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REVIEW

Does the Implementation of a Telestroke Program Play a Role in Improving the Clinical Outcomes of Acute Stroke Patients in South East Asian Region?: A Literature Review

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Abstract: Telestroke is an innovation in telemedicine, in the form of a method for identifying, assessing, treating, and monitoring stroke patients remotely using internet technology. Telestroke can speed up diagnosis and treatment in acute stroke by allowing direct video consultations between doctors and patients separated by distance. The Southeast Asia Region (SEAR) accounts for nearly 50% of the developing world's stroke burden. With various commonalities across the countries regarding health services, user awareness, and healthcare-seeking behavior, SEAR still presents profound diversities in stroke-related services across the continuum of care. With telestroke, "door-to-needle time" can be reduced without additional costs, thereby reducing morbidity/mortality due to stroke. In the context of telestroke, the objective is a real-time clinical assessment by a stroke specialist-test review, diagnosis, and emergency management plan-in consultation with local healthcare providers. The increased access to stroke care through telestroke provides a promising innovation for the rural area. It is envisaged that telestroke will bridge this gap, enabling hospitals in rural areas to give care equal to hospitals that have stroke specialists, especially in SEAR.

Keywords: acute stroke, telestroke, clinical outcome, SEAR

Introduction

The world's second most fatal disease is stroke, which also accounts for a significant portion of the economic burden.[1] The public health issue that is most significant in low-income and middle-of-the-road countries is stroke. From 1990 to 2019, stroke-related deaths increased by 70%, while the prevalence of strep throats increased 102% and Disability Adjusted Life Years (DALY) rates rose 143% globally.[2] With a disability rate of 3,382.2 per 100,000 people, Indonesia is one of the countries in Southeast Asia with the highest number of fatalities. The Southeast Asia Region has been separated and categorized according to either geographical or organizational factors. Although the World Health Organization (WHO) covers all countries from east of India to south of China, the SEAR is made up of 11 member nations, including Bangladesh, Bhutan, India and Indonesia. The South East Asian Region (SEAR) makes up 25% of the world's population and can cover as much as 3% of global land. Presently, this region is responsible for almost half of the stroke burden in developing countries and is also the primary cause of stroke mortality worldwide.[2,3]

A significant proportion of stroke survivors are severely disabled, while a high percentage have recurrent strokes. There is a significant gap between the accessibility of stroke care services and the prevalent stroke burden in this locality. The low- and middle-income countries are where SEAR is located, and it does not have sufficient infrastructure or skilled personnel.[4] The challenges of providing consistent stroke care in this area are not solely due to the aging population, geographical differences, and sociocultural factors. The SEAR has not adequately addressed the issue of stroke in acute care, with low rates of thrombolysis, mechanical thrombectomy, and availability stroke units.[4,5] Rehabilitation professionals' inability to provide services and their lack of knowledge and skills are causing significant neglect towards

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rehabilitation after strokes. The unacknowledged but crucial task of reintegrating into society is another issue in this region. In Indonesia, the latest Riset Kesehatan Dasar (Riskesdas) study indicates that the overall prevalence is 10.9/1,000,000, with different provinces reporting levels, including Papua which has the lowest level at 4.9/100,000,000.[6]

Rapid evaluation and intervention are crucial in addressing acute stroke, which is based on the notion that "time is brain".[7–9] This applies to the limited time frame for determining intravenous thrombolysis therapy and mechanical thrombectomy. The World Stroke Association has established intravenous thrombolysis with recombinant-tissue plasminogen activator (r-TPA) as the gold standard treatment for acute ischemic stroke.[10] The procedure involves the administration of r-tPA through intravenous injections. According to the AHA/ASA, mechanical thrombectomy is performed within 6–24 hours, and symptoms appear every hour, so IV-tPA should be administered within 4.5 hours. With every minute of untreated stroke, one may lose their neurological recovery chances.[11]

The contribution of pre-hospital factors is relatively large, resulting in delays in thrombolytic action. Basically, this is multifactorial related to patients, transportation, referral systems, and delays in entering and leaving the hospital, but most of them are caused by contacting emergency services. This may be because the patient or his family believes that the symptoms he has experienced are not severe enough for medical treatment. Whereas Emergency Room (ER) visits associated with more severe symptoms of stroke demonstrated an earlier timeline, less severe ones contributed to a delay of admission.[12,13]

