

PRE-READ

Developing a stroke dashboard for Malaysia

Literature Review

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1. Introduction and Rationale

Stroke is the second leading cause of death and the third leading cause of disability worldwide; between 2020 and 2050, stroke-related deaths are anticipated to increase by 50%, with the majority of this burden borne by low- and middle-income countries¹.

In Malaysia, stroke is the third leading cause of death, with nearly 48,000 new cases recorded in 2019 and about 130 daily incidences². Consequently, stroke imposes a substantial healthcare and social burden, emphasising the urgent need for not only enhanced prevention and treatment strategies, but also better monitoring and tracking of key indicators.

This literature review aims to synthesise current evidence on stroke care, data systems, and performance measurement in Malaysia to inform the development and design of a national stroke dashboard.

2. Malaysia's Stroke Burden and Care Landscape

Stroke has become increasingly common in Malaysia in the last two decades^{3,4,5}. Ischemic events account for 73–80% of cases^{6,7}, with some reports citing annual increases of 11–29.5% for ischemic strokes and 18.7% for haemorrhagic strokes⁸. Exacerbated by risk factors including hypertension, diabetes, and obesity, stroke incidence among younger adults, particularly those aged 35–39, is rising (approximately 50–53%). In contrast, the overall mean age at onset remains in the early 60s^{9,10,11}.

Although stroke ranks as the 4th leading cause of premature mortality among Malaysians after ischaemic heart disease, lower respiratory infections, and road traffic injuries¹², mortality indicators reveal gradual improvement. Reports document 28-day mortality falling from 19.4% to 17.2% in men and from 22.0% to 19.7% in women, and one study noted discharge mortality dropping from 20.7% to 7.8% over time; however, women and haemorrhagic cases tend to experience higher mortality^{13,14,15}. Functional outcomes have also improved. For example, in

¹ 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>

² Tan, K. S., & Venketasubramanian, N. (2022). Stroke Burden in Malaysia. *Cerebrovascular Diseases Extra*, 12(2), 58–62.

<https://doi.org/10.1159/000524271> [https://doi.org/10.1159/000524271]

³ Aziz, Z. A., Lee, Y. Y. L., Ngah, B. A., Sidek, N. N., Looi, I., Hanip, Md. R., & Basri, H. B. (2015). *Acute Stroke Registry Malaysia, 2010–2014: Results from the National Neurology Registry*. *Journal of Stroke and Cerebrovascular Diseases*, 24(12), 2701–2709.

<https://doi.org/10.1016/j.jstrokecerebrovasdis.2015.07.025> [https://doi.org/10.1016/j.jstrokecerebrovasdis.2015.07.025]

⁴ Hwang, W. Y., Ang, S. H., Bots, M. L., Sivasampu, S., Selvarajah, S., Law, W. C., Latif, L. A., & Vaartjes, I. (2021). *Trends of Stroke Incidence and 28-Day All-Cause Mortality after a Stroke in Malaysia: A Linkage of National Data Sources*. *Global Heart*, 16(1). <https://doi.org/10.5334/gh.791> [https://doi.org/10.5334/gh.791]

⁵ Tan, K. S., & Venketasubramanian, N. (2022).

⁶ Department of Community Medicine, M., School of Medical Sciences, Universiti Sains Malaysia Kelantan, Biostatistics and Research Methodology Unit, M., School of Medical Sciences, Universiti Sains Malaysia Kelantan, Department of Community Medicine, M., School of Medical Sciences, Universiti Sains Malaysia Kelantan, & Neurology Division, M., Sultanah Nur Zahirah Hospital, Terengganu. (2024). *Survival of Ischaemic and Haemorrhagic Stroke: Analysis of the Malaysian National Stroke Registry Data from 2009 to 2013*. *Malaysian Journal of Medical Sciences*. Penerbit Universiti Sains Malaysia. <https://doi.org/10.21315/mjms2024.31.5.14> [https://doi.org/10.21315/mjms2024.31.5.14]

⁷ Nazifah, S., Azmi, I., Hamidon, B., Looi, I., Zariah, A., & Hanip, M. (2012). *National Stroke Registry (NSR): Terengganu and Seberang Jaya experience*. *The Medical Journal of Malaysia*.

⁸ Aziz, Z. A., Lee, Y. Y. L., Ngah, B. A., Sidek, N. N., Looi, I., Hanip, Md. R., & Basri, H. B. (2015). *Acute Stroke Registry Malaysia, 2010–2014: Results from the National Neurology Registry*. *Journal of Stroke and Cerebrovascular Diseases*, 24(12), 2701–2709.

<https://doi.org/10.1016/j.jstrokecerebrovasdis.2015.07.025> [https://doi.org/10.1016/j.jstrokecerebrovasdis.2015.07.025]

⁹ Hwang, W. Y., Ang, S. H., Bots, M. L., Sivasampu, S., Selvarajah, S., Law, W. C., Latif, L. A., & Vaartjes, I. (2021).

¹⁰ Li, S. P., Loh, H. C., Ganasegeran, K., Abdul Aziz, Z., & Looi, I. (2021). *P-OT026. Epidemiological trends on the risk factors and outcomes of stroke*. *Clinical Neurophysiology*, 132(8), e129. <https://doi.org/10.1016/j.clinph.2021.02.323> [https://doi.org/10.1016/j.clinph.2021.02.323]

¹¹ Tan, K. S., & Venketasubramanian, N. (2022). Stroke Burden in Malaysia. *Cerebrovascular Diseases Extra*, 12(2), 58–62.

<https://doi.org/10.1159/000524271> [https://doi.org/10.1159/000524271]

¹² Khaw, W. F., Chan, Y. M., Nasaruddin, N. H., Alias, N., Tan, L., & Ganapathy, S. S. (2023). Malaysian burden of disease: years of life lost due to premature deaths. *BMC public health*, 23(1), 1383. <https://doi.org/10.1186/s12889-023-16309-z>

¹³ Chen, X. W., Shafiei, M. N., Aziz, Z. A., Sidek, N. N., & Musa, K. I. (2019). *Trends in stroke outcomes at hospital discharge in first-ever stroke patients: Observations from the Malaysia National Stroke Registry (2009–2017)*. *Journal of the Neurological Sciences*, 401, 130–135. <https://doi.org/10.1016/j.jns.2019.04.015>

¹⁴ Hwang, W. Y., Ang, S. H., Bots, M. L., Sivasampu, S., Selvarajah, S., Law, W. C., Latif, L. A., & Vaartjes, I. (2021). *Trends of Stroke Incidence and 28-Day All-Cause Mortality after a Stroke in Malaysia: A Linkage of National Data Sources*. *Global Heart*, 16(1). <https://doi.org/10.5334/gh.791>

¹⁵ Aziz, Z. A., Lee, Y. Y. L., Sidek, N. N., Ngah, B. A., Looi, I., Hanip, Md. R., & Basri, H. B. (2016). *Gender disparities and thrombolysis use among patient with first-ever ischemic stroke in Malaysia*. *Neurological Research*, 38(5), 406–413. <https://doi.org/10.1080/01616412.2016.1178948>

a study using 2019 National Stroke Registry data, the proportion of patients discharged with independence increased from 23.3% to 46.5%¹⁶, and 57% of cases in a Sarawak hospital-based study achieved good outcomes on standardised scales¹⁷. Meanwhile, integrated care strategies have been associated with gains in quality-adjusted life years¹⁸.

Demographic patterns deepen disparities. Men represent 55-65% of cases, yet women exhibit steeper incidence increases and poorer outcomes^{19,20,21,22}. Malays predominate (up to 81.3% in selected cohorts), although non-Malays have longer survival rates^{23,24}. Regional differences persist: urban centres or areas with higher neurologist availability and better access to thrombolysis report more favourable outcomes than rural settings²⁵.

Malaysia's stroke care system spans public hospitals, primary care centres, and limited private and digital health services²⁶. The care pathway begins with acute recognition and hyperacute treatment in hospitals: intravenous thrombolysis (IVT) is available in about 20% of Ministry of Health (MOH) hospitals, while only about 5% provide both IVT and mechanical thrombectomy (MT)^{27,28}. University hospitals often provide both, many with 24-hour services²⁹. However, persistent challenges remain, including rural care delivery gaps, low overall ischaemic stroke thrombolysis rates, and the high out-of-pocket costs of thrombectomy devices for use in large vessel occlusions³⁰.

Following hospital discharge, post-stroke survivors enter primary care and community rehabilitation, though services are fragmented. The iCaPPS® integrated care pathway helps public health centres provide rehabilitation and regular complication screening in underserved areas cost-effectively³¹.

