemiology of stroke in a general Japanese population: the Hisayama study. *J Atheroscler Thromb* 2023;30(7):710–9. <https://doi.org/10.5551/jat.RV22004>.
- [12] Riyadina W, Pradono J, Kristanti D, Turana Y. Stroke in Indonesia: risk factors and predispositions in young adults. *J Cardiovasc Dis Res* 2020;11(2):178–83.
- [13] Pandian JD, Padma Srivastava MV, Aaron S, Ranawaka UK, Venketasubramanian N, Sebastian IA, et al. The burden, risk factors and unique etiologies of stroke in South-East Asia Region (SEAR). *Lancet Reg Health - Southeast Asia* 2023;17:100290. <https://doi.org/10.1016/j.lansea.2023.100290>.
- [14] Wahab A, Choiriyyah I, Wilopo SA. Determining the cause of death: mortality surveillance using verbal autopsy in Indonesia. *Am J Trop Med Hyg* 2017;97(5): 1461–8. <https://doi.org/10.4269/ajtmh.16-0815>.
- [15] Venketasubramanian N, Yoon BW, Pandian J, Navarro JC. Stroke epidemiology in South, East, and South-East Asia: a review. *J Stroke* 2017;19(3):286–94. <https://doi.org/10.5853/jos.2017.00234>.
- [16] Iso H, Shimamoto T, Naito Y, Sato S, Kitamura A, Iida M, et al. Effects of a long-term hypertension control program on stroke incidence and prevalence in a rural community in Northeastern Japan. *Stroke* 1998 Aug;29(8):1510–8. <https://doi.org/10.1161/01.STR.29.8.1510>.
- [17] Yamanie N, Felistia Y, Susanto NH, Lamuri A, Sjaaf AC, Miftahussurur M, et al. Prognostic model of in-hospital ischemic stroke mortality based on an electronic health record cohort in Indonesia. *Ang YG, editor. PLoS One* 2024;19(6):e0305100. <https://doi.org/10.1371/journal.pone.0305100>.
- [18] Maeda K, Toyoda K, Minematsu K, Kobayashi S. Effects of sex difference on clinical features of acute ischemic stroke in Japan. *J Stroke Cerebrovasc Dis* 2013;22(7): 1070–5. <https://doi.org/10.1016/j.jstrokecerebrovasdis.2012.07.006>.
- [19] IHME's Guide to Global Burden of Disease (GBD) web-based tools. Available online: <https://vizhub.healthdata.org/gbd-compare/> (Accessed on 21 March 2025).
- [20] Takashima N, Arima H, Kita Y, Fujii T, Miyamatsu N, Komori M, et al. Incidence, management and short-term outcome of stroke in a general population of 1.4 million Japanese – Shiga Stroke Registry –. *Circ J* 2017;81(11):1636–46. <https://doi.org/10.1253/circj.CJ-17-0177>.
- [21] World Health Ranking. Available online: <https://www.worldlifeexpectancy.com/> (Accessed 5 April 2025).
- [22] Number of magnetic resonance imaging (MRI) units in selected countries as of 2023. Statista. Available online: <https://www.statista.com/statistics/282401/density-of-magnetic-resonance-imaging-units-by-country/> (Accessed on 5 April 2025).
- [23] Ministry of Health Republic of Indonesia. National Stroke Program. 2023;Available online: https://keslan.kemkes.go.id/unduh/fileunduh/1684965444_953452.pdf (Accessed on 28 March 2025).
- [24] Nakayama H, Minematsu K, Yamaguchi T, Miyamoto S, Isobe M, Komuro I, et al. Approval of stroke and cardiovascular disease control act in Japan: comprehensive nationwide approach for prevention, treatment, and patients' support. *Int J Stroke* 2020;15(1):7–8. <https://doi.org/10.1177/1747493019873549>.
- [25] Akiyama H, Hasegawa Y. Stroke knowledge: a nationwide, internet-based survey of 11,121 inhabitants in Japan. *Intern Med* 2013;52(5):529–37. <https://doi.org/10.2169/internalmedicine.52.9170>.
- [26] Kim JS. Stroke in Asia: a global disaster. *Int J Stroke* 2014;9(7):856–7. <https://doi.org/10.1111/ijis.12317>.
- [27] The Japan Stroke Association. Available online: <https://www.jsa-web.org/> (Accessed on 21 March 2025).
- [28] Rilianto B, Kurniawan R, Rajab N, Prasetyo B. Endovascular thrombectomy for acute ischemic stroke in Indonesia: challenging and strategic planning. *Neuropsychiatr Dis Treat* 2024;20:621–30. <https://doi.org/10.2147/NDT.S453629>.

- [29] Amano T, Yokota C, Sakamoto Y, Shigehatake Y, Inoue Y, Ishigami A, et al. Stroke education program of act FAST for junior high school students and their parents. *J Stroke Cerebrovasc Dis* 2014;23(5):1040–5. <https://doi.org/10.1016/j.jstrokecerebrovasdis.2013.08.021>.