In addition to pre-hospital and in-hospital causes of delay, there is the gap in access to health services between urban and rural settings as another one of the important barriers in utilizing thrombolysis, especially in SEAR. Only around 3% to 5% of acute stroke patients received IV r-tPA, based on a recent analysis.[14] The number of stroke experts in small hospitals located in rural areas has been a primary cause for the low rate of utilization.[15] Rural and urban areas are found to have life expectancy rates which are associated with very significant disparities.[15] Such a striking difference was seen in stroke mortality between the two areas.[15] Based on Vital Statistics data, the mortality rate due to stroke in rural and urban areas rose from 15% to 25% from 1999 to 2010 and then decreased to 8% in 2019. Another cause for the deaths in the area is the high incidence of stroke in rural areas.[14]

Further studies showed that patients with acute stroke living in rural areas had less intravenous thrombolysis therapy compared to urban patients. This is because of the slow diffusion of new treatments and technologies to rural hospitals, and a lack of resources to have access to specialized stroke care or central hospitals. Besides that, the lack of specialist doctors in rural hospitals is also a factor in this gap. Especially, when stroke patients need time to travel long distances to seek adequate stroke care, this lengthens the time from symptom onset to therapy.[16] Inter-hospital transportation factors also play an important role in treatment delays, which directly affects the effectiveness of thrombolytic interventions.[17]

For this reason, health service providers, based on those things, have to design regionalization efforts or centralization of acute stroke care by utilizing technology such as telehealth and referral systems. Recent studies have identified that stroke telehealth programs, also known as telestroke, can safely and effectively extend the use of intravenous thrombolysis and subsequently improve stroke patients' clinical outcomes.[18] Telestroke is an innovation within telemedicine, which refers to a method of identifying, assessing, treating, and monitoring stroke patients remotely using internet technology. Telestroke can speed up diagnosis and treatment in acute stroke through direct video consultations between doctors and patients separated by distance.[18] In a "hub-and-spoke" model, stroke specialist doctors at primary health centers (hubs) can cooperate with the source facility (spoke) to provide timely remote care. Telestroke is able to reduce "door-to-needle time" and reduce morbidity and mortality due to stroke in a cost-efficient manner. Increasing access to care for stroke by telestroke is a promising innovation for rural areas. It is hoped that telestroke will help bridge this gap by allowing hospitals in rural areas to provide a level of care similar to hospitals that have specialists in stroke care.[19]

There is still limited published study explaining the effectiveness of telestroke itself in improving the clinical outcomes of acute stroke patients, especially in SEAR countries. Therefore, this narrative review will assess the effectiveness of telestroke in improving clinical outcomes of acute stroke patients in South East Asia Region (SEAR).

Role of Telestroke in Acute Stroke

Telestroke and Door-to-Needle (DTN) Time

Telestroke consultations are experiencing a phenomenal surge in popularity globally, with the number of instances increasing.[20,21] Telestroke programs have reported an important outcome in the treatment of acute ischemic stroke, with

increased use of thrombolytic therapy.[15] Among patients treated at tertiary stroke centers, telestroke has been found to increase the rates of thrombolysis therapy, particularly in hospitals without stroke units and with no adverse events associated with them. In the United States, thrombolysis is mostly done using a drip-and-ship model, with some assistance from telestroke consultations. Telestroke services have broadened beyond the initial focus of thrombolysis treatment for acute stroke to encompass post-alteplase follow-up, non-emergent consults, and supportive care to enable patients to remain under local care.[21]

Dutta et al found that intravenous thrombolysis, which involved telephone consultation, teleradiology, and local doctors, was safe and effective in managing stroke in hospitals with a structured stroke care system. Among the 22 minutes that were added to Door-to-Needle (DTN) time by Telecare, 14 minutes of it was directly related to the remote consultation process, while another 20 minutes was recorded as slow processing outside normal working hours.[22] The study conducted by Fong et al suggests that using telestroke to manage patients without a specialist doctor in on-site neurology can be equally effective and safe. The shortage of neurologists on site for acute stroke services outside of regular hours can be resolved by telestroke.[23]

