The Application of Technological Intervention for Stroke Rehabilitation in Southeast Asia: A Scoping Review With Stakeholders' Consultation

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Background: The technological intervention is considered as an adjunct to the conventional therapies applied in the rehabilitation session. In most high-income countries, technology has been widely used in assisting stroke survivors to undergo their treatments. However, technology use is still lacking in Southeast Asia, especially in middle- and low-income countries. This scoping review identifies and summarizes the technologies and related gaps available in Southeast Asia pertaining to stroke rehabilitation.

Methods: The JBI manual for evidence synthesis was used to conduct a scoping study. Until September 2021, an electronic search was performed using four databases (Medline, CINAHL, Scopus, ASEAN Citation Index). Only the studies that were carried out in Southeast Asia were chosen.

Results: Forty-one articles were chosen in the final review from 6,873 articles found during the initial search. Most of the studies reported the implementation of technological intervention combined with conventional therapies in stroke rehabilitation. Advanced and simple technologies were found such as robotics, virtual reality, telerehabilitation, motion capture, assistive devices, and mobility training from Singapore, Thailand, Malaysia, and Indonesia. The majority of the studies show that technological interventions can enhance the recovery period of stroke survivors. The consultation session suggested that the technological interventions should facilitate the needs of the survivors, caregivers, and practitioners during the rehabilitation.

Conclusions: The integration of technology into conventional therapies has shown a positive outcome and show significant improvement during stroke recovery. Future studies are recommended to investigate the potential of home-based technological intervention and lower extremities.

Keywords: technological intervention, rehabilitation, developing countries, low-middle income countries, developed countries, Southeast Asia, cerebrovascular accident

INTRODUCTION

Strokes or a cerebrovascular accident (CVA) is caused by the blockage or bursting of the cerebral blood vessels—the leading cause of neurological disorder globally (1). Stroke is one of the most common non-communicable diseases worldwide, especially in Asia (2, 3). In high-income regions of Asia Pacific, North America, East, and Southeast Asia, those aged 50–64 years have the highest prevalence rates of both ischemic and hemorrhagic stroke (2). According to the World Health Organization (WHO), stroke or cerebrovascular accidents are the second leading cause of death and the third leading cause of the disabilities (3–5). Aldehaim et al. (6) also stated that 40% of those who survived a stroke experience a physical disability that needs special treatment, and another 10% of them end up in a nursing home or other long-term rehab centres. Caring for stroke survivors can be depressing and burdensome, and it may affect the well-being of both survivors and caregivers.

The Southeast Asia region with the size of over 4.5 million km^2 constitute of low-income (Myanmar, East Timor, Cambodia, Laos), middle-income (Vietnam, Philippines, Indonesia, Thailand, Malaysia), and high-income (Brunei, Singapore) countries (2–7). The region is heavily populated with a population of nearly 700 million people and the area is diverse in terms of ethnicity and culture, but it also shares similarities in dietary, climate, and lifestyle (2, 3, 8). In terms of stroke prevalence, Indonesia is at 8.0, the Philippines is at 9.0, Singapore is 36.5 (>45 years old), Thailand (18.8 for >45 years old), Vietnam (6.1), and Malaysia (7.0) for every 1,000 population (2). Stroke is a major public health problem because it is the predominant cause of physical impairment and disability among adults (9).

Stroke recovery treatment or rehabilitation typically requires conventional therapy, where it is labor intensive involving therapist-clients education and training (10). Rehabilitation is a goal-oriented process that helps people with disabilities reach their full potential in emotional, physical, cognitive, social, and functional skills (11, 12). Rehabilitation physicians, occupational therapists, physiotherapists, speech therapists, rehabilitation nurses, and medical social workers are among the healthcare professionals involved (13, 14). Generally, the rehabilitation process may take place in various settings, including inpatient, outpatient, group, and home-based (15–18). The survivor's period of recovery from stroke depends on the stroke's severity stage, and usually, the treatment starts once the main cause of stroke has been diagnosed (13).

The rehabilitation treatment is essential for stroke survivors to achieve the highest level of functional independence, reducing or preventing the impairments (11). However, this process could be time-consuming and will lead to extra costs. The cost is described as medical procedure on ancillary or referral and an idea of loss of productivity and the costs generated from the recovery processes (8). This fact has become a critical issue to both health practitioners and clients. Thus, due to these scenarios, technological solutions could be the beneficial adjunct and alternative toward the existing conventional method or therapy, making it more accessible to everyone.

In addition, the technological intervention provides access to rehabilitation services for those facing physical, financial, and attitudinal barriers.

Most developed countries implement the technology in rehabilitation therapy as an initiative to help stroke survivors during their recovery period other than focusing only on conventional therapy (19, 20). It is known that the recovery process can be varied depending on several factors such as the client's impairment level, the therapy intensity and access, or the individual activity and participation. Technological interventions such as robotics, video-based therapy, teleconferencing, virtual reality, and assistive devices are more commonly explored and utilized in developed countries, mainly due to their readiness and availability (21, 22).