Rehabilitation services like outpatient rehab and home therapy, while available, are oversubscribed, rely on self-funding or health insurance in private settings, and cost and logistical constraints (transport, frequency) curtail uptake³². Digital health developments, including tele-stroke consultations and mobile health, are limited³³.

Other challenges include workforce limitations (a neurologist-to-patient ratio of 1:323,000), uneven specialist distribution, constrained imaging resources, and fragmented care transitions that affect acute treatment and long-term recovery^{34,35}.

¹⁶ Chen, X. W., Shafei, M. N., Aziz, Z. A., Sidek, N. N., & Musa, K. I. (2019).

¹⁷ King, T. L., Tiong, L. L., Kaman, Z., Zaw, W. M., Abdul Aziz, Z., & Chung, L. W. (2020). A hospital-based study on ischaemic stroke characteristics, management, and outcomes in Sarawak: Where do we stand? *Journal of Stroke and Cerebrovascular Diseases*, 29(9), 105012. <https://doi.org/10.1016/j.jstrokecerebrovasdis.2020.105012> <https://doi.org/10.1016/j.jstrokecerebrovasdis.2020.105012>

¹⁸ Tan, K. S., & Venketasubramanian, N. (2022). Stroke Burden in Malaysia. *Cerebrovascular Diseases Extra*, 12(2), 58–62. <https://doi.org/10.1159/000524271> <https://doi.org/10.1159/000524271>

¹⁹ Aziz, Z. A., Lee, Y. Y. L., Ngah, B. A., Sidek, N. N., Looi, I., Hanip, Md. R., & Basri, H. B. (2015).

²⁰ Aziz, Z. A., Lee, Y. Y. L., Sidek, N. N., Ngah, B. A., Looi, I., Hanip, Md. R., & Basri, H. B. (2016).

²¹ Department of Community Medicine, M., School of Medical Sciences, Universiti Sains Malaysia Kelantan, Biostatistics and Research Methodology Unit, M., School of Medical Sciences, Universiti Sains Malaysia Kelantan, Department of Community Medicine, M., School of Medical Sciences, Universiti Sains Malaysia Kelantan, & Neurology Division, M., Sultanah Nur Zahirah Hospital, Terengganu. (2024). *Survival of Ischaemic and Haemorrhagic Stroke: Analysis of the Malaysian National Stroke Registry Data from 2009 to 2013*. Malaysian Journal of Medical Sciences. Penerbit Universiti Sains Malaysia. <https://doi.org/10.21315/mjms2024.31.5.14>

²² Tan, K. S., & Venketasubramanian, N. (2022). Stroke Burden in Malaysia. *Cerebrovascular Diseases Extra*, 12(2), 58–62. <https://doi.org/10.1159/000524271> <https://doi.org/10.1159/000524271>

²³ Chan, Y. K., Tan, K. S., & Abdul Latif, L. (2021). Stroke in young adults in Malaysia: 1 year outcome and functional status. *Neurology Asia*, 26(4), 657–664. <https://doi.org/10.54029/2021iaui> <https://doi.org/10.54029/2021iaui>

²⁴ Department of Community Medicine, M., School of Medical Sciences, Universiti Sains Malaysia Kelantan, Biostatistics and Research Methodology Unit, M., School of Medical Sciences, Universiti Sains Malaysia Kelantan, Department of Community Medicine, M., School of Medical Sciences, Universiti Sains Malaysia Kelantan, & Neurology Division, M., Sultanah Nur Zahirah Hospital, Terengganu. (2024).

²⁵ Tan, K. S., & Venketasubramanian, N. (2022).

²⁶ Tan, K. S., & Venketasubramanian, N. (2022).

²⁷ Chin, C. J., Albart, S. A., Yusof Khan, A. H. K., Wan Zaidi, W. A., Sidek, N. N., Schee, J. P., Looi, I., & Hoo, F. K. (2025). An overview of hyperacute stroke services and National Stroke Registry in Malaysia - Improving stroke care through evidence. *The Medical journal of Malaysia*, 80(2), 266–274.

²⁸ Chia, P. K., Mohamad, N. A., Mat, L. N. I., Khan, A. H. K. Y., Loh, W. C., Sulaiman, W. A. W., ... & Basri, H. (2020). Regional Emergency Stroke Quick-Response (RESQ) Network: A Proposed Paradigm of Malaysia Stroke Care Services. *Malaysian Journal of Medicine & Health Sciences*, 16(4).

²⁹ Chin, C. J., Albart, S. A., Yusof Khan, A. H. K., Wan Zaidi, W. A., Sidek, N. N., Schee, J. P., Looi, I., & Hoo, F. K. (2025).

³⁰ Tan, K. S., & Venketasubramanian, N. (2022).

³¹ Abdul Aziz, A., Mohd Nordin, N., Muhd Nur, A. et al. (2020) The integrated care pathway for managing post-stroke patients (iCaPPS®) in public primary care Healthcentres in Malaysia: impact on quality adjusted life years (QALYs) and cost-effectiveness analysis. *BMC Geriatr* 20, 70 (2020). <https://doi.org/10.1186/s12877-020-1453-z>

³² Nik Ramli, N. N., Asokan, A., Mayakrishnan, D., & Annamalai, H. (2021). Exploring Stroke Rehabilitation in Malaysia: Are Robots Better than Humans for Stroke Recuperation?. *The Malaysian journal of medical sciences : MJMS*, 28(4), 14–23.

³³ Abdul Aziz, A., Mohd Nordin, N., Muhd Nur, A. et al. (2020).

³⁴ Hwong, W. Y., Ng, S. W., Tong, S. F., Ab Rahman, N., Law, W. C., Kaman, Z., Wong, S. K., Puvanarajah, S. D., & Sivasampu, S. (2022). Stroke thrombolysis in a middle-income country: A case study exploring the determinants of its implementation. *Frontiers in neurology*, 13, 1048807. <https://doi.org/10.3389/fneur.2022.1048807>

³⁵ Tan, K. S., & Venketasubramanian, N. (2022).

An overview of national strategies, clinical guidelines, and other initiatives to address stroke in Malaysia are summarised in the table below:

Initiative	Description and Purpose
Clinical Practice Guidelines (CPG) for Management of Ischaemic Stroke (3rd edition, 2020/2021)	Guidelines focused on reducing ischemic time, improving pre-hospital care, hyperacute management, and secondary prevention; emphasise hyperacute interventions (thrombolysis, thrombectomy) and management tailored to older persons ³⁶
MyStroke Hospital programme	A collaboration between the ANGELs Initiative and Malaysia Stroke Council; maps “stroke-ready hospitals” across public and private sectors, helping patients identify facilities capable of delivering acute stroke care ³⁷
National Stroke Association of Malaysia (NASAM)	Runs centres offering affordable rehabilitation, caregiver support, and public education ³⁸
Malaysian Stroke Council	A working council within the Malaysia Society of Neuroscience (MSN), formed to achieve high-quality stroke care through evidence-based practice, advocacy, and public awareness-raising
Pelan Tindakan Strok Kebangsaan (National Stroke Action Plan) ³⁹	Action plan that outlines the current state, challenges, and future plans for stroke care in Malaysia over the next decade in phases as follows: - Phase 1 (2019-2020): Establish primary stroke centres in all state-level hospitals, develop acute care guidelines, and train multidisciplinary teams - Phase 2 (2021-2022): Set up primary stroke centres in hospitals with specialists and neuroimaging capabilities - Phase 3 (2022-2024): Establish comprehensive stroke centres with advanced facilities like endovascular thrombectomy and neuro-intensive care units Ultimate goals include : - Redesigning stroke care delivery to improve access to hyperacute care, optimise resources, provide patient-centred care, ensure value-based care, and enhance monitoring through the National Stroke Registry - Developing a structured system to connect district hospitals, primary stroke centres, acute stroke-ready hospitals, and comprehensive stroke centres - Transforming multidisciplinary collaboration among primary care, emergent care, specialists, community organisations, behavioural health, and government to improve stroke care and rehabilitation

A key policy gap in Malaysia’s current stroke care landscape is the lack of a comprehensive national stroke policy⁴⁰.