- [30] Matsuzono K, Yokota C, Takekawa H, Okamura T, Miyamatsu N, Nakayama H, et al. Effects of stroke education of junior high school students on stroke knowledge of their parents: tohigi project. *Stroke* 2015;46(2):572–4. <https://doi.org/10.1161/STROKEAHA.114.007907>.
- [31] Kato S, Okamura T, Kuwabara K, Takekawa H, Nagao M, Umesawa M, et al. Effects of a school-based stroke education program on stroke-related knowledge and behaviour modification—school class based intervention study for elementary school students and parental guardians in a Japanese rural area. *BMJ Open* 2017;7(12):e017632. <https://doi.org/10.1136/bmjopen-2017-017632>.
- [32] Katsuki M, Kawahara J, Senda H, Yamagishi C, Mizusawa S, Ueki Y, et al. School-based stroke education through on-demand e-learning during coronavirus disease 2019 pandemic: Itoigawa stroke awareness campaign. *Cureus* 2023;15(4):e37380. <https://doi.org/10.7759/cureus.37380>.
- [33] Fujiwara S, Kuroda T, Matsuo K, Ohara N, Imamura H, Yamamoto Y, et al. Prehospital stroke notification and endovascular therapy for large vessel occlusion: a retrospective cohort study. *Sci Rep* 2022;12(1):10107. <https://doi.org/10.1038/s41598-022-14399-0>.
- [34] Wake K, Noguchi T, Hishinuma H, Zaito M, Kikuchi J, Uchida M, et al. Characteristics of patients who received helicopter emergency medical services in Japan from 2012 to 2019: a retrospective analysis of data from Tochigi Prefecture. *Scand J Trauma Resusc Emerg Med* 2022;30(1):25. <https://doi.org/10.1186/s13049-022-01012-6>.
- [35] Sablot D, Gaillard J, Smadja P, Bonnet JM, Bonafe A. Thrombectomy accessibility after transfer from a primary stroke center: analysis of a three-year prospective registry. *Int J Stroke* 2017;12(5):519–23. <https://doi.org/10.1177/1747493017701151>.
- [36] Suzuki N. Introduction of the standard prehospital stroke life support (PSLS) training of EMS paramedics for the prehospital management of cerebrovascular disease in Japan. *Nagoya J Med Sci* 2010;72:101–6.
- [37] LVO Scale by JSS. Available on: https://www.fdma.go.jp/singi_kento/kento/items/r4-2/01/shiryu2-1.pdf (Accessed on 28 April 2025).
- [38] Koga M, Toyoda K. SCU Green Note for residents. 2nd edition. 2025.
- [39] Moawad MHED, Salem T, Alaaeldin A, Elaraby Y, Awad PD, Khalifa AA, et al. Safety and efficacy of intravenous thrombolysis: a systematic review and meta-analysis of 93,057 minor stroke patients. *BMC Neurol* 2025;25(1):33. <https://doi.org/10.1186/s12883-024-04000-8>.
- [40] Yamaguchi T, Mori E, Minematsu K, Nakagawara J, Hashi K, Saito I, et al. Alteplase at 0.6 mg/kg for acute ischemic stroke within 3 hours of onset: Japan Alteplase clinical trial (J-ACT). *Stroke* 2006;37(7):1810–5. <https://doi.org/10.1161/01.STR.0000227191.01792.e3>.
- [41] Menon BK, Saver JL, Prabhakaran S, Reeves M, Liang L, Olson DM, et al. Risk score for intracranial hemorrhage in patients with acute ischemic stroke treated with intravenous tissue-type plasminogen activator. *Stroke* 2012;43(9):2293–9. <https://doi.org/10.1161/STROKEAHA.112.660415>.
- [42] Guo Y, Yang Y, Zhou M, He L. Risk factors of haemorrhagic transformation for acute ischaemic stroke in Chinese patients receiving intravenous recombinant tissue plasminogen activator: a systematic review and meta-analysis. *Stroke Vasc Neurol* 2018;3(4):203–8. <https://doi.org/10.1136/svn-2018-000141>.
- [43] Nakagawara J, Minematsu K, Okada Y, Tanahashi N, Nagahiro S, Mori E, et al. Thrombolysis with 0.6 mg/kg intravenous alteplase for acute ischemic stroke in routine clinical practice: the Japan post-marketing alteplase registration study (J-MARS). *Stroke* 2010;41(9):1984–9. <https://doi.org/10.1161/STROKEAHA.110.589606>.
- [44] National Guideline for Stroke Management. 2019. Available online: <https://kemkes.go.id/id/pnpk-2019—tata-laksana-stroke> (Accessed on 2 April 2025).