However, the extent of technology use in low-and middle-income countries is uncertain as it is not explored comprehensively. Therefore, this scoping review aims to systematically identify and review the evidence of using technological intervention combined with conventional therapy or traditional methods in helping the recovery period of stroke survivors. The efficacy of rehabilitative interventions is investigated and discussed according to technological clusters or categorizations.

METHODOLOGY

The framework consists of seven consecutive stages following the Joanna Briggs Institute (JBI) framework (23): (i) developing the review question, (ii) defining inclusion and exclusion criteria, (iii) conducting a search strategy, (iv) evidence screening and study selection, (v) data extraction, (vi) data analysis, and (vii) presentation of results. Each stage is discussed further in the following subtopics, and the Preferred Reporting Items for Systematic Reviews and Meta-analysis extension for scoping reviews (PRISMA-ScR) (24) (**Supplementary Table 1**) was adopted as a guideline for the report of the scoping review.

Developing a Review Question

The study adopted the Population-Concept-Context (PCC) framework (25) to determine the research question's extent. The population is stroke survivors, and the concepts are the implementations of the technological intervention in stroke rehabilitation. The context of this study is focused on the Southeast Asia region. This scoping review was developed based on the question, "What are the technologies and gaps available in Southeast Asia pertaining to stroke rehabilitation?"

Defining Inclusion and Exclusion Criteria

Studies considered to be included in this scoping review when they fulfill the following criteria:

(i) Stroke rehabilitation as defined by Young and Forster (26) as using a mixture of a therapeutic and problem-solving approach to limit the impact of stroke-related brain damage on daily life,

(ii) Utilizing technology as a medium of therapy or rehabilitation delivery. Technology is a broad term that refers to how

one uses and understands the instruments and craft and how it affects the ability to control and adapt to the social and physical environment. It can also refer to physical objects that people use, such as computers, hardware, or utensils, but may also lead to broader themes such as structure, organizational methods, and techniques. Meanwhile, rehabilitation technology uses technology to meet the needs of people with disabilities. It helps cut the barriers and gives more opportunity to people with disabilities in education, rehabilitation, employment, living at home, and recreation.

(iii) The technology investigated is either for the stroke survivors or people surrounding them (i.e., family members, caregivers) or anybody that deals with the stroke cases,

(iv) The study is conducted in Southeast Asia, and

(v) Any study design (i.e., case study, qualitative study, quantitative survey, experiment) and setting (i.e., clinical, community, institution) are eligible to be included.

Meanwhile, exclusion criteria are as follows: (i) Non-English, (ii) gray literature (i.e., thesis, dissertation, book), (iii) non-original or review study (i.e., letter to editor, literature review, protocol), and (iv) no full text available (i.e., conference abstracts). The exclusion of non-English and gray literature is expected to have minimal impact on the findings (27, 28).

Conducting a Search Strategy

The electronics search was conducted using the following databases: MEDLINE, CINAHL, Scopus, MyCite, and ASEAN Citation Index on 30th November 2019 and last updated on 22nd September 2021. The keywords used are related to strokes and its associated terminologies (e.g., cerebrovascular accidents, CVA), rehabilitation (including physiotherapy, occupational therapy, speech therapy, etc.), and Southeast Asia (including each name of the countries members). Boolean operators, parenthesis, exact, and wildcards were used when necessary. Search string used was ("cerebrovascular accident" OR "CVA" OR "stroke") AND ("rehabilitation" OR "therapy" OR "therap*" OR "occupational therapy" OR "physiotherapy" OR "physical therap*" OR "speech therap*") AND ("Southeast Asia" OR "Malaysia" OR "Singapore" OR "Thailand" OR "Indonesia" OR "Brunei" OR "East Timor" OR "Cambodia" OR "Myanmar" OR "Vietnam" OR "Laos" OR "Philippines") on those four databases.

Evidence Screening and Study Selection

The titles and abstracts were independently reviewed by two authors (SNSS and HAA), and the eligibility of the studies for inclusion was based on the previously mentioned criteria. Any conflicts between the two authors were resolved through discussions for each article. Studies were included in the first screening stage (titles plus abstract) if any of the two authors agreed that they were eligible for inclusion or if there was a dispute about whether to exclude them. Studies were included in the second screening stage (full text) when both authors agreed to match all the inclusion criteria. When contradictory studies were detected during the full-text screening, an independent arbitrator (MHR) an author with a healthcare background, was consulted.

The two authors' pre-consensus agreement on the included full-text articles was calculated using percentages. Because a critical appraisal of each study is not required for scoping reviews, no quality evaluation was carried out.