Acute stroke patients can be treated safely and with minimal delay by neurological examination using a web and a drip and treat protocol as researched by Nardetto et al. The satisfactory results of onset-to-door (OTD) and door-to-CT scan (DTC) times have been presented by this study in both telemedicine and non-telemedicine procedures. However, the starting time for therapy is still quite long, especially in hub centers. This is induced by the presence of second level confirmation at the hub center itself, such as a brain MRI or ultrasound scan, to determine the right diagnosis before treating the patients in the acute phase; this causes delays in treatment. These conclusions indicate that the findings from this study present the reliability of telestroke in making available the facility of follow-up monitoring by specialists for the patients and receipt of as intensive care in a stroke unit, particularly crucial hours following thrombolysis. An achievement considered to increase more access for the patients to more specialist care is wherever they might be staying and is due to telestroke.[24]

The TRUST-tPA study is the other one on the therapeutic trial conducted to test the efficacy of telemedicine of patients suffering from acute stroke and proves that telestroke can increase patient access to r-tPA fivefold as opposed to the usual care group, while the trial did not result in clinical outcome improvement. It results from the patient characteristics; in the telestroke group, they are higher in age as well as increased NIHSS.[25]

Alteplase given within 4.5 hours from the time the symptoms of acute stroke began to appear will be able to reduce the patients' disabilities for the long term. Timely tPA administration offers significant benefits that have been considered related to speed: earlier initiation yielding superior long-term functional outcome along with fewer complications. Recent guidelines recommend a door-to-needle time of less than 60 minutes from arrival to the hospital.[26] Better DTN times have been associated with improved clinical outcomes, such as reduced symptomatic intracranial hemorrhage, reduced inpatient mortality, and improved functional outcomes. However, only about 30% of the patients receive tPA within this time frame successfully.[27]

Based on research conducted by Martínez-Sánchez et al, telestroke can increase tPA use and better decision-making, as well as reduce unnecessary patient transfers. Additionally, telestroke can also reduce DTN time contributing to better clinical outcomes. In this study, telestroke allowed tPA administration to be performed at the spoke center; thus, the DTN time was reduced by approximately 77 minutes, with a median time of 66 minutes in the group telestroke, faster than many previous telestroke studies.[28]

Raulot et al revealed that the intra-hospital or DTN time was longer in local hospitals using telestroke compared with stroke units because of the preparatory procedures in setting up a video conference between the spoke and the hub. However, ultimately, the overall onset-to-needle (OTN) time had similar results. This research also thus suggests that telestroke implementation should be targeted at >30-minute centers from a stroke unit.[29]

Al Kasab et al reported that the percentage of patients who achieved DTN time thresholds was lower in spoke than in hub hospitals. This study demonstrated that stroke patients at spoke hospitals with telestroke received tPA has administered at spoke hospitals lately. This is because of the inexperience of the spoke hospital in the treatment of stroke and time required to carry out telestroke consultations and brain imaging. This study also suggested that the DTN

times in spoke hospitals can be improved. This can be done with various interventions such as training, education, and increasing comfort or confidence of medical staff at spoke hospitals in treating acute stroke patients.[30]

Improvement in Stroke Outcome

Most of the telestroke networks remotely use the NIHSS assessment of the stroke. NIHSS performed remotely has a degree of reliability equivalent to an in-person examination in both sub-acute and acute stroke patients.[15] This assessment by telemedicine can be done without significant delays in time. Furthermore, the results of the assessment using NIHSS through telemedicine are very reliable because it has consistent results even though carried out by different assessors. This is reinforced by the very good correlation (r = 0.9552), between NIHSS performed at the bedside and at a remote location. NIHSS can be performed on a variety of devices and technologies: computer, laptop, and mobile video.[31] Remote video assessment using smartphone was evaluated in a study showing an excellent level of "agreement" on most of the NIHSS components.[15]

In addition to NIHSS assessments, most stroke care studies and reports use 90-day functional studies as long-term outcome indicators in monitoring post-stroke patient outcomes. The expectation, therefore, exists that telestroke networks should follow these standards within the stroke care systems. One of the most applied assessment tools of outcomes in this measure is mRS, which ought to be measured at 90 days post-stroke. The mRS assessment is a trained, certified, person-to-person test that can be either in person or completed over the telephone, but sometimes obtaining long-term follow-up is tough and requires more than the capacity of a few telestroke systems. In such cases, interim indicators of the patient's functional outcome include short-term outcome indicators such as in-hospital mortality, NIHSS within 24 hours, mRS score at the time of discharge, information about the location to which the patient is discharged may indicate the improvement in the patient's condition.[15]

