Original Article

Effectiveness of A Newly Developed Comprehensive Rehabilitation Service Model for Subacute Stroke Patients: A Quasi-Experimental Study at A Tertiary Care Hospital in Northern Thailand

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ABSTRACT

Objectives: To evaluate the effectiveness of a newly developed comprehensive rehabilitation service model for patients with subacute stroke at a tertiary care hospital in Northern Thailand

Study design: A quasi-experimental study with pretest-posttest control group design

Setting: Department of Rehabilitation Medicine, Uttaradit Hospital, a 680-bed tertiary care hospital serving as a regional referral center in Northern Thailand

Subjects: One hundred and fifty-four patients (77 per group) with first-ever stroke, aged 18-80 years, admitted 2-6 weeks post-onset between January and December 2021, with Modified Rankin Scale scores 2-4

Methods: The intervention group received a 12-week comprehensive rehabilitation program including (1) intensive, multidisciplinary rehabilitation (3 hours/day, 5 days/week), (2) structured caregiver education and training, (3) technology-assisted home-based rehabilitation with telemedicine support, (4) regular multidisciplinary team review and care plan adjustment. The control group received standard rehabilitation care. The primary outcome measure was Barthel Index (BI) score. Secondary outcome measures included the Stroke Impact Scale (SIS), Hospital Anxiety and Depression Scale (HADS), EuroQol 5-Dimension (EQ-5D) quality of life assessment, and Modified Caregiver Strain Index (MCSI).

Results: At 12 weeks, the intervention group showed statistically significantly greater improvement in BI scores (mean difference 11.4, 95%CI: 6.8-16.0, $p < 0.001$), SIS scores (mean difference 15.6, 95%CI: 10.2-21.0, $p < 0.001$), HADS scores (mean difference -3.2, 95%CI: -4.8 to -1.6, $p = 0.003$), EQ-5D index (mean difference 0.15, 95%CI: 0.08-0.22, $p < 0.001$), MCSI scores (mean difference -6.4, 95%CI: -9.1 to -3.7, $p < 0.001$). These participants maintained their improvement at a 6-month follow-up.

Conclusions: The newly developed comprehensive rehabilitation service model significantly improved functional independence, quality of life, psychological well-being, and reduced caregiver burden in patients with subacute stroke compared to standard care. This model demonstrates the clinical and cost-effectiveness in a Thai healthcare setting, supporting its potential for broader implementation in similar settings.

Keywords: stroke rehabilitation, subacute care, multidisciplinary care, telemedicine, caregiver training

ASEAN J Rehabil Med. 2025; 35(2): 76-83.

Introduction

Stroke remains a leading cause of disability and mortality worldwide, significantly impacting patients' quality of life and placing substantial burdens on healthcare systems and families.[1] In Thailand, the age-standardized prevalence of stroke is 1.88% (95%CI: 1.83-1.92), with approximately 250,000 new cases annually. The estimated economic burden exceeds 50 billion THB (approximately US$1.4 billion) annually, highlighting the urgent need for effective rehabilitation strategies.[2] The subacute phase, typically spanning from 2 to 6 weeks post-stroke onset, represents a critical window for rehabilitation interventions due to heightened neuroplasticity and potential for recovery.[3]

The existing stroke rehabilitation system in Thai public hospitals faces several significant challenges. A critical issue is the limited availability of rehabilitation personnel, with an average ratio of one physiotherapist per 50-100 stroke patients.[4] Care delivery is often fragmented, characterized by poor coordination between departments and insufficient rehabilitation intensity, typically consisting of only 30-45 minutes per session, 2-3 times per week.[5] Furthermore, inadequate caregiver training and limited follow-up care after discharge contribute to suboptimal functional recovery and high readmission rates, approximately 25.0% within 30 days.[6] These systemic limitations result in increased caregiver burden, poor community reintegration, and escalating long-term healthcare costs.[7]

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Received: August 1, 2024 Revised: November 22, 2024 Accepted: November 27, 2024

To address these challenges, a multidisciplinary team at Uttaradit Hospital, a 680-bed tertiary care facility, conducted a comprehensive review of existing practices and developed an innovative rehabilitation model.[8] The development process of the new model involved multiple stakeholders, including rehabilitation physicians, nurses, therapists, social workers, and hospital administrators. Through systematic analysis of service gaps and stakeholder interviews,[9] the team integrated international best practices with locally appropriate solutions, including technology-assisted care coordination[10] and standardized protocols for seamless care transitions between hospital and community settings.[11]

The primary objective of this study is to evaluate the effectiveness of this newly developed comprehensive rehabilitation service model for patients with subacute stroke at a tertiary care hospital in Northern Thailand. Secondary objectives include assessing the impact on caregiver burden, evaluating cost-effectiveness, measuring the sustainability of functional improvements, and analyzing the effectiveness of technology-assisted components.