Data Extraction

The summary of all the study details, including the citation, nation, study objective, design, setting, interventions, and findings, was presented in a matrix table. The technological intervention was then classified either as advanced or simple.

Data Analysis

The findings obtained from the review were summarized into observational studies, intervention studies, and qualitative studies. The review syntheses were integrated with the stakeholders' consultation session described extensively in the next section. All the data on the efficacious and validity of using the technological intervention in stroke rehabilitation in Southeast Asia was documented.

Consultation

As part of the data analysis, stakeholders were invited to engage in a roundtable discussion or known as consultation. The discussion-like exercise aims to identify stakeholders' priorities and questions to guide the literature review (2). The session with the stakeholders mimics a qualitative research design on FGD session (29) but could be not rigorous as it is a complementary step in a scoping review (30). Six stakeholders were recruited from various fields to provide richness and expertise contribution. Prior to the discussion, all the participants gave their informed consent. The six stakeholders chosen were an industrial designer ($n = 1$), an ergonomist ($n = 1$), an engineer ($n = 1$), a physiotherapist ($n = 1$), an occupational therapist ($n = 1$) and a physiatrist ($n = 1$). The consultation session was done virtually via the Zoom teleconference platform. Each participant was given a summary of the preliminary findings of this scoping review and a set of open-ended questions to guide the discussions; (i) What is the current practice of technology-use intervention compared to the gathered literature? (ii) What is the perception of the efficacy of technologies used in stroke rehabilitation? (iii) What is the perception of implementing technologies as a medium of intervention for stroke rehabilitation? and (iv) What improvements and suggestions can be provided for technology-based application for stroke rehabilitation intervention? The discussion was conducted in pidgin languages which were convenient to the participants. The whole session was recorded using a voice recorder and through note-taking. The qualitative data were analyzed by developing a coding excerpt from the session. The themes were generated and selected by comparing with review findings and discussions among the authors. One session was conducted and required two and a half hours to complete.

Presentation of the Results

The findings were reported narratively, and the literature and stakeholders' consultation information were synthesized. The narrative review is sequenced in themes generated among the

FIGURE 1 | Screening process flowchart.
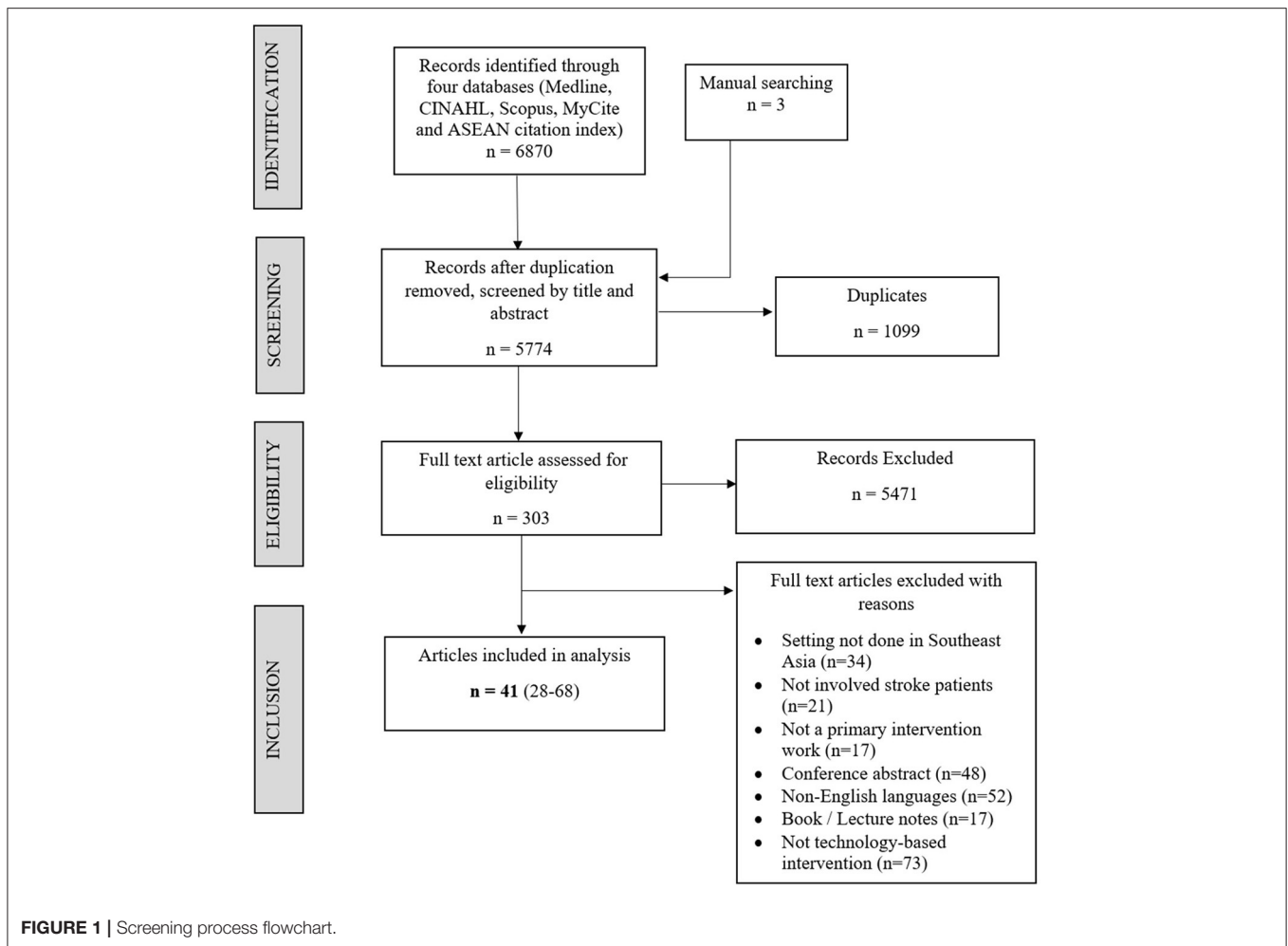
authors. The result is combined with external literature—not only from the systematic searching inclusion, to enhance the understanding and synthesis.