The contribution of Martínez-Sánchez et al presented evidence for telestroke to decrease three-month mRS by reducing DTN time. At this point, it is possible that early intravenous thrombolysis after ischemic stroke may lead to better clinical outcomes.[28] Previous studies stated that there was no difference in clinical outcomes in patients with Large Vessel Occlusion (LVO) who were first treated at a spoke hospital and at the Comprehensive Stroke Centre (CSC). However, this study shows that there are differences in the distribution of reperfusion therapy. More patients with telestroke received IV r-tPA, but less and needed longer access to mechanical thrombectomy. This finding is relevant in areas where the distance between the spoke center and the CSC is quite large.[32]

Implementation of Telestroke in SEAR

Health care systems in the SEAR are characterized by their heterogeneous nature, with a complex combination of public and private delivery, including government insurance and high-out-of-pocket funding. Thailand and Singapore have the highest level of public health coverage, respectively. The implementation of Universal Health Coverage (UHC) in Thailand since 2002 has resulted in stroke being covered under public health, but the use of thrombolysis remains low (0.18–8.04%).[29] Bhutan's citizens can receive UHC as well. Most SEAR countries have access to UHC, but its use is restricted due to poor affordability. In most countries, the increasing demand for high-quality healthcare and rising education levels have spurred a push towards privatization. India's healthcare system comprises of primary, secondary, and tertiary level hospitals with 3 levels. Across different regions, there is a wide range of accessibility and affordability for physicians as well as facilities due to the prevalence of private health care, lack of social insurance, and large urban-rural divide. Nepal relies heavily on out-of-pocket funding for its healthcare.[30] Notwithstanding the health sector's increased policy priority, public investment in healthcare is below US$20 per capita, and private ownership controls more than two-thirds of hospital beds.[33,34] Decentralization of healthcare systems in low and middle income countries (LMICs), including Indonesia, has replaced devolution to district/local governments since 2001. These changes in the health system have put pressure on the public sector to adapt, evolve and provide.[31,35] Due to the significant need to restructure healthcare delivery and financing, various innovative financing schemes have been introduced throughout the region.[36–38] In India, the Ayushman Bharat Yojana and PM-JAY scheme is a government-funded initiative that provides comprehensive healthcare services, including secondary and tertiary healthcare insurance, to patients with strokes, who can also receive intravenous thrombolysis, mechanical thrombectomy, or Stroke Unit (SU) care.[39,40] The use of mobile

phone technology, which has revolutionized telestroke care in SEAR countries, is being harnessed to provide stroke care. This trend is especially evident in countries like India, where numerous trials have been started on app-based, technology-driven, affordable telestroke models of care.[41] Twenty-six patients were successfully thrombolysed at 9 district hospitals in North India through a trial using telestroke models, with the hub and spoke tunable model being used by only 2 tertiary hospitals and 17 districts hospitals.[42] No neurologist was present on site. Telestroke care has gained recognition in Indonesia and Nepal for challenging terrain.[43,44]

The SMART-India app is a telephone application to provide low-cost telestroke services from a neurologist and physiotherapist to doctors in district hospitals. This application allows doctors to transmit patient data, such as CT scans, to make clinical decisions in patient management. This application also facilitates interaction between doctors and physiotherapists in the tele-rehab module. It is hoped that this application will meet the rehabilitation needs of stroke survivors in rural areas with limited resources in low and middle income countries, such as India.[42]

Changi General Hospital (CGH) is an acute regional hospital in Singapore that treats around 150,000 emergency patients every year. CGH provides 24-hour telestroke services with a hub-and-spoke model. Eligible patients will come to CGH as spokes and be evaluated by neurologists at the National Neuroscience Institute (NNI) as hubs. The telestroke workflow is achieved through four Plan-Do-Study-Act (PDSA) cycles. The aim of the PDSA cycle is to evaluate the five phases of telestroke for more precise monitoring. The five phases are: (1) patient arrival at the ER until stroke alert; (2) stroke alert until completion of CT imaging; (3) completion of CT imaging to stroke activation; (4) stroke activation to decision for tPA; and (5) decision for tPA until administration of tPA. The study shows that new measures can reduce DTN time delays. Even though it did not reach a DTN time of less than 60 minutes, there was a significant increase in DTN time which was comparable to other centers that used telestroke, namely 61–106 minutes. Median time to obtain imaging (ED arrival time to brain CT) increased from 17 minutes to 13 minutes. The average time for videoconference and adjudication by a neurologist (phase 4) increased from 35 minutes to 26 minutes. Ultimately, these quality improvements may reduce the overall median time to DTN for acute ischemic stroke patients receiving thrombolysis after using telestroke program.[5,45,46]