Lessons from regional peers demonstrate how coordinated national strategies can yield measurable results. Thailand’s nationwide fast-track programme, backed by universal coverage, increased thrombolysis rates from under 1% to over 10%. Vietnam’s development of regional stroke centres and telemedicine networks improved access to care despite limited

³⁶Malaysian Society of Neurosciences (2021). Clinical Practice Guidelines – Management of Ischaemic Stroke. 3rd Edition. Malaysian Society of Neurosciences (MSN), the Academy of Medicine Malaysia, and Ministry of Health. <https://doi.org/10.32896/cvns.v3n1.1-155>

³⁷Boehringer Ingelheim. (n.d.). *MyStroke Hospital Malaysia*. Retrieved October 13, 2025, from <https://patient.boehringer-ingelheim.com/my/my-stroke-hospital>

³⁸CodeBlue. (2023, September). The stroke journey: Immediate survival and recovery after. CodeBlue. Retrieved October 13, 2025, from <https://codeblue.galencentre.org/2023/09/the-stroke-journey-immediate-survival-and-recovery-after/>

³⁹Public Health Priority: Way Forward for Stroke Care in Malaysia For the Next 10 Years (n.d.). Unpublished; privately shared. [slide deck]

⁴⁰Wan Zaidi, W. A. (2025). Private correspondence.

resources. These examples, along with the European Stroke Action Plan model, demonstrate how national coordination, data-driven monitoring, and investment in specialised stroke infrastructure can significantly reduce stroke-related mortality and disability.

Comparatively, Malaysia's stroke care is fragmented and uneven, and the absence of a unified framework perpetuates disparities in access, resource distribution, and patient outcomes. Without central policy direction and funding, registry-based audits and quality improvement efforts will remain unsustainable.

A national stroke policy would arguably provide the structure needed not only to integrate prevention, acute care, and rehabilitation, but also set national KPIs (e.g. thrombolysis rate, functional recovery, mortality), and use registry data for continuous audit and benchmarking, including the development and upkeep of a national stroke dashboard.

3. Stroke Data Sources in Malaysia and Suitability for A National Stroke Dashboard

The table below summarises the major existing data sources used to measure stroke care, outcomes and risk in Malaysia, their strengths and weaknesses/gaps, and a preliminary assessment of their potential utility to inform the development of a national stroke dashboard.

Data source	Custodian/Users	Examples of captured variables	Strengths	Weaknesses/Gaps	Suitability for National Stroke Dashboard
National Neurology Registry: National Stroke Registry (NSR / NNeuR)	National Neurology Registry / Ministry of Health / participating hospitals	Hospital-based clinical case data / case report forms (CRF) for stroke (admission clinical data, treatments, KPIs such as thrombolysis, outcomes at discharge)	National, multicentre clinical registry; tracks stroke incidence, treatment practices and outcomes, and documents improvements in IV thrombolysis availability and functional outcomes, supporting quality improvement, benchmarking, and research ⁴¹ ; standard CRF and KPI set; used in publications and audits ⁴²	Voluntary hospital-based participation may lead to under-capture of non-participating hospitals, incl. private hospitals; variable data completeness across sites/time; limited long-term follow-up beyond discharge	High: established structure for national-level stroke indicators, need to check on integration with mortality data
Ministry of Health hospital admission registers / Hospital Information Systems (HIS) - MOH inpatient data	Ministry of Health hospital administrative units / researchers	Admission/discharge records, ICD diagnoses, basic demographics, length of stay	Covers MOH hospitals at national scale and therefore useful for incidence and healthcare utilisation analyses; data routinely collected; used in national linkage studies ⁴³	Limited clinical details; does not include private hospital data	Moderate; good for healthcare utilisation trends, need to check on linkage to NSR/NNeuR for quality and outcomes indicators
National Death Register / Department of Statistics Malaysia (cause-of-death statistics)	Department of Statistics Malaysia / MOH / researchers	Vital registration: deaths, underlying cause (ICD-coded), basic demographics	Official mortality counts and cause-of-death statistics; can be used for stroke-specific outcome analyses when linked to hospital data ⁴⁴	Possible misclassification of cause of death; potential delays in release/processing	Moderate to high if outcome indicators (e.g. 1-year mortality) can be linked to hospital data

⁴¹ Chin, C. J., Albart, S. A., Yusof Khan, A. H. K., Wan Zaidi, W. A., Sidek, N. N., Schee, J. P., Looi, I., & Hoo, F. K. (2025). An overview of hyperacute stroke services and National Stroke Registry in Malaysia - Improving stroke care through evidence. The Medical journal of Malaysia, 80(2), 266–274.

⁴² Aziz, Z. A., & Sidek, N. N. (Eds.). (2016). Annual report of the Malaysian stroke registry 2009-2016. National Stroke Registry. <https://www.neuro.org.my/assets/guideline/Stroke%20registry%20report%202009-2016.pdf>

⁴³ Hwong, W. Y., Ang, S. H., Bots, M. L., Sivasampu, S., Selvarajah, S., Law, W. C., Latif, L. A., & Vaartjes, I. (2021). Trends of Stroke Incidence and 28-Day All-Cause Mortality after a Stroke in Malaysia: A Linkage of National Data Sources. Global Heart, 16(1). <https://doi.org/10.5334/gh.791>

⁴⁴ Hwong, W. Y., Ang, S. H., Bots, M. L., Sivasampu, S., Selvarajah, S., Law, W. C., Latif, L. A., & Vaartjes, I. (2021). Trends of Stroke Incidence and 28-Day All-Cause Mortality after a Stroke in Malaysia: A Linkage of National Data Sources. Global Heart, 16(1). <https://doi.org/10.5334/gh.791> [<https://doi.org/10.5334/gh.791>]

National Health and Morbidity Survey (NHMS)	Institute for Public Health, National Institutes for Health (NIH, MOH)	Population-level survey data on non-communicable disease (NCD) prevalence and risk factors relevant to stroke (e.g. hypertension, diabetes, obesity)	Nationally representative population estimates of risk factors and self-reported stroke prevalence; useful for prevention policymaking and trend monitoring	Data not continuously captured; does not capture clinical stroke episodes or other detailed stroke care metrics	Low to moderate; if dashboard includes population-level risk factor and/or stroke prevention indicators
Registry of Stroke Care Quality (RES-Q)	ANGELS Initiative/ participating hospitals	Case-level data on acute stroke processes (door-to-needle, thrombolysis/thrombectomy metrics), monthly audit dashboards	Enables international data dictionary and benchmarking through a common dataset; Malaysia is one of 103 participating countries, with 41 hospitals registered and >10,000 patients enrolled as of 2024 ⁴⁵ ; widely used for acute care quality improvement; supports process improvement and rapid feedback	Non-universal hospital participation; tends to capture mainly centres engaged with ANGELS Initiative, which are often better resourced/urban hospitals	Moderate to high complementary data source, if it can be integrated with NSR/NNurR data
Hospital/regional research registries and academic cohorts (i.e. single- or multi-centre research registries)	University hospitals, academic groups	Detailed clinical data, outcomes, cost studies and implementation projects	High levels of clinical detail and data quality; used in publications ^{46,47}	Typically local/regional and not generalisable to national level	Selective suitability; may be useful if dashboard integrates local/state-level/regional-level interfaces

⁴⁵RES-Q Data for Life (2025). Live Metrics. Retrieved October 13, 2025 from <https://stroke.qualityregistry.org/useful-information/live-metrics>

⁴⁶King, T. L., Tiong, L. L., Kaman, Z., Zaw, W. M., Abdul Aziz, Z., & Chung, L. W. (2020). A hospital-based study on ischaemic stroke characteristics, management, and outcomes in Sarawak: Where do we stand? *Journal of Stroke and Cerebrovascular Diseases*, 29(9), 105012. [<https://doi.org/10.1016/j.jstrokecerebrovasdis.2020.105012>][<https://doi.org/10.1016/j.jstrokecerebrovasdis.2020.105012>]

⁴⁷Mohammed, M., Zainal, H., Ong, S.C. et al. Direct medical cost of first-ever acute ischemic stroke in Malaysia: a retrospective cohort study. *Sci Rep* 15, 22571 (2025). <https://doi.org/10.1038/s41598-025-07026-1>

From the summary table, several cross-cutting gaps can be gleaned that have implications for the development, quality, and sustainability of a national stroke dashboard:

- *Incomplete health system coverage*: NSR/NNurR and MOH-HIS data cover the majority of public hospitals, but private hospitals and primary and community care facilities are not fully represented, potentially resulting in underestimation of national incidence/prevalence and/or overrepresentation of urban centres
- *Variable clinical details and/or follow-up data*: administrative data provide limited stroke-specific clinical variables, while clinical registries are detailed but lacking in population completeness and linkages to relevant outcomes (e.g. mortality, rehab)
- *Data linkage is valuable but still limited*: published academic work has linked hospital admissions data to the national death register⁴⁸, but wider, routine linkages are lacking
- *The promise of quality improvement registries (e.g. RES-Q)*: helpful for international benchmarking, but limited utility for now due to poor integration with national data and non-universal hospital participation

4. International Models and Lessons for Malaysia

Stroke audit systems and dashboards

Globally, major stroke audit systems and dashboards vary substantially in design and implementation. Combined findings from systematic reviews conducted in 2016 and 2024^{49,50} show that across systems, whether national stroke registries, audit programmes, or combined approaches, manual data entry, web-based, or hybrid collection methods are used. Electronic health records (EHRs), audit documentation, and medical records serve as primary data sources^{51,52,53}. Commonly cited barriers to participation in audits/data collection to inform dashboards included time, skills, and administrative burdens of manual entry, difficulties automatically populating data from EHRs, cross-dataset linkage issues, and data gaps if using retrospective review^{54,55}.