RESULTS

The initial search yielded a total of 6,873 citations from five electronic databases, and three additional manually founded citations based on **Figure 1**. The reasons for excluding the articles during the full-text screening are provided in **Figure 1**. From the screening process, a total of 41 studies (31–71) met the eligibility requirements and were included in this scoping analysis, as summarized in **Supplementary Table 1**.

A total of 1,470 participants participated from the selected 41 studies with different impairments, types, and stages of stroke severity. The data was narratively summarized according to a pre-defined theme on survivors' diagnosis, rehabilitation intervention available in recovery sessions, and stroke survivors' intervention. The theme was established through discussions among researchers, who compared the findings of various studies. The review's findings were combined with the stakeholders' consultation support.

Characteristics of Included Studies

The studies found were in the following countries: Singapore ($n = 25$) (31, 34, 35, 38, 39, 42, 44–46, 48–54, 56–58, 64–69), Thailand ($n = 10$) (32, 33, 36, 41, 43, 47, 51, 59, 61, 63), Malaysia ($n = 5$) (37, 40, 55, 68, 71), Indonesia ($n = 1$) (62) and no study were found from Myanmar, Vietnam, Philippines, Laos, Brunei, East Timor and Cambodia. All the included studies were written in the English language. The studies were published between 2009 until 2021. From the 41 articles, there are randomized-controlled studies ($n = 18$), clinical studies ($n = 7$), case report ($n = 2$), an experimental study ($n = 2$), a crossover study ($n = 1$), a pilot study ($n = 7$), an open-labeled study ($n = 2$) and a qualitative study ($n = 2$). Thirty-two studies ($n = 32$) were conducted in the hospitals and the remaining nine ($n = 9$) were conducted in the community.

Types of Technological Intervention in Southeast Asia

The most complex or newest technology accessible in post-stroke rehabilitation can also be referred to as advanced technological intervention (72, 73). Simple technology is referred to as

traditional or non-mechanical, such as crafts and tools that pre-date the Industrial Revolution 4.0 concept (74–77). The simple technology can be practiced or fabricated with a minimal capital investment by an individual, and a single individual's knowledge of the practice can be comprehended (77).

Advanced Technological Intervention

The study has classified six ($n = 6$) types of advanced technological intervention for post-stroke rehabilitation, which are robotics, transcranial magnetic stimulation (TMS), transcranial direct current stimulation (tDCS), motion analysis, motion capture, and virtual reality.

Robotics

Modern robotics have made tremendous progress and contribution to healthcare as they can help physicians perform various tasks (74–80). Robotic adoption is increasing tremendously in hospitals—robotics help regain and improves the function in both upper and lower extremities. In this scoping review, seven ($n = 7$) studies (31, 35, 42, 45, 47, 62, 67) were identified that implemented the robot-assisted therapy intervention in helping the survivors regain their abilities to the highest level of independence. Robotics technology found in the literature include: MIT-Manus robot coupled with EEG-based MI-BCI, a combination of EEG-based MI-BCI Haptic Knob robotic rehabilitation, a robotic exoskeleton with EMG signal, a Haptic Knob rehabilitation robot, and a soft robotic glove both focuses on grasping assistance. All the robotics mentioned before focus on upper extremities rehabilitation. From the studies mentioned, six ($n = 6$) studies (31, 35, 42, 45, 47, 67) showed that the use of robotics was effective in helping stroke survivors, while only Utomo et al. (62) reported that the use of the robotic is not effective for short-term rehabilitation. Medical robots are extremely useful in assisting physicians. However, being professionally trained to work with the medical robots and for the robot to fully respond to the clinician's instructions are somewhat time-consuming and require continuous training (81).