Factors Influencing Implementation of Telestroke in SEAR

The implementation of telestroke requires the effective training and education of health workers. Despite the existence of pre-existing consensus stroke protocols, telestroke's implementation was linked to a specific training program for spoke hospital physicians. Studies have revealed that the implementation of stroke reperfusion strategies in educational programs and stroke protocols can lead to a decrease in DTN time to effective tPA administration. The telestroke group's improvement in tPA administration may be partly due to the need for physician education and compliance with stroke management guidelines at spoke hospitals, and also government policy for telestroke financing program.[8,9,37,38]

Public knowledge about stroke symptoms and their associated signs is inadequate in SEAR. Awareness studies from India have revealed that 23–48% of participants were unaware about stroke warning symptoms, and over half had no knowledge of any risk factors or treatments. The average stroke awareness among patients with stroke in Sri Lanka was found to be 47.79%, but higher levels of awareness were observed in those with more extensive education.[7] The failure to acknowledge early symptoms of stroke and sociocultural beliefs in indigenous modalities like faith healing leads many patients to overlook the need for effective medical treatment. The inadequate organization of pre-hospital services contributes to the challenge of accessing stroke-ready centers.[10] Most countries lack the standard Emergency Medical Services (EMS) systems that are currently in place and vary in their accessibility. Although the SEAR shares a significant burden of strokes in India, there is no established system for managing it.[11] Most patients arrive at hospitals in either self-owned or hired private vehicles. Only 1–13% of patients in India use EMS to get to the hospital, as opposed to 50% from high-income countries.[12,47] The 108-ambulance system is utilized in 22 out of 28 states and 2 out of 8 union territories in India. The emphasis is on maternal and trauma care, while paramedical staff lacking stroke care education. The national ambulance transport system Suwaseriya is available to patients in Sri Lanka from 1990.[13] While this service has gained more public awareness and usage, training for paramedics in stroke recognition and fast-track referrals is still required. Nepal's landslides and primitive ambulance services pose challenges in providing timely care. Notwithstanding the improved system architecture in Thailand, past studies indicate that only 5.5–20.5% of stroke victims use EMS-based

management strategies.[14,15] EMS fails to organize the integration of fast-track protocols with their systems, resulting in only half of suspected stroke patients being sent to appropriate stroke centers.[16] A strong referral system is reported by Maldives. Despite the Maldives' scattered island-flunge location, its air and sea ambulance services are highly developed and equipped to facilitate rapid patient transport and referral.[17]

According to a separate study, medical and paramedical teams were trained in specific workshops to treat patients during the acute phase of stroke. This training equips the hub team to obtain precise information about the patient from the spoke team staff. The management of patients at branch hospitals was standardized to enable access to video conferencing, imaging, and care. The operation of the telestroke system is under the supervision of neurologists and radiologists who are available 24/7. By relying on the hub team's expertise, they can expedite the decision-making process for the spoke team.[8,35,36]

Trials that have encountered obstacles in the TRUST-tPA trial include those that involve video conferencing time, such as collecting history and administering NIHSS to individuals with comprehensive neurological examination. This can hinder patient progress due to the importance of OTT timing in achieving good clinical outcomes. Furthermore, imaging at the endorsed hospital is not accessible. A compact disc is necessary for its storage. The telestroke team experienced a significant increase in videoconference time and CT imaging visualization time.[8]

Stroke care services in SEAR countries require urgent strengthening and improvement. Multidisciplinary approach should account geographical, cultural/social/economic differences. Setting realistic targets and achieving context-appropriate goals is part of the Global Stroke Action Plan, which recognizes that different systems may be involved in stroke care across the world.[10,36,37] To ensure effective primary prevention and reduce treatment delays, it is essential to raise awareness about stroke and risk factors. Behavioral modification programs for stroke awareness and government policies, such as taxes, are necessary to control lifestyle determinants.[10] Countries lacking skilled workers should adopt hub-and spoke, task-sharing, and physician-led models of stroke care as effective approaches. The use of telestroke networks, digital technology, and mobile apps for knowledge sharing can occur both within and between countries.[21,35,36] Further research is needed on the effectiveness and implementation of telestroke in SEAR.