Performance indicators in these audits/dashboards vary, ranging from 6 to 86 items, and span functional, process, and survival domains^{56,57}. Few audit/dashboard systems demonstrate high levels of standardisation and external evaluation, and detailed reporting on quality assurance, data governance, and stakeholder engagement is uneven and overall lacking^{58,59}.

The table below provides a brief overview of a selected sample of major stroke dashboards internationally, with examples of performance indicators captured, strengths, and weaknesses/gaps.

⁴⁸ Hwang, W. Y., Ang, S. H., Bots, M. L., Sivasampu, S., Selvarajah, S., Law, W. C., Latif, L. A., & Vaartjes, I. (2021). *Trends of Stroke Incidence and 28-Day All-Cause Mortality after a Stroke in Malaysia: A Linkage of National Data Sources*. Global Heart, 16(1). <https://doi.org/10.5334/gh.791>

⁴⁹ Cadilhac, D.A., Kim, J., Lannin, N.A., Kapral, M.K., Schwamm, L.H., Dennis, M.S., Norrving, B., & Meretoja, A. (2016). National stroke registries for monitoring and improving the quality of hospital care: A systematic review. *International Journal of Stroke*, 11, 28 - 40.

⁵⁰ Jonsson, A., Cosgrave, N., Healy, A., Mellon, L., Williams, D.J., & Hickey, A. (2024). Maximising the Quality of Stroke Care: Reporting of Data Collection Methods and Resourcing in National Stroke Registries: A Systematic Review. *Journal of medical systems*, 48 1, 100 .

⁵¹ Cadilhac, D.A., Kim, J., Lannin, N.A., Kapral, M.K., Schwamm, L.H., Dennis, M.S., Norrving, B., & Meretoja, A. (2016).

⁵² Jonsson, A., Cosgrave, N., Healy, A., Mellon, L., Williams, D.J., & Hickey, A. (2024). Maximising the Quality of Stroke Care: Reporting of Data Collection Methods and Resourcing in National Stroke Registries: A Systematic Review. *Journal of medical systems*, 48 1, 100 .

⁵³ Lynch, E., Laver, K., Levy, T., Schultz, T. (2023). 'The way that we are collecting and using data has evolved' evaluating the Australian National Stroke Audit programme to inform strategic direction. *BMJ Open Quality*. 2023;12:e002136. <https://doi.org/10.1136/bmjog-2022-002136>

⁵⁴ Jonsson, A., Cosgrave, N., Healy, A., Mellon, L., Williams, D.J., & Hickey, A. (2024).

⁵⁵ Heuschmann, P.U., Biegler, M.K., Busse, O., Elsner, S.A., Grau, A.J., Hasenbein, U., Hermanek, P., Janzen, R.W., Kolominisky-Rabas, P.L., Kraywinkel, K., Lowitzsch, K., Misselwitz, B., Nabavi, D.G., Otten, K., Pientka, L., von Reutern, G., Ringelstein, E.B., Sander, D., Wagner, M., & Berger, K. (2006). Development and Implementation of Evidence-Based Indicators for Measuring Quality of Acute Stroke Care: The Quality Indicator Board of the German Stroke Registers Study Group (ADSR). *Stroke*, 37, 2573-2578.

⁵⁶ Cadilhac, D.A., Kim, J., Lannin, N.A., Kapral, M.K., Schwamm, L.H., Dennis, M.S., Norrving, B., & Meretoja, A. (2016).

⁵⁷ Rudd, A. G., Hoffman, A., Paley, L., & Bray, B. (2018). 20 years of researching stroke through audit. *Clinical Rehabilitation*. Advance online publication. <https://doi.org/10.1177/0269215518784645>

⁵⁸ Cadilhac, D.A., Kim, J., Lannin, N.A., Kapral, M.K., Schwamm, L.H., Dennis, M.S., Norrving, B., & Meretoja, A. (2016). National stroke registries for monitoring and improving the quality of hospital care: A systematic review. *International Journal of Stroke*, 11, 28 - 40.

⁵⁹ Lowitzsch, K., Misselwitz, B., Nabavi, D.G., Otten, K., Pientka, L., von Reutern, G., Ringelstein, E.B., Sander, D., Wagner, M., & Berger, K. (2006). Development and Implementation of Evidence-Based Indicators for Measuring Quality of Acute Stroke Care: The Quality Indicator Board of the German Stroke Registers Study Group (ADSR). *Stroke*, 37, 2573-2578.

Country	Dashboard	Coverage and Purpose	Examples of Performance Indicators Captured	Strengths	Weaknesses and Gaps
Australia	Australian Stroke Clinical Registry (AuSCR) ⁶⁰	National clinical registry monitoring quality of stroke care and outcomes; collects baseline, process and patient-reported/90–180 day outcome data from participating hospitals ⁶¹	Acute process metrics (e.g. thrombolysis, thrombectomy, stroke unit admission), plus 90–180 day outcomes: survival, modified Rankin Scale, residence, rehospitalisation, QoL ⁶²	Strong follow-up for patient-centred outcomes (e.g. QoL, mRS) ⁶³ Supports research and annual reporting Complementary to AuSDaT	Participation is voluntary so not every hospital contributes Registry coverage/representativeness is limited and varied Linkages to administrative datasets is not universal ⁶⁴
Australia	Stroke Foundation Data Tool (AuSDaT) ⁶⁵	National data-capture tool used for audits of acute and in-hospital rehab services; centralised data entry platform	Process measures used in national audits, including time-to-imaging, thrombolysis rates & door-to-needle times, stroke unit care, rehab metrics ⁶⁶	Integrates data collection across hospitals Supports both national audit cycles and local quality improvement Complementary to AuSCR	Primarily focused on in-hospital processes Linkage to long-term outcome data depends on whether hospital/site participates in related registries, e.g. AuSCR Implementation burdens Variations in data completeness at local level
Estonia	Estonian Health Insurance Fund (EHIF) and Nordic Healthcare Group (NHG) National Stroke Patient Pathway Visual Dashboard Pilot ⁶⁷	Displayed results and enable benchmarking of patient-reported outcomes (PROMs) between 4 out of 6 Estonian hospitals providing stroke care,	Parallel presentation of costs and outcomes, including outcome index, average cost of patient journey, outcome index vs. cost of journey, share	Useful tool for evaluating impact of different interventions being piloted at hospital level Measures quality of life and considers both	Pilot project covering only 4 hospitals; unclear scalability and limited information on whether it was successfully expanded

⁶⁰ Australian & New Zealand Stroke Organisation. (n.d.). Australian Stroke Clinical Registry. Retrieved October 15, 2025, from <https://www.anzso.org/research/australian-stroke-clinical-registry/>

⁶¹ Australian Stroke Clinical Registry (AuSCR). (n.d.). Variables & program bundles. Retrieved October 15, 2025, from <https://auscr.com.au/health-professionals/variables-program-bundles/>

⁶² Cadilhac, D., Morrison, J., Birhanu, M., Dalli, L. L., Paice, K., Carter, H., Campbell, B. C. V., et al. (2024, December 20). The Australian Stroke Clinical Registry Annual Report 2023. The University of Melbourne. Retrieved October 15, 2025, from https://figshare.unimelb.edu.au/articles/report/The_Australian_Stroke_Clinical_Registry_Annual_Report_2023/28059638/2

⁶³ Cadilhac, D., Morrison, J., Birhanu, M., Dalli, L. L., Paice, K., Carter, H., Campbell, B. C. V., et al. (2024, December 20). The Australian Stroke Clinical Registry Annual Report 2023. The University of Melbourne. Retrieved October 15, 2025, from https://figshare.unimelb.edu.au/articles/report/The_Australian_Stroke_Clinical_Registry_Annual_Report_2023/28059638/2

⁶⁴ Cadilhac, D., Morrison, J., Birhanu, M., Dalli, L. L., Paice, K., Carter, H., Campbell, B. C. V., et al. (2024, December 20). The Australian Stroke Clinical Registry Annual Report 2023. The University of Melbourne. Retrieved October 15, 2025, from https://figshare.unimelb.edu.au/articles/report/The_Australian_Stroke_Clinical_Registry_Annual_Report_2023/28059638/2

⁶⁵ Australian Stroke Coalition. (n.d.). Australian Stroke Data Tool (AuSDaT). Retrieved October 15, 2025, from <https://australianstrokecoalition.org.au/portfolio/ausdat/>