Transcranial Magnetic Stimulation

In the TMS method, magnetic impulses were sent through the skull to stimulate the brain. The treatments have shown promising results in improving the upper extremities in stroke survivors (82, 83). Three ($n = 3$) studies (41, 51, 60) included in this scoping review reported the use of TMS as a treatment to help stroke survivors. Most of the survivors who completed the entire course of this treatment experienced an improvement in their impairments after 6 months of treatment (51). The treatment used was able to help the stroke survivors to recover their movement and brain function. All the studies included here implemented this technology to treat upper-limb impairment (shoulder to hand). The results show that TMS may enhance the paretic arm reach-to-grasp performance on the non-lesioned hemisphere. From the studies mentioned, it is found that two ($n = 2$) studies (41, 51) had shown that using the TMS method is helpful for stroke survivors. Although most of the studies had shown the effectiveness of using the TMS method, a study

from Tretriluxana et al. (60) shows that this intervention is only applicable toward the smaller objects when using the reach-to-grasp (RTG) action.

Transcranial Direct Current Stimulation

From the past three decades, tDCS has become an increasingly popular technique in rehabilitation treatment (84). The use of tDCS in stroke research has gained particular interest, because both online and offline effects of tDCS can improve functional outcomes (85, 86). In the tDCS technique, a mild electrical current travel through the skulls and stimulates the brain. This treatment can help the survivors recover their movement from stroke and other conditions. Seven ($n = 7$) studies (38, 46, 56, 59, 63, 69, 71) in this scoping review found that this technique did improve the recovery process. Majority (38, 46, 56, 63, 71) showed positive results in both upper and lower limb functions, except two ($n = 2$) studies (59, 69). These two studies reported that tDCS does not increase the motor activity on lower limb muscles and gait performance and does not improve any motor function in stroke survivors.

Motion Analysis [Motor Imagery Brain-Computer Interface (MI-BCI), Electroencephalogram (EEG), and Electrocardiograms (ECG)]

Motion analysis captures the video of the human motion with specialized computer software that analyses the motion in detail. This technique provides the healthcare practitioner with a detailed picture of a person's specific movement challenges to guide proper therapy. In this scoping review, nine ($n = 9$) studies (38, 39, 45, 46, 48, 56, 62, 64, 69) implemented this treatment with stroke survivors. Most studies (39, 45, 46, 56, 64) have shown a tremendous enhancement on the upper limb rehabilitation treatment with this technique, except for two studies (62, 69). The intervention is less effective for short-term improvement on lower-limb function (62), similar to the single conventional intervention (69).

Motion Capture

Motion capture is a technique that involves using technology capable of recording and determining the location of points on an actor's body in a particular amount of time (87). A motion capture device is required to precisely monitor participants' movement, to allow physicians to deliver therapeutic advice based on observable data (88). It typically occurs by using a costume or other similar device, which the actor should dress him or herself (87). Only three ($n = 3$) studies (34, 50, 70) included in this scoping review used motion capture as a strategy for stroke recovery, such as Nintendo Wii. All the studies mentioned above show that motion capture in the rehabilitation setting could enhance the conventional therapy in upper limb subacute and chronic stroke survivors. The studies showed much potential as an adjunct therapy in upper limb stroke recovery and can be employed effectively in an acute inpatient environment.

Virtual Reality

Virtual reality has emerged as a therapeutic tool facilitating motor learning for balance and gait rehabilitation (89–91). The survivors can retrain themselves to perform the motions within a virtual environment (92). The use of VR-based therapy could provide a positive learning experience while at the same time could be engaging and motivating. Besides, VR applications have a huge potential for education and training purposes since the simulation can be conducted repeatedly which could not be replicated in a real-world application (93). This offers a significant advantage over conventional training. From the included studies in this scoping review, seven ($n = 7$) studies (39, 40, 44, 50, 53, 55, 57) implemented VR intervention combined with the conventional method for the rehabilitation treatment. Five ($n = 5$) studies demonstrate that the combined intervention has improved both upper limb function and lower limb postural standing balance, while only two ($n = 2$) studies (40, 53) show the opposite result. Both studies stated that this technology does not necessarily enhance physical function or improve the upper extremity recovery in stroke survivors.

Simple Technological Intervention

Simple technological intervention can also refer to a system or equipment that is non-battery powered and relatively easier to fabricate (61). This technology is affordable, adaptable, easily managed, and only uses little energy and resources to stay entirely environmentally friendly. The study has identified three ($n = 3$) types of simple technological interventions for post-stroke rehabilitation, which are telerehabilitation, simple tech assistive technologies (AT), and gait training (GT).