Conclusion

Increasing access to stroke care via telestroke is a promising innovation for rural areas, especially in SEAR. It is hoped that telestroke can bridge this gap, allowing hospitals in rural areas to provide care equivalent to hospitals that have stroke specialists. Achieving equitable stroke care in SEAR requires the implementation of evidence-based policy-making, which involves a multidisciplinary approach with active participation from stakeholders such as stakeholders (eg healthcare policymakers for telestroke financing program), government agencies, and ministries of health. Enhancing social literacy on stroke through the wide dissemination of stroke awareness programs, specialized stroke recognition training for paramedical staff, establishment of a national stroke hotline number to expedite referrals, and the adoption of hospital prenotification is necessary in order to improve telestroke healthcare services.

Disclosure

The author reports no conflicts of interest in this work.

References

1. World Health Organization. About WHO in the South-East Asia Region. https://www.who.int/southeastasia/about. Accessed July 11, 2023.
2. Venketasubramanian N, Yoon BW, Pandian J, Navarro JC. Stroke epidemiology in South, East, and South-East Asia: a review. *J Stroke*. 2017;19(3):286–294. doi:10.5853/jos.2017.00234
3. Ng JC, Churojana A, Pongpech S, et al. The current state of acute stroke care in Southeast Asian countries. *Interv Neuroradiol*. 2019;25(3):291–2963. doi:10.1177/1591019918811804
4. Sebastian I, Gandhi B, Padmavati N, et al. Stroke systems of care in South-East Asia Region (SEAR): commonalities and diversities. *Lancet Regional Health*. 2023;17:100289. doi:10.1016/j.lansea.2023.100289
5. Mohamed A, Elsherif S, Legere B, Fatima N, Shuaib A, Saqqur M. Is telestroke more effective than conventional treatment for acute ischemic stroke? A systematic review and meta-analysis of patient outcomes and thrombolysis rates. *Int J Stroke*. 2023;19(3):280–292. doi:10.1177/17474930231206066
6. Directorate of Health Promotion and Community Empowerment. Get to Know Stroke and Its Causes. *Ministry Health*. 2023;13–15.