⁶⁶ Australian Stroke Clinical Registry (AuSCR). (2022). Expressions of interest: Australian Stroke Data Tool v2.0 [PDF]. Retrieved October 15, 2025, from <https://auscr.com.au/wp-content/uploads/2022/06/expressions-of-interest-australian-stroke-data-tool-v2.0.pdf>

⁶⁷ Nordic Healthcare Group. (n.d.). Visual dashboard to benchmark outcomes and costs between hospitals. ICHOM. Retrieved October 21, 2025, from <https://www.ichom.org/nordic-healthcare-group/visual-dashboard-to-benchmark-outcomes-and-costs-between-hospitals/>

		accessible by EHIF and hospitals to improve stroke patient pathways	of journeys by treatment type	patient and provider point of view Allows comparability across participating hospitals	
Ireland	Irish National Audit of Stroke (INAS) ⁶⁸⁶⁹	National audit focusing on acute stroke care across participating hospitals, with annual national reporting and hospital-level feedback	Timeliness (e.g. door-to-medical review, door-to-imaging), thrombolysis and thrombectomy rates, stroke unit admission, length of stay, in-hospital outcomes and trends	Clear national reporting Focus on timeliness improvements	Variable participation across hospitals Some targets remain below national benchmarks
Singapore	Singapore Stroke Registry (SSR) ⁷⁰⁷¹⁷²	Nationwide prospective registry collecting incident and recurrent stroke data from public hospitals Used to inform research, national surveillance, and planning	Demographics, risk factors, stroke subtype, acute management (thrombolysis/thrombectomy), in-hospital outcomes and longer-term outcomes in published analyses	Population-level data useful for public health and policymaking	Most output documented in academic publications, rather than publicly accessible dashboard Limited capture of private hospitals and real-time public benchmarking
United Kingdom	Sentinel Stroke National Audit Programme (SSNAP) ⁷³	Nationwide stroke audit covering England, Wales, and Northern Ireland Prospective longitudinal audit of stroke care across care pathway, from acute to up to 6 month outcomes ⁷⁴	Approx. 40 key indicators across 7 domains, e.g. e.g. time-to-scan, time-to-thrombolysis, % admitted to stroke unit, swallow screen, rehabilitation access, 6-month outcomes	High case ascertainment and longitudinal follow-up facilitated by NHS information systems infrastructure Transparent public reporting to support benchmarking and quality improvement	Many and complex indicators make data collection difficult Variation between NHS trusts means that timely reporting targets are not met

⁶⁸ National Office of Clinical Audit. (2023). Irish National Audit of Stroke: National report 2023. Retrieved October 15, 2025, from <https://www.noca.ie/documents/irish-national-audit-of-stroke-national-report-2023/>

⁶⁹ Health Service Executive. (2022). Irish National Audit of Stroke: National report 2022 [PDF]. Retrieved October 15, 2025, from <https://www.hse.ie/eng/about/who/cspd/hcps/stroke/resources/irish-national-audit-of-stroke-national-report-2022.pdf>

⁷⁰ National Registry of Diseases Office (2025). Singapore Stroke Registry Annual Report 2022. January 2025. Retrieved October 15, 2025 from https://nrdo.gov.sg/docs/librariesprovider3/default-document-library/ssr-annual-report-2022_web.pdf?sfvrsn=7bd47466_1

⁷¹ Venketasubramanian, N., Chang, H. M., Chan, B. P., Young, S. H., Kong, K. H., Tang, K. F., Ang, Y. H., Ahmad, A., Chow, K. Y., & Singapore Stroke Registry (2015). Countrywide stroke incidence, subtypes, management and outcome in a multiethnic Asian population: the Singapore Stroke Registry--methodology. International journal of stroke : official journal of the International Stroke Society, 10(5), 767–769. <https://doi.org/10.1111/ijss.12472>

⁷² Tan, B. Y. Q., Tan, J. T. C., Cheah, D., Zheng, H., Pek, P. P., De Silva, D. A., Ahmad, A., Chan, B. P. L., Chang, H. M., Kong, K. H., Young, S. H., Tang, K. F., Tu, T. M., Yeo, L. L., Venketasubramanian, N., Ho, A. F. W., & Ong, M. E. H. (2020). Long-Term Trends in Ischemic Stroke Incidence and Risk Factors: Perspectives from an Asian Stroke Registry. Journal of stroke, 22(3), 396–399. <https://doi.org/10.5853/jos.2020.00878>

⁷³ Sentinel Stroke National Audit Programme. (n.d.). SSNAP - Home. Retrieved October 15, 2025, from <https://www.strokeaudit.org/>

⁷⁴ Royal College of Physicians. (n.d.). Sentinel Stroke National Audit Programme (SSNAP). Retrieved October 15, 2025, from <https://www.rcp.ac.uk/improving-care/resources/sentinel-stroke-national-audit-programme-ssnap/>

Common stroke dashboard indicators

This table summarises the common performance indicators found across the major national stroke dashboards covered in the previous section and their availability in the most recent Annual Report of the Malaysian Stroke Registry 2009-2016.

Indicator	Dashboard				Availability of indicator/s in Annual Report of the Malaysian Stroke Registry 2009-2016 ⁷⁵
	UK SSNAP	AU AuSDaT and/or AU AuSCR	SG SSR	IR INAS	
Time to brain imaging (e.g. time from arrival to CT/MRI)	✓ Includes imaging timeliness indicators ⁷⁶	✓ Includes indicators for “timely assessments and diagnostic procedures” ⁷⁷	✓ Reports time to neuro-imaging ⁷⁸	✓ Reports imaging-related timeliness ⁷⁹	Unclear Form in Section 12: Investigations collects CT data on date of first scan, time to first scan, duration of onset from CT to scan, and neuroimaging findings, but these are not articulated in the report
Admission to dedicated stroke unit	✓ Includes stroke unit care as a domain ⁸⁰	✓ Includes stroke unit access ⁸¹	✓ Captures management using stroke care pathways ⁸²	✓ KPIs include admission to stroke unit” and % of hospital stay in stroke unit ⁸³	Unclear Form in Section 4: Vital Signs at Emergency Department collects data on date, time and location of admission, but these are not articulated in the report
Time-critical therapy (e.g. thrombolysis rate, door-to-needle times)	✓ Includes thrombolysis rates and door-to-needle times ⁸⁴	✓ Includes time-critical therapy/thrombolysis and door-to-needle times ⁸⁵	✓ Reports use of thrombolytic agents ⁸⁶	✓ Reports thrombolysis rate for ischaemic stroke ⁸⁷	✓ Duration (time of onset to time of arrival to ED) Duration door to scan (time of arrival to ED - time of first scan) Duration door-to-needle (time arrival to ED - time of thrombolytic therapy)

⁷⁵ Malaysian National Stroke Registry. (2016). Annual report of the Malaysian Stroke Registry 2009-2016. National Stroke Registry, Clinical Research Centre, Hospital Sultanah Nur Zahirah. Retrieved October 15, 2025 from

<https://www.neuro.org.my/assets/guideline/Stroke%20Registry%20Report%202009-2016.pdf>

⁷⁶ Sentinel Stroke National Audit Programme. (n.d.). Domains, key indicators and scoring. Retrieved October 15, 2025, from <https://www.strokeaudit.org/Audits/Clinical-audit-information/Domains%2C-key-indicators-and-scoring.aspx>

⁷⁷ Australian Stroke Coalition. (n.d.). Australian Stroke Data Tool (AusDAT). Retrieved October 15, 2025, from <https://australianstrokecoalition.org.au/portfolio/ausdat/>

⁷⁸ National Registry of Diseases Office (2025). Singapore Stroke Registry Annual Report 2022. January 2025. Retrieved October 15, 2025 from https://nrdo.gov.sg/docs/librariesprovider3/default-document-library/ssr-annual-report-2022_web.pdf?sfvrsn=7bd47466_1

⁷⁹ Health Service Executive. (2022). Irish National Audit of Stroke: National report 2022 [PDF]. Retrieved October 15, 2025, from <https://www.hse.ie/eng/about/who/cspd/ncps/stroke/resources/irish-national-audit-of-stroke-national-report-2022.pdf>

⁸⁰ Sentinel Stroke National Audit Programme. (n.d.).