Telerehabilitation

Telerehabilitation, commonly referred to as tele-therapy or tele-stroke, is information and telecommunications technology that allows clients to get medical care from doctors located remotely (76). It is one of the distance-supporting therapies to help both survivors and caregivers. Five ($n = 5$) studies (37, 52, 65, 66, 68) were identified in this scoping review explored telerehabilitation as the technological aid to help the clients in rehabilitation. These studies (37, 52, 68) show that the application of telerehabilitation is effective as an adjunct to the rehabilitation process because it is comfortable and easy to be used, which contributes to the stroke recovery process. In addition, telerehabilitation could be a promising solution in stroke rehabilitation since this technology may simulate autonomous repetitive practice to improve the health outcome (65, 66). The telerehabilitation technologies used in the studies were video-based therapy, a smartphone with ECG-recording, and videoconferencing with tele-therapists.

Low-Tech Assistive Technology

Equipment used to increase, maintain or improve the functional capabilities of individuals with disabilities in all aspects of life, including at work, home, or in the community-dwelling is referred to as assistive technology (AT) (32, 61). Whereas low-tech assistive technology or low-tech AT is defined as devices or equipment that do not require much training, inexpensive, and do not have complex or mechanical features (32). Low-tech AT differs from high-tech AT because it does not require the use of a power source (36). There are three studies ($n = 3$) (32, 36, 61) identified to use low-tech AT, such as light touch and force contact cane, insole shoe wedges, and a new multidirectional reach tool. The use of this simple technological intervention has shown a progressive effect to improve the stability and balance of stroke survivors. Integration of low-tech AT toward conventional training is suggested to enhance gait speed, standing and walking symmetry, and balance. In addition, low-tech AT is considered an alternative and inexpensive tool for balance training in stroke rehabilitation treatment (61).

Gait Training (Treadmill Training)

Gait analysis measures movement in various situations, making it significant and helpful in numerous applications such as rehabilitation activities, sports training, and identifying problems, among others (80). Walking speed, body-weight-bearing abilities, and balance have all improved because of the training. The training allows therapists to track oxygen uptake, which helps the cardiovascular health assessments (94). It aids in treating neurophysiological problems and the stimulation of paretic muscles. Treadmill training was used in two ($n = 2$) studies (49, 54) to assist stroke survivors in their rehabilitation sessions. A variable automated speed and sensing treadmill (VASST) was adopted for chronic stroke by Chua et al. (49) and this technique was proven to be beneficial, safe, and practicable to use. In contrast to another study (54), the combination of electromechanical gait trainers (GT) and conventional therapy has the same effect on stroke survivors' ambulation and health status than conventional therapy alone. As a result, there is no significant difference compared to merely using conventional treatments.

Stakeholder's Consultation

The stakeholders involved were from two major disciplines i.e., technical sciences (industrial designer, engineer) and health sciences (physiatrist, occupational therapists, and physiotherapist). Findings from the stakeholders' discussion are summarized below.

The current method implemented in stroke rehabilitation or stroke recovery process is mostly conventional methods. The technological intervention is said to be an adjunct to the current conventional therapies where it can be implemented to help stroke survivors to recover faster. In Southeast Asia countries, however, especially in the less developed nations, there is still a lack of technological interventions applied for rehabilitation purposes even in the tertiary hospitals.

In addition, the intervention implemented should be able to motivate the stroke survivors during the rehabilitation session and give meaningful outcome to them. The technological intervention also needs to reduce the labor costs of stroke rehabilitation, while simultaneously allow the survivors to undergo their treatments with minimum supervision. In some cases, however, survivors tend to rely entirely on the interventions and become too dependent on the therapy, which eventually causes other impairments to occur. If this happens,

the technological intervention is not much different from the conventional method and could be neglected. The appropriate technological intervention to be implemented should be flexible and not limited to only specific functional impairment and easy to be learned by the practitioners and caregivers.

On the other hand, technological intervention in rehabilitation might bring challenges to both practitioners and survivors. For example, the survivors need to be fully assisted during the rehabilitation session when using the advanced technological intervention at the hospitals. It is preferred for the technological intervention with long and continuous practice to be carried out as a home-based therapy to improve the recover process. The technology-based therapy is recommended to be applicable toward most stroke survivors with various stages or severities, and diverse functional impairments. Moreover, the technology should be intuitive, interesting and attractive in terms of functionality and physical appearance to encourage the continuous use (95).

From the consultation session, it can be concluded that the technological interventions are expected to facilitate the needs of survivors, practitioners, and caregivers during the rehabilitation. The intervention should also be user-friendly, safe to use, and easily operated by the clients and healthcare practitioners. In addition, most of the existing interventions found in Southeast Asia were classified as high-tech interventions, and the clients are required to attend the therapy session in the hospital or rehab center. This adds to the financial burden of the survivors and their families. Therefore, it is highly recommended to make full use of the current advanced technology to help reduce the recovery period and provide a more affordable home-based technological intervention for post-stroke rehabilitation.