7. Balgis B, Sumardiyono S, Handayani S. Hubungan antara prevalensi hipertensi, prevalensi dm dengan prevalensi stroke di Indonesia (analisis data riskesdas dan profil kesehatan 2018). *J Kesehatan Masyarakat*. 2022;10(3):379–384. doi:10.14710/jkm.v10i3.33243
8. Saver JL, Smith EE, Fonarow GC, et al. GWTG-Stroke Steering Committee and Investigators.The "golden hour" and acute brain ischemia: presenting features and lytic therapy in >30,000 patients arriving within 60 minutes of stroke onset. *Stroke*. 2010;41(7):1431–1439. doi:10.1161/STROKEAHA.110.583815. Epub 2010 Jun 3. PMID: 20522809; PMCID: PMC2909671.
9. Randhawa AS, Pariona-Vargas F, Starkman S, et al. Beyond the Golden Hour: treating Acute Stroke in the Platinum 30 Minutes. *Stroke*. 2022;53(8):2426–2434. doi:10.1161/STROKEAHA.121.036993. Epub 2022 May 12. PMID: 35545939; PMCID: PMC9329219.
10. Mathur S, Walter S, Grunwald IQ, Helwig SA, Lesmeister M, Fassbender K. Improving Prehospital Stroke Services in Rural and Underserved Settings With Mobile Stroke Units. *Front Neurol*. 2019;10. doi:10.3389/fneur.2019.00159
11. Powers WJ, Rabinstein AA, Ackerson T, et al. Guidelines for the early management of patients with acute ischemic stroke: 2019 update to the 2018 guidelines for the early management of acute ischemic stroke a guideline for healthcare professionals from the American Heart Association/American Stroke Association. *Stroke*. 2019;50(12):E344–418. doi:10.1161/STR.0000000000000211
12. Sharobeam A, Jones B, Walton-Sonda D, Lueck CJ. Factors delaying intravenous thrombolytic therapy in acute ischaemic stroke: a systematic review of the literature. *J Neurol*. 2021;268(8):2723–2734. doi:10.1007/s00415-020-09803-6
13. Amalia L. Factors Affecting the Delay of intravenous Thrombolysis in Hyperacute Ischemic Stroke Patients: a Single Centre Study. *Int J Gen Med*. 2023;16:2157–2163. doi:10.2147/IJGM.S412262
14. Howard G. Rural-urban differences in stroke risk. *Prev Med*. 2021;152(Pt 2):106661. doi:10.1016/j.ypmed.2021.106661
15. Wechsler LR, Demaerschalk BM, Schwamm LH, et al. Telemedicine Quality and Outcomes in Stroke: a Scientific Statement for Healthcare Professionals From the American Heart Association/American Stroke Association. *Stroke*. 2017;48(1):e3–25. doi:10.1161/STR.0000000000000114
16. Hammond G, Luke AA, Elson L, Towfighi A, Joynt Maddox KE. Urban- Rural Inequities in Acute Stroke Care and In-Hospital Mortality. *Stroke*. 2020;51(7):2131–2138. doi:10.1161/STROKEAHA.120.029318
17. Riegler C, Behrens JR, Gorski C, et al. Time-to-care metrics in patients with interhospital transfer for mechanical thrombectomy in north-east Germany: primary telestroke centers in rural areas vs. primary stroke centers in a metropolitan area. *Front Neurol*. 2023;13. doi:10.3389/fneur.2022.1046564
18. Qurat Ul Ain H, Junaid Tahir M, Abbasher Hussien Mohamed Ahmed K, et al. Tele- stroke: a strategy to improve acute stroke care in low- and middle-income countries. *Ann Med Surg*. 2024;86(7):3808–3811. doi:10.1097/MS9.0000000000002187
19. Arumuganathan P, Adcock AK, Espinosa C, Findley S. Analysis of Telestroke Usage in Rural Critical Access Emergency Departments. *Telemed J E Health*. 2023;29(12):1828–1833. doi:10.1089/tmj.2022.0408
20. Zihni E, McGarry BL, Kelleher JD. Moving Toward Explainable Decisions of Artificial Intelligence Models for the Prediction of Functional Outcomes of Ischemic Stroke Patients. In: *Digital Health*. Exon Publications; 2022:73–90.
21. Demaerschalk BM, Berg J, Chong BW, et al. American Telemedicine Association: telestroke Guidelines. *Telemed E-Health*. 2017;23(5):376–389. doi:10.1089/tmj.2017.0006
22. Adeoye O, Nyström K, Yavagal DR, et al. Recommendations for the Establishment of Stroke Systems of Care: a 2019 Update. *Stroke*. 2019;50(7). doi:10.1161/STR.0000000000000173.
23. Dutta D, Kendall J, Holmes C, et al. Evaluation of a Telephone Advice System for Remote Intravenous Thrombolysis in Ischemic Stroke. *Stroke*. 2015;46(3):867–869. doi:10.1161/STROKEAHA.114.008190
24. Fong WC, Ismail M, Jwt L, et al. Telephone and Teleradiology-Guided Thrombolysis Can Achieve Similar Outcome as Thrombolysis by Neurologist On-site. *J Stroke Cerebrovascular Dis*. 2015;24(6):1223–1228. doi:10.1016/j.jstrokecerebrovasdis.2015.01.022
25. Nardetto L, Dario C, Tonello S, et al. A one-to-one telestroke network: the first Italian study of a web-based telemedicine system for thrombolysis delivery and patient monitoring. *Neurol Sci*. 2016;37(5):725–730. doi:10.1007/s10072-016-2569-y
26. Mazighi M, Meseguer E, Labreuche J, et al. TRUST-tPA trial: telemedicine for remote collaboration with urgentists for stroke-tPA treatment. *J Telemed Telecare*. 2017;23(1):174–180. doi:10.1177/1357633X15615762
27. Harvey J, Al Kasab S, Almallouhi E, et al. Door to needle time and functional outcome for mild ischemic stroke over telestroke. *J Telemed Telecare*. 2019;25(6):365–369. doi:10.1177/1357633X18774460
28. Martínez-Sánchez P, Miralles A, Sanz de Barros R, et al. The effect of telestroke systems among neighboring hospitals: more and better? The Madrid Telestroke Project. *J Neurol*. 2014;261(9):1768–1773. doi:10.1007/s00415-014-7419-3
29. Raulot L, Mione G, Hoffmann CP, et al. Intravenous thrombolytic therapy for ischemic stroke via telemedicine compared with bedside treatment in an experienced stroke unit. *Eur Res Telemed*. 2015;4(4):119–125. doi:10.1016/j.eurtel.2015.09.001
30. Al Kasab S, Harvey JB, Debenham E, Jones DJ, Turner N, Holmstedt CA. Door to Needle Time over Telestroke—A Comprehensive Stroke Center Experience. *Telemed E-Health*. 2018;24(2):111–115. doi:10.1089/tmj.2017.0067
31. Bladin CF, Cadilhac DA. Effect of Telestroke on Emergent Stroke Care and Stroke Outcomes. *Stroke*. 2014;45(6):1876–1880. doi:10.1161/STROKEAHA.114.003825
32. Kaminsky AL, Mione G, Omorou Y, et al. Outcome of patients with large vessel occlusion stroke after first admission in telestroke spoke versus comprehensive stroke center. *J Neurointerv Surg*. 2020;12(8):753–757. doi:10.1136/neurintsurg-2019-015342
33. Phuyal S, Poudel R, Shrestha GS, et al. Endovascular management of acute ischaemic stroke in Nepal. *Lancet Glob Health*. 2020;8(5):e635–e636. doi:10.1016/S2214-109X(20)30071-1
34. Sairanen T, Soinila S, Nikkanen M, et al. Two years of Finnish Telestroke. *Neurology*. 2011;76(13):1145–1152. doi:10.1212/WNL.0b013e318212a8d4
35. Lazarus G, Permana AP, Nugroho SW, Audrey J, Wijaya DN, Widyahening IS. Telestroke strategies to enhance acute stroke management in rural settings: a systematic review and meta-analysis. *Brain Behav*. 2020;10(10):e01787. doi:10.1002/brb3.1787
36. Tunkl C, Agarwal A, Ramage E, et al. Telemedicine networks for acute stroke: an analysis of global coverage, gaps, and opportunities. *Int J Stroke*. 2024;20(3):297–309. doi:10.1177/17474930241298450
37. Kim J, Tan E, Gao L, et al. Cost-effectiveness of the Victorian Stroke Telemedicine program. *Aust Health Rev*. 2022;46(3):294–301. doi:10.1071/AH21377
38. Tan E, Gao L, Tran HN, Cadilhac D, Bladin C, Moodie M. Telestroke for acute ischaemic stroke: a systematic review of economic evaluations and a de novo cost–utility analysis for a middle income country. *J Telemed Telecare*. 2021;30(1):18–30. doi:10.1177/1357633X211032407