⁸¹ Australian Stroke Coalition. (n.d.). Australian Stroke Data Tool (AusDAT). Retrieved October 15, 2025, from <https://australianstrokecoalition.org.au/portfolio/ausdat/>

⁸² National Registry of Diseases Office (2025). Singapore Stroke Registry Annual Report 2022. January 2025. Retrieved October 15, 2025 from https://nrdo.gov.sg/docs/librariesprovider3/default-document-library/ssr-annual-report-2022_web.pdf?sfvrsn=7bd47466_1

⁸³ Health Service Executive. (2022). Irish National Audit of Stroke: National report 2022 [PDF]. Retrieved October 15, 2025, from <https://www.hse.ie/eng/about/who/cspd/ncps/stroke/resources/irish-national-audit-of-stroke-national-report-2022.pdf>

⁸⁴ Sentinel Stroke National Audit Programme. (n.d.). Domains, key indicators and scoring. Retrieved October 15, 2025, from <https://www.strokeaudit.org/Audits/Clinical-audit-information/Domains%2C-key-indicators-and-scoring.aspx>

⁸⁵ Australian Stroke Coalition. (n.d.). Australian Stroke Data Tool (AusDAT). Retrieved October 15, 2025, from <https://australianstrokecoalition.org.au/portfolio/ausdat/>

⁸⁶ National Registry of Diseases Office (2025). Singapore Stroke Registry Annual Report 2022. January 2025. Retrieved October 15, 2025 from https://nrdo.gov.sg/docs/librariesprovider3/default-document-library/ssr-annual-report-2022_web.pdf?sfvrsn=7bd47466_1

⁸⁷ Health Service Executive. (2022). Irish National Audit of Stroke: National report 2022 [PDF]. Retrieved October 15, 2025, from <https://www.hse.ie/eng/about/who/cspd/ncps/stroke/resources/irish-national-audit-of-stroke-national-report-2022.pdf>

Mortality/case-fatality/short-term outcome	✓ Includes outcome indicators like mortality and patient-centred outcomes ⁸⁸	✓ Includes date of discharge or death, discharge location ⁸⁹	✓ Reports 30-day case-fatality rate and mortality trends ⁹⁰	✓ Reports in-hospital mortality and case-fatality rate ⁹¹	✓ Overall mortality Causes of death in stroke patients
Follow-up/functional outcome/disability (e.g. modified Rankin Scale, discharge destination)	✓ Includes 6-month outcomes such as disability, residence ⁹²	✓ AuSCR captures 90-180 day post discharge outcomes including mRS, quality of life, re-hospitalisation, residence ⁹³	Partial Includes outcome and discharge destination, but functional disability measures less prominent in public outputs ⁹⁴	Partial Focus on acute/hospital-based outcomes rather than longer-term functional outcomes Discharge destination and stroke severity may be reported, but mRS or extended follow-up less complete ⁹⁵	✓ Disability at discharge by mRS, stratified by gender

⁸⁸ Sentinel Stroke National Audit Programme. (n.d.). Domains, key indicators and scoring. Retrieved October 15, 2025, from <https://www.strokeaudit.org/Audits/Clinical-audit-information/Domains%2C-key-indicators-and-scoring.aspx>

⁸⁹ Australian Stroke Clinical Registry (AuSCR). (n.d.). Variables & program bundles. Retrieved October 15, 2025, from <https://auscr.com.au/health-professionals/variables-program-bundles/>

⁹⁰ National Registry of Diseases Office (2025).

⁹¹ Health Service Executive. (2022). Irish National Audit of Stroke: National report 2022 [PDF]. Retrieved October 15, 2025, from <https://www.hse.ie/eng/about/who/cspd/ncps/stroke/resources/irish-national-audit-of-stroke-national-report-2022.pdf>

⁹² Sentinel Stroke National Audit Programme. (n.d.).

⁹³ Australian Stroke Clinical Registry (AuSCR). (n.d.).

⁹⁴ National Registry of Diseases Office (2025).

⁹⁵ Health Service Executive. (2022). Irish National Audit of Stroke: National report 2022 [PDF]. Retrieved October 15, 2025, from <https://www.hse.ie/eng/about/who/cspd/ncps/stroke/resources/irish-national-audit-of-stroke-national-report-2022.pdf>

Other disease dashboards: potentially adaptable strengths

Below is a summary of selected disease dashboards from other countries and key strengths that could inform the development of a national stroke dashboard for Malaysia.

Country	Dashboard	Key strengths	Potential usefulness for Malaysia's national stroke dashboard
Aotearoa New Zealand	Public Health and Forensic (PHF) Science Notifiable Disease Dashboard ⁹⁶	- Has interactive selectors per disease with breakdowns by district, age, sex, ethnicity, and geographical region - Is frequently updated and accompanied by downloadable data and GitHub/data repository	For stroke in Malaysia, including ethnicity, urban/rural or state breakdowns plus open data/ downloadable CSVs helps equity monitoring (e.g. differing thrombolysis rates by region) and facilitates external research
Australia	NINDSS / National Notifiable Disease Surveillance System: National Communicable Disease Surveillance Dashboard ⁹⁷ Australia	- National notifiable system integration: single portal to multiple disease dashboards - Designed for both public and professional audiences; consistent user interface (UI) across diseases	For stroke in Malaysia, potentially helpful to develop a central portal that standardises UI and accessibility across indicators (e.g., acute care, rehab, prevention) to enable cross-programme comparisons and easier navigation for public, clinicians, and policymakers
Canada	British Columbia Chronic Disease Dashboard (BCCDC/BC Observatory) ⁹⁸	- Aggregates multiple chronic-disease registries (i.e. provincial administrative datasets) so users can view disease incidence and prevalence by geography, age, sex, and time - Includes clear data notes, definitions and methodology pages, with transparency on case definitions and data sources - Dashboard has the ability to filter by health region/sub-region and export data	- Linking stroke registry and administrative data (e.g. admissions, thrombolysis, outcomes) and publishing clear data definitions can enhance comparability and improve trust - Geographic and demographic filters support the understanding and policy targeting of regional service gaps

⁹⁶ PHF Science (2025). Aotearoa New Zealand Public Health and Forensic (PHF) Science Notifiable Disease Dashboard. Retrieved October 21, 2025 from <https://www.phfscience.nz/digital-library/notifiable-disease-dashboard/>

⁹⁷ Australian Government: Department of Health, Disability and Ageing (2025). NINDSS / National Notifiable Disease Surveillance System: National Communicable Disease Surveillance Dashboard. Retrieved October 21, 2025 from <https://nindss.health.gov.au/pbi-dashboard/>

⁹⁸ British Columbia Observatory – Population and Public Health and BC Centre for Disease Control (2025). Chronic Disease Dashboard. Retrieved October 21, 2025 from <https://www.bccdc.ca/health-professionals/data-reports/chronic-disease-dashboard#Dashboard>

Switzerland	IDD: Infectious Diseases Dashboard ⁹⁹	• Has API/portal data downloads and programmatic access (portal-data), weekly updates, and canton (subnational) views • Integrates multiple surveillance systems (including lab, wastewater, and mandatory reporting) and provides disease-specific pages and data export	• Using programmatic API access would allow Malaysia's stroke dashboard to automate updates (e.g. from hospital registries, imaging logs, lab/imaging metadata), enabling near-real-time monitoring and reproducible analyses
United States	South Dakota State Department of Health Infectious Disease Dashboard ¹⁰⁰	• Clear narrative explaining purpose and contact points, disease pages with breakdowns (including county, onset month, age, sex, race) • Logs content last-updated date and provides historical dashboards	• Clear public narrative + contact information and clear update timestamps increase accountability to users • For stroke in Malaysia, this could be done by including historical comparisons (e.g. year-on-year) and listing names and contact details of data stewards for queries
Global: World Health Organization (WHO)	WHO COVID-19 Dashboard: Global Summary ¹⁰¹	• Uses a multi-layered structure (e.g. overall summary, cases, deaths, hospitalisations, vaccines, variants) with methodological notes and metadata • Clearly mentions data limitations, assumptions, and/or other relevant footnotes to support data interpretation • Regular, dated reporting windows and standardised indicators for regional comparison	• Potentially helpful to use WHO's clear metadata, explicit limitations and modular sections as a "template" for Malaysia's national stroke dashboard • For example: dashboard should separate incidence, acute treatments, outcomes, resources (# of hospital beds/CT/TPA centres) and always show update date + caveats

⁹⁹Federal Office of Public Health, Switzerland (2025). Infectious Diseases Dashboard. Retrieved October 21, 2025 from <https://www.idd.bag.admin.ch/>

¹⁰⁰South Dakota Department of Health (2025). South Dakota Infectious Disease Dashboard. Retrieved October 21, 2025 from <https://doh.sd.gov/health-data-reports/data-dashboards/infectious-disease-dashboard/>

¹⁰¹World Health Organization (2025). WHO COVID-19 Dashboard. Retrieved October 21, 2025 from <https://data.who.int/dashboards/covid19/summary>

In summary, other disease dashboards point to the following takeaways that are relevant to the development of a Malaysian national stroke dashboard that prioritises clarity, data quality, accessibility, and usefulness to multiple audiences (e.g. general public, healthcare professionals, researchers, policymakers):

- Combine multiple data sources (e.g. national stroke registry, hospital administrative data, imaging logs, ambulance and mortality data) and publish data-lineage/definitions
- Offer stratifiers for equity (i.e. age, sex, ethnicity, state/region/urban–rural) and downloadable data
- Provide programmatic access and regular timestamps so dashboard can be refreshed and audited
- Provide clear metadata, caveats, and contact points to facilitate rigorous data use, enhance comparability, and reduce misinterpretation

5. Next Steps: Building a Framework for Malaysia's National Stroke Dashboard

Moving forward, the Galen Centre would like to conduct a one-day workshop to co-design the framework for a National Stroke Dashboard for Malaysia. We propose a structure that begins with establishing a shared vision and purpose before transitioning to technical detail and implementation planning to ensure alignment with Malaysia's health priorities, data realities, and user needs.