DISCUSSIONS

This scoping review addresses a new research area related to the technological therapy implemented in stroke rehabilitation for stroke survivors in Southeast Asia. It provides a comprehensive understanding of this topic and has identified the critical gaps. The consultation session conducted with the stakeholders provides additional value to the review. According to a framework designed by Arksey and O'Malley (96), a review can be improved, and the findings generated are more valuable when practitioners and consumers contribute to the work in the consultation session (97).

The main goal of rehabilitation is to help stroke survivors be as independent as possible and attain the best quality of life (98). The treatment receives by the stroke survivors is to help them relearn the lost skills when part of the brain is damaged. These skills may include coordinating the leg movements to regain walking ability or teaching survivors new ways of performing tasks by complementing the remining disabilities (99). There is a strong consensus among the rehabilitation experts that the most important element in any rehabilitation programme is for the stroke survivors to be carefully directed, well-focused, and perform a continuous practice (100).

From the past decade, new technology is constantly changing the rehabilitation arena. Technological treatment is helping in neuroplasticity and learning progress i.e., the key in the recovery process of stroke (94). Moreover, the technological treatment gives clients more repetitions, practice time, and intensity than the conventional method.

The Lack of Technology Utilization

It is pertinent that many countries in Southeast Asia build rehabilitation centres to benefit in stroke rehabilitation treatment. However, most centres rely on conventional therapy rather than utilizing technology for rehabilitation. The critical factor to the lack of technology utilization in rehabilitation facilities is the dearth of urgency and emphasis for clinical rehabilitation by the policy-making authorities (101). The clients at the rehabilitative phase are often not in dire need than those in emergency trauma or requiring a lifesaving procedure (102). Besides, the lack of awareness among healthcare professionals toward advanced rehabilitation technology may influence the utilization of technology in rehabilitation facilities (103). The absence of active interest groups or society in promoting rehabilitation technology also hinders the awareness of the advantage of advanced rehabilitation equipment. Furthermore, conventional practices and manual therapy have long been accepted by therapists to be providing substantial benefits to clients (104). One of the purposes of using the technological intervention is to reduce the burden of stroke survivors' caregivers and families. However, if the cost of the technology is not proportional to the benefits obtained from its application, it will lead to financial burden for the stroke survivors and their family members. Thus, there is a need to ensure the cost-effectiveness of the interventions implemented for this purpose.

Country's Economic Status Influences the Implementation of Technological Interventions

Based on this scoping review, Singapore has reported the highest number of studies ($n = 25$) involving the advanced technological intervention implemented in stroke rehabilitation and followed by Thailand ($n = 10$), Malaysia ($n = 5$), and Indonesia ($n = 1$). In Southeast Asia, Singapore has rapidly developed from a low-income country to a high-income country (105) and has become another developed country after Brunei (106). Likewise, Thailand has made extraordinary social and economic development progress during the last four decades, shifting from a low-income to an upper-middle-income country in less than a generation (107). As a result, Thailand has become a reference for a nation's development success story, with robust growth and significant poverty reduction and significant social progress (107).

This paper reveals that the acceptance of technological advancement has a relevant correlation with the country's economic growth. This correlation is apparent when comparing the number of studies using technological interventions in stroke rehabilitation in Southeast Asia countries based on their

economic status. It justifies why Singapore has reported the most studies followed by other countries. Unfortunately, in low and middle-income countries, the technology for rehabilitation is not widely used, though there are attempts on its applications for therapeutic purposes (108, 109).

In this scoping review, most of the interventions used were advanced technologies and found mostly in the tertiary hospitals or the rehabilitation units. Besides, the stroke rehabilitation facilities available are platform-based. This could be somewhat inconvenient in terms of traveling and logistics, especially if the client stays far away from the health institutions. Due to this, the home-based therapies should at least offer compatible benefits and affordable in price. An overpriced technological aid causes a burden on survivors' caregivers and their family members, eventually demotivating them to continue the therapy sessions.

Further Promoting the Use of Technological Interventions in Stroke Rehabilitation

The mentioned technological interventions in the selected studies were mostly practical to be implemented as an adjunct to conventional therapy. However, in this scoping review, it is found that most of the technological interventions applied were focused on physical training, especially on the upper extremities, and only a few studies were meant for the lower extremities. When a person is diagnosed with a stroke, he/she usually experience difficulties in performing the activities of daily living (ADL) due to weakened mobility (110). A review by Hobbs & Artemiadis (111) suggested the exploration of other technologies for lower limb stroke rehabilitation—which were not found in this scoping review, such as on physical implementation (i.e., exoskeleton and powered orthoses) and targeted sensorimotor pathways (i.e., vision and auditory feedback, equilibrioception, cutaneous and haptic perception, inter-limb coordination mechanisms). Hence, it is necessary for the stroke survivors to perform repetitive lower limb exercises to help them regain the gait, balance, and overall mobility. This is, therefore, highlights the need to encourage more studies on technological intervention for lower extremity rehabilitation.