39. Chaffin HM, Nakagawa K, Koenig MA. Impact of Statewide Telestroke Network on Acute Stroke Treatment in Hawaii. *Hawaii J Health Soc Welf*. 2019;78(9):280–286.
40. Agarwal S, Day DJ, Sibson L, et al. Thrombolysis Delivery by a Regional Telestroke Network—Experience From the UK National Health Service. *J Am Heart Assoc*. 2014;3(1). doi:10.1161/JAHA.113.000408.
41. Lin CH, Lee KW, Chen TC, et al. Quality and safety of Telemedicine in acute ischemic stroke: early experience in Taiwan. *J Formos Med Assoc*. 2022;121(1):314–318. doi:10.1016/j.jfma.2021.04.024
42. Vishnu VY, Bhatia R, Khurana D, et al. Smartphone-Based Telestroke Vs "Stroke Physician" led Acute Stroke Management (SMART India). *Ann Indian Acad Neurol*. 2022;25(3):422–427. doi:10.4103/aian.aian_1052_21
43. Sharma S, Padma MV, Bhardwaj A, Sharma A, Sawal N, Thakur S. Telestroke in resource-poor developing country model. *Neurol India*. 2016;64 (5):934–940. doi:10.4103/0028-3886.190243
44. Venketasubramanian N, Yudiarto FL, Tugasworo D. Stroke burden and stroke services in Indonesia. *Cerebrovasc Dis Extra*. 2022;12(1):53–57. doi:10.1159/000524161
45. Mong R, Tiah L, Wong M, Tan C. Improving telestroke treatment times through a quality improvement initiative in a Singapore emergency department. *Singapore Med J*. 2019;60(2):69–74. doi:10.11622/smedj.2018083
46. Baratloo A, Rahimpour L, Abushouk AI, Safari S, Lee CW, Abdalvand A. Effects of Telestroke on Thrombolysis Times and Outcomes: a Meta-analysis. *Prehospital Emergency Care*. 2018;22(4):472–484. doi:10.1080/10903127.2017.1408728
47. Herpich F, Rincon F. Management of Acute Ischemic Stroke. *Crit Care Med*. 2020;48(11):1654–1663. doi:10.1097/CCM.0000000000004597