Participants should reflect the multidisciplinary of stroke care and ideally include stroke physicians, neurologists, rehabilitation specialists, public health and health informatics experts, hospital administrators and MOH data officers, health economists and policymakers, and importantly, representatives from patient advocacy groups and NGOs.

The key components of this workshop should include:

- *Setting expectations and desired outputs:* clear vision, priority indicators, target audiences, data sources, and governance plan
- *Scene-setting and global insights:* review of literature review findings and establishing the need for a national stroke dashboard for Malaysia + lessons from other countries and relevance/learning lessons for Malaysia
- *Defining purpose:* identify dashboard's primary and secondary audiences (e.g. policymakers, clinicians, public) + main purpose: monitoring performance, informing policy, supporting clinical improvement, promoting transparency and public awareness, promoting competition
- *Identifying key questions the dashboard should answer:* what should users be able to see, learn, and understand from using the dashboard?
- *Prioritising and selecting core indicators:* which indicators across the stroke care continuum should be prioritised and why? What existing data sources can be reliably drawn on to enable this?
- *Determining data flows and feasibility:* data availability, gaps, frequency of updates, data quality issues, and data governance + potential integrations and responsible parties
- *Designing the dashboard and its user interface:* mock-up/wireframe sketching, views (e.g. national, state), visualisations (e.g. maps, trends, benchmarks)
- *Implementing the dashboard:* draw up a roadmap, including timeline and resourcing need

6. References

- Aziz, Z. A., & Sidek, N. N. (Eds.). (2016). Annual report of the Malaysian stroke registry 2009-2016. National Stroke Registry. <https://www.neuro.org.my/assets/guideline/Stroke%20registry%20report%202009-2016.pdf>
- Abdul Aziz, A., Mohd Nordin, N., Muhd Nur, A. et al. (2020). The integrated care pathway for managing post-stroke patients (iCaPPS©) in public primary care Healthcentres in Malaysia: impact on quality adjusted life years (QALYs) and cost-effectiveness analysis. *BMC Geriatr* 20, 70 (2020). <https://doi.org/10.1186/s12877-020-1453-z>
- Australian Government: Department of Health, Disability and Ageing (2025). NINDSS / National Notifiable Disease Surveillance System: National Communicable Disease Surveillance Dashboard. Retrieved October 21, 2025 from <https://nindss.health.gov.au/pbi-dashboard/>
- Australian & New Zealand Stroke Organisation. (n.d.). Australian Stroke Clinical Registry. Retrieved October 15, 2025, from <https://www.anzso.org/research/australian-stroke-clinical-registry/>
- Australian Stroke Clinical Registry (AuSCR). (n.d.). Variables & program bundles. Retrieved October 15, 2025, from <https://auscr.com.au/health-professionals/variables-program-bundles/>
- Australian Stroke Clinical Registry (AuSCR). (2022). Expressions of interest: Australian Stroke Data Tool v2.0 [PDF]. Retrieved October 15, 2025, from <https://auscr.com.au/wp-content/uploads/2022/06/expressions-of-interest-australian-stroke-data-tool-v2.0.pdf>
- Australian Stroke Coalition. (n.d.). Australian Stroke Data Tool (AusDAT). Retrieved October 15, 2025, from <https://australianstrokecoalition.org.au/portfolio/ausdat/>
- Aziz, Z. A., Lee, Y. Y. L., Ngah, B. A., Sidek, N. N., Looi, I., Hanip, Md. R., & Basri, H. B. (2015). *Acute Stroke Registry Malaysia, 2010-2014: Results from the National Neurology Registry*. *Journal of Stroke and Cerebrovascular Diseases*, 24(12), 2701–2709. <https://doi.org/10.1016/j.jstrokecerebrovasdis.2015.07.025>
- Aziz, Z. A., Lee, Y. Y. L., Sidek, N. N., Ngah, B. A., Looi, I., Hanip, Md. R., & Basri, H. B. (2016). *Gender disparities and thrombolysis use among patient with first-ever ischemic stroke in Malaysia*. *Neurological Research*, 38(5), 406–413. <https://doi.org/10.1080/01616412.2016.1178948>
- Boehringer Ingelheim. (n.d.). *MyStroke Hospital Malaysia*. Retrieved October 13, 2025, from <https://patient.boehringer-ingelheim.com/my/my-stroke-hospital>
- British Columbia Observatory – Population and Public Health and BC Centre for Disease Control (2025). Chronic Disease Dashboard. Retrieved October 21, 2025 from <https://www.bccdc.ca/health-professionals/data-reports/chronic-disease-dashboard#Dashboard>
- Cadilhac, D.A., Kim, J., Lannin, N.A., Kapral, M.K., Schwamm, L.H., Dennis, M.S., Norrving, B., & Meretoja, A. (2016). National stroke registries for monitoring and improving the quality of hospital care: A systematic review. *International Journal of Stroke*, 11, 28 - 40.
- Cadilhac, D., Morrison, J., Birhanu, M., Dalli, L. L., Paice, K., Carter, H., Campbell, B. C. V., et al. (2024, December 20). The Australian Stroke Clinical Registry Annual Report 2023. The University of Melbourne. Retrieved October 15, 2025, from https://figshare.unimelb.edu.au/articles/report/The_Australian_Stroke_Clinical_Registry_Annual_Report_2023/28059638/2
- Chan, Y. K., Tan, K. S., & Abdul Latif, L. (2021). *Stroke in young adults in Malaysia: 1 year outcome and functional status*. *Neurology Asia*, 26(4), 657–664. <https://doi.org/10.54029/2021iau>
- Chen, X. W., Shafei, M. N., Aziz, Z. A., Sidek, N. N., & Musa, K. I. (2019). *Trends in stroke outcomes at hospital discharge in first-ever stroke patients: Observations from the Malaysia National Stroke*

Registry (2009–2017). *Journal of the Neurological Sciences*, 401, 130–135.
<https://doi.org/10.1016/j.jns.2019.04.015>

Chia, P. K., Mohamad, N. A., Mat, L. N. I., Khan, A. H. K. Y., Loh, W. C., Sulaiman, W. A. W., ... & Basri, H. (2020). Regional Emergency Stroke Quick-Response (RES-Q) Network: A Proposed Paradigm of Malaysia Stroke Care Services. *Malaysian Journal of Medicine & Health Sciences*, 16(4).

Chin, C. J., Albart, S. A., Yusof Khan, A. H. K., Wan Zaidi, W. A., Sidek, N. N., Schee, J. P., Looi, I., & Hoo, F. K. (2025). An overview of hyperacute stroke services and National Stroke Registry in Malaysia - Improving stroke care through evidence. *The Medical journal of Malaysia*, 80(2), 266–274.

CodeBlue. (2023, September). The stroke journey: Immediate survival and recovery after. CodeBlue. Retrieved October 13, 2025, from <https://codeblue.galencentre.org/2023/09/the-stroke-journey-immediate-survival-and-recovery-after/>

Department of Community Medicine, M., School of Medical Sciences, Universiti Sains Malaysia Kelantan, Biostatistics and Research Methodology Unit, M., School of Medical Sciences, Universiti Sains Malaysia Kelantan, Department of Community Medicine, M., School of Medical Sciences, Universiti Sains Malaysia Kelantan, & Neurology Division, M., Sultanah Nur Zahirah Hospital, Terengganu. (2024). *Survival of Ischaemic and Haemorrhagic Stroke: Analysis of the Malaysian National Stroke Registry Data from 2009 to 2013*. *Malaysian Journal of Medical Sciences*. Penerbit Universiti Sains Malaysia.