Equally important, more attention on other components such as cognitive, social, and emotional support using technology is required, as agreed by the previous review finding (2). There are several other technological advancements for rehabilitation that can be researched by referring to the international reviews, which include the use of information technology and apps for home-based, cognitive and caregivers' intervention (112–115), wearable devices for upper-limb, participation intervention (116, 117), and other emergence availability of the Industrial Revolution 4.0 and Internet of Things.

Another essential point, technological interventions reported in the reviewed studies mostly took place in hospitals and rehabilitation centres, with very few in the community-dwelling population. Traveling from home to the hospitals regularly for continuous therapy sessions could be burdensome, especially for rural areas (118). More importantly, the current coronavirus

(COVID-19) pandemic outbreak causes an urgent need to reduce hospital stays and visits (119). At this crucial time, stroke clients have been forced to be catered to as a lower priority to avoid overburdening the healthcare system (119, 120). Because of this, the clients' therapy sessions have been reduced as a result of physical distancing and this has indirectly affected the quality of care in stroke survivors. For the same reason, the technological intervention should be fundamentally safe, user-friendly, cost-effective, engaging and motivating. The home-based technological aids or devices can also be designed to be portable or even wearable to fit into a limited space. Furthermore, these devices or tools should be durable so that little maintenance is required over potentially long periods of use (119).

It is relevant to use technological intervention as an alternative method to provide clients with high-quality therapy to optimize long-term functional outcomes and promote stroke survivors' independence and quality of life. This is particularly for those who have difficulties traveling to the hospitals or rehabilitation facilities. Therefore, it is undoubtedly that there is an obvious need to further promote the integration of technological aids toward the conventional techniques in stroke rehabilitation, due to positive effect shown on the client's recovery period, a decrease of human labor intensive, reducing the traveling cost, and lessening the hospital visits.

Limitation

This scoping review has several limitations. Firstly, although the exclusion of gray literature gives a small impact, it may still be beneficial in controlling for the overestimation of conclusion (121), providing better coverage and wider evidence mapping (122). Hence, limited resources in terms of facility and access to gray literature, lack of expertise in searching such evidence, and lack of manpower and financial support have prevented our efforts from including the gray literature. Many publications are made available in English due to the lingua franca status and most of the findings from gray literature were also translated into journal publications for knowledge-sharing purposes (28). Nevertheless, this scoping review is still valuable and comprehensive in conveying the practice.

Secondly, during the stakeholders' consultation, some panels briefly raised the limitation on utilization and acceptance of technology in practice and limited client preferences. Nevertheless, although it is interesting to explore users' perspectives in understanding the use of technology and how it benefits them, it is beyond the scope of this scoping review.

CONCLUSION

Strokes cause survivors to live with severe disabilities that affect their daily activities due to paralysis and impaired balance and mobility. From the standpoint of rehabilitation, the clients must engage in an extensive and continuous therapeutic exercise for the recovery process. The conventional stroke rehabilitation techniques usually take longer for stroke survivors to fully recover since they rely on the therapy sessions and exercises conducted by the therapists. New rehabilitation techniques, such as constraint-induced, biofeedback, and robot-assisted therapy,

have evolved in recent years and have been embraced as an adjunct to conventional techniques.

The integration of technological intervention toward conventional therapies has shown a positive outcome to the survivor's post-stroke recovery process. This is indeed a better form of therapy especially during the pandemic, where face-to-face consultation is restricted, which at the same time encourages the survivors to undergo treatments. As a result, they could regain independence on mobility and perform the activities of daily living (ADLs). However, there are several gaps identified in this scoping review, which include the lack of studies on technological intervention toward lower extremities. Besides, most of the interventions were found in the hospitals and rehabilitation units, and only a few studies were done in the community-dwelling or home-based therapy. In addition, many technologies are still yet to be explored since this scoping review only covers Southeast Asia countries and the technologies available are predominated by prosperous countries. International references and collaborations should be further encouraged to promote the use latest technological advancements. Nevertheless, this scoping review reveals that the utilization of technologies in stroke rehabilitation has begun to be acknowledged and established in Southeast Asia.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/**Supplementary Material**, further inquiries can be directed to the corresponding author/s.

AUTHOR CONTRIBUTIONS

The inclusion/exclusion criteria and search strategy were developed under the supervision of MR and RC. The search in the databases was carried out by SS, HA, and MR who also led the writing of the methodology section in the manuscript. SS, RC, HA, and MR worked together on data analysis and manuscript writing. SS, MS, and HR contributed information on the direction of the data analysis and revised continuous amendments of the manuscript draft. The final manuscript was read and approved by all the authors.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2021.783565/full#supplementary-material

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