- [45] Yoshimura S, Sakai N, Yamagami H, Uchida K, Beppu M, Toyoda K, et al. Endovascular therapy for acute stroke with a large ischemic region. *N Engl J Med* 2022;386(14):1303–13. <https://doi.org/10.1056/NEJMoa2118191>.
- [46] Egashira S, Ho Shin J, Yoshimura S, Koga M, Ihara M, Kimura N, et al. Cost-effectiveness of endovascular therapy for acute stroke with a large ischemic region in Japan: impact of the Alberta Stroke Program Early CT score on cost-effectiveness. *J NeuroInterventional Surg* 2025;17(e1):e60–7. <https://doi.org/10.1136/jnis-2023-021068>.
- [47] Nodera H. International issues: postgraduate neurologic training in Japan. *Neurology* 2009;72(7). <https://doi.org/10.1212/01.wnl.0000342477.70435.ef>.
- [48] Hisaka Y, Ito H, Yasuhara Y, Takase K, Tanioka T, Locsin R. Nurses' awareness and actual nursing practice situation of stroke care in acute stroke units: a Japanese cross-sectional web-based questionnaire survey. *Int J Environ Res Public Health* 2021;18(23):12800. <https://doi.org/10.3390/ijerph182312800>.
- [49] Muharram FR, Sulistya HA, Swannjo JB, Firmansyah FF, Rizal MM, Izza A, et al. The Indonesia health workforce quantity and distribution [internet] [cited 2025 Apr 6]. Available from: Health Policy 2024. <http://medrxiv.org/lookup/doi/10.1101/2024.03.31.24305126>. <https://doi.org/10.1101/2024.03.31.24305126>.
- [50] Salahuddin H, Nguyen TN, Masoud HE, Martins SO, Mansour OY, Al-Mufti F, et al. Bridging the gap: training and infrastructure solutions for mechanical thrombectomy in low- and middle-income countries. *Stroke* 2025;5:1–4. <https://doi.org/10.1161/STROKEAHA.124.047329>.
- [51] The Japan Stroke Society. Stroke Certification. Available on: https://www.jsts.gr.jp/common/facility_psc.html (Accessed on 28 March 2025).
- [52] Kinoshita S, Abo M, Okamoto T, Miyamura K. Transitional and long-term care system in Japan and current challenges for stroke patient rehabilitation. *Front Neurol* 2022;11(12):711470. <https://doi.org/10.3389/fneur.2021.711470>.
- [53] Miyamoto S, Ogasawara K, Kuroda S, Itabashi R, Toyoda K, Itoh Y, et al. Japan stroke society guideline 2021 for the treatment of stroke. *Int J Stroke* 2022;17(9):1039–49. <https://doi.org/10.1177/17474930221090347>.
- [54] Amalia L. 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 Manag Healthc Policy* 2023;16:455–61. <https://doi.org/10.2147/RMHP.S405986>.
- [55] Mahardika IGAPD, Nita Y, Priyandani Y. A comparative study of real hospital costs and INA-CBG rates for stroke in Indonesia. *Pharm Educ* 2024;24(3):166–72. <https://doi.org/10.46542/pe.2024.243.166172>.
- [56] Standard Rates for Health Services in the Implementation of the Health Insurance Program. 2023.
- [57] Yoshimura S. Medical management of acute stroke based on Japan stroke society guidelines and the Japan Stroke Data Bank. *J Atheroscler Thromb* 2024;31(12):1652–9. <https://doi.org/10.5551/jat.RV22027>.
- [58] The Japan Stroke Society Guideline 2021 for the Treatment of Stroke (Revised version 2023).
- [59] Ambarika R, Saifulaman M, Hastuti Apriyani Puji, Anggraini NA. Risk factors of stroke in Indonesian population: literature review. *J Nurs Pract* 2023;7(1):133–48. <https://doi.org/10.30994/jnp.v7i1.439>.
- [60] Miura K. Epidemiology and prevention of hypertension in Japanese: how could Japan get longevity? *EPMA J* 2011;2(1):59–64. <https://doi.org/10.1007/s13167-011-0069-y>.
- [61] Sugiyama T, Ikeda N, Minowa K, Nishi N. Estimation of the effect of salt-intake reduction on cardiovascular mortality decline between 1950 and 2017 in Japan: a retrospective simulation study. *Nutrients* 2022;14(18):3747. <https://doi.org/10.3390/nu14183747>.
- [62] Umemura S, Arima H, Arima S, Asayama K, Dohi Y, Hirooka Y, et al. The Japanese society of hypertension guidelines for the management of hypertension (JSH 2019). *Hypertens Res* 2019;42(9):1235–481. <https://doi.org/10.1038/s41440-019-0284-9>.
- [63] Takeuchi M, Shinozaki T, Kawakami K. Universal health checkups and risk of incident diabetes and hypertension. *JAMA Netw Open* 2024;7(12):e2451813. <https://doi.org/10.1001/jamanetworkopen.2024.51813>.