<https://doi.org/10.21315/mjms2024.31.5.14>

Federal Office of Public Health, Switzerland (2025). Infectious Diseases Dashboard. Retrieved October 21, 2025 from <https://www.idd.bag.admin.ch/>

Health Service Executive. (2022). Irish National Audit of Stroke: National report 2022 [PDF]. Retrieved October 15, 2025, from <https://www.hse.ie/eng/about/who/cspd/ncps/stroke/resources/irish-national-audit-of-stroke-national-report-2022.pdf>

Heuschmann, P.U., Biegler, M.K., Busse, O., Elsner, S.A., Grau, A.J., Hasenbein, U., Hermanek, P., Janzen, R.W., Kolominisky-Rabas, P.L., Kraywinkel, K., Lowitzsch, K., Misselwitz, B., Nabavi, D.G., Otten, K., Pientka, L., von Reutern, G., Ringelstein, E.B., Sander, D., Wagner, M., & Berger, K. (2006). Development and Implementation of Evidence-Based Indicators for Measuring Quality of Acute Stroke Care: The Quality Indicator Board of the German Stroke Registers Study Group (ADSR). *Stroke*, 37, 2573-2578.

Hwong, W. Y., Ang, S. H., Bots, M. L., Sivasampu, S., Selvarajah, S., Law, W. C., Latif, L. A., & Vaartjes, I. (2021). *Trends of Stroke Incidence and 28-Day All-Cause Mortality after a Stroke in Malaysia: A Linkage of National Data Sources*. *Global Heart*, 16(1). <https://doi.org/10.5334/gh.791>

Hwong, W. Y., Ng, S. W., Tong, S. F., Ab Rahman, N., Law, W. C., Kaman, Z., Wong, S. K., Puvanarajah, S. D., & Sivasampu, S. (2022). Stroke thrombolysis in a middle-income country: A case study exploring the determinants of its implementation. *Frontiers in neurology*, 13, 1048807.
<https://doi.org/10.3389/fneur.2022.1048807>

Jonsson, A., Cosgrave, N., Healy, A., Mellon, L., Williams, D.J., & Hickey, A. (2024). Maximising the Quality of Stroke Care: Reporting of Data Collection Methods and Resourcing in National Stroke Registries: A Systematic Review. *Journal of medical systems*, 48 1, 100.

Khaw, W. F., Chan, Y. M., Nasaruddin, N. H., Alias, N., Tan, L., & Ganapathy, S. S. (2023). Malaysian burden of disease: years of life lost due to premature deaths. *BMC public health*, 23(1), 1383.
<https://doi.org/10.1186/s12889-023-16309-z>

Li, S. P., Loh, H. C., Ganasegeran, K., Abdul Aziz, Z., & Looi, I. (2021). P-OT026. *Epidemiological trends on the risk factors and outcomes of stroke*. *Clinical Neurophysiology*, 132(8), e129.
<https://doi.org/10.1016/j.clinph.2021.02.323>

Lynch, E., Laver, K., Levy, T., Schultz, T. (2023). 'The way that we are collecting and using data has evolved' evaluating the Australian National Stroke Audit programme to inform strategic direction. *BMJ Open Quality*. 2023;12:e002136. <https://doi.org/10.1136/bmjopen-2022-002136>

King, T. L., Tiong, L. L., Kaman, Z., Zaw, W. M., Abdul Aziz, Z., & Chung, L. W. (2020). *A hospital-based study on ischaemic stroke characteristics, management, and outcomes in Sarawak: Where do we stand?* *Journal of Stroke and Cerebrovascular Diseases*, 29(9), 105012. <https://doi.org/10.1016/j.jstrokecerebrovasdis.2020.105012>

Malaysian National Stroke Registry. (2016). Annual report of the Malaysian Stroke Registry 2009-2016. National Stroke Registry, Clinical Research Centre, Hospital Sultanah Nur Zahirah. Retrieved October 15, 2025 from <https://www.neuro.org.my/assets/guideline/Stroke%20registry%20report%202009-2016.pdf>

Malaysian Society of Neurosciences (2021). Clinical Practice Guidelines – Management of Ischaemic Stroke. 3rd Edition. Malaysian Society of Neurosciences (MSN), the Academy of Medicine Malaysia, and Ministry of Health. <https://doi.org/10.32896/cvns.v3n1.1-155>

Mohammed, M., Zainal, H., Ong, S.C. et al (2025) Direct medical cost of first-ever acute ischemic stroke in Malaysia: a retrospective cohort study. *Sci Rep* 15, 22571. <https://doi.org/10.1038/s41598-025-07026-1>

National Office of Clinical Audit. (2023). Irish National Audit of Stroke: National report 2023. Retrieved October 15, 2025, from <https://www.noca.ie/documents/irish-national-audit-of-stroke-national-report-2023/>

National Registry of Diseases Office (2025). Singapore Stroke Registry Annual Report 2022. January 2025. Retrieved October 15, 2025 from https://nrdo.gov.sg/docs/librariesprovider3/default-document-library/ssr-annual-report-2022_web.pdf?sfvrsn=7bd47466_1

Nazifah, S., Azmi, I., Hamidon, B., Looi, I., Zariah, A., & Hanip, M. (2012). *National Stroke Registry (NSR): Terengganu and Seberang Jaya experience*. *The Medical Journal of Malaysia*.

Nik Ramli, N. N., Asokan, A., Mayakrishnan, D., & Annamalai, H. (2021). Exploring Stroke Rehabilitation in Malaysia: Are Robots Better than Humans for Stroke Recuperation?. *The Malaysian journal of medical sciences : MJMS*, 28(4), 14–23.

Nordic Healthcare Group. (n.d.). Visual dashboard to benchmark outcomes and costs between hospitals. ICHOM. Retrieved October 21, 2025, from <https://www.ichom.org/nordic-healthcare-group/visual-dashboard-to-benchmark-outcomes-and-costs-between-hospitals/>

PHF Science (2025). Aotearoa New Zealand Public Health and Forensic (PHF) Science Notifiable Disease Dashboard. Retrieved October 21, 2025 from <https://www.phfscience.nz/digital-library/notifiable-disease-dashboard/>

Public Health Priority: Way Forward for Stroke Care in Malaysia For the Next 10 Years (n.d.). Unpublished; privately shared. [slide deck]

RES-Q Data for Life (2025). Live Metrics. Retrieved October 13, 2025 from <https://stroke.qualityregistry.org/useful-information/live-metrics>

Royal College of Physicians. (n.d.). Sentinel Stroke National Audit Programme (SSNAP). Retrieved October 15, 2025, from <https://www.rcp.ac.uk/improving-care/resources/sentinel-stroke-national-audit-programme-ssnap/>

Rudd, A. G., Hoffman, A., Paley, L., & Bray, B. (2018). 20 years of researching stroke through audit. *Clinical Rehabilitation*. Advance online publication. <https://doi.org/10.1177/0269215518784645>

Sentinel Stroke National Audit Programme. (n.d.). SSNAP - Home. Retrieved October 15, 2025, from <https://www.strokeaudit.org/>

Sentinel Stroke National Audit Programme. (n.d.). Domains, key indicators and scoring. Retrieved October 15, 2025, from <https://www.strokeaudit.org/Audits/Clinical-audit-information/Domains%2C-key-indicators-and-scoring.aspx>

South Dakota Department of Health (2025). South Dakota Infectious Disease Dashboard. Retrieved October 21, 2025 from <https://doh.sd.gov/health-data-reports/data-dashboards/infectious-disease-dashboard/>

Tan, B. Y. Q., Tan, J. T. C., Cheah, D., Zheng, H., Pek, P. P., De Silva, D. A., Ahmad, A., Chan, B. P. L., Chang, H. M., Kong, K. H., Young, S. H., Tang, K. F., Tu, T. M., Yeo, L. L., Venketasubramanian, N., Ho, A. F. W., & Ong, M. E. H. (2020). Long-Term Trends in Ischemic Stroke Incidence and Risk Factors: Perspectives from an Asian Stroke Registry. *Journal of stroke*, 22(3), 396–399. <https://doi.org/10.5853/jos.2020.00878>

Tan, K. S., & Venketasubramanian, N. (2022). *Stroke Burden in Malaysia*. *Cerebrovascular Diseases Extra*, 12(2), 58–62. <https://doi.org/10.1159/000524271>

Wan Zaidi, W. A. (2025). Private correspondence.

Venketasubramanian, N., Chang, H. M., Chan, B. P., Young, S. H., Kong, K. H., Tang, K. F., Ang, Y. H., Ahmad, A., Chow, K. Y., & Singapore Stroke Registry (2015). Countrywide stroke incidence, subtypes, management and outcome in a multiethnic Asian population: the Singapore Stroke Registry--methodology. *International journal of stroke : official journal of the International Stroke Society*, 10(5), 767–769. <https://doi.org/10.1111/ijis.12472>