We hypothesize that the new service model will significantly improve patients' ability to perform daily living activities as measured by the Barthel Index. Additional hypotheses propose that the model will enhance quality of life (measured by EuroQol 5-Dimension), reduce caregiver burden (measured by Modified Caregiver Strain Index), demonstrate cost-effectiveness from a healthcare system perspective, and maintain functional improvements through the 6-month follow-up period.

This study represents the first comprehensive attempt in Thailand to integrate technology-assisted rehabilitation monitoring[12] with structured caregiver training programs and standardized multidisciplinary care protocols. This innovative approach includes seamless care transitions between hospital and community, and developing evidence-based, culturally appropriate rehabilitation guidelines.[13] The findings could significantly inform policy decisions and improve long-term outcomes for stroke patients in Thailand and similar healthcare contexts. The model's design carefully considers resource limitations and cultural factors specific to the Thai healthcare system, making it potentially scalable to other regional hospitals.[14]

Methods

Study design

This study was quasi-experimental, comparing a prospective intervention cohort (January-December 2021) with retrospectively collected historical controls (January-December 2020). For the historical control group, data were obtained from medical records, rehabilitation documents, and hospital database systems. All outcome measures were routinely collected as part of standard care documentation at the rehabilitation department. Two trained research assistants independently extracted and verified the historical data using a standardized data extraction form. Cases with incomplete outcome measures were excluded from the study. The study was approved by the Ethics Committee of Uttaradit Hospital on August 27, 2021 (Approval No. 46/2021). The Thai Clinical Trials Registry Number was TCTR20250402003.

The study was conducted at the Department of Rehabilitation Medicine, Uttaradit Hospital, a 680-bed tertiary care hospital in Northern Thailand. The rehabilitation service includes inpatient and outpatient care, a dedicated stroke unit, and a rehabilitation ward.

Participants

Patients were recruited from both the inpatient and outpatient departments. Neurologists confirmed stroke diagnoses based on clinical presentation and neuroimaging (CT/MRI). The National Institutes of Health Stroke Scale (NIHSS) was used to assess stroke severity at baseline as part of the standard stroke protocol.

Inclusion criteria were:

1. Age 18-80 years
2. First-ever stroke diagnosis
3. Modified Rankin Scale (mRS) score of 2-4
4. Basic communication ability in the Thai language (ability to follow simple commands and express basic needs, allowing for mild-moderate dysarthria or aphasia)

Exclusion criteria were expanded to include:

1. Severe cognitive impairment (Montreal Cognitive Assessment Thai version score < 10)
2. Severe communication disorders preventing meaningful participation
3. Unstable medical conditions (e.g., uncontrolled hypertension, unstable cardiac conditions)
4. Severe psychiatric disorders
5. Active participation in other rehabilitation research studies

Sample size was calculated using GPower, with effect size = 0.5, $\alpha = 0.05$, and power = 0.8. This resulted in 64 participants per group. Accounting for a 20.0% dropout rate, the total sample size was 154 participants.

Intervention

The standard care group (historical controls) received:

1. Initial rehabilitation assessment by a physiatrist within 48 hours of hospital admission
2. Physical therapy sessions:
   - Duration: 30-45 minutes per session
   - Frequency: 2-3 times per week
   - Total program duration: 12 weeks
   - Total planned sessions: 24-36 sessions
3. Basic activities of daily living training integrated into each session
4. A simple home exercise program with weekly updates
5. Regular follow-up appointments every 4-6 weeks
6. Referral to other specialists as needed

The actual number of completed sessions and reasons for missed sessions were documented. Patients who completed less than 75.0% of planned sessions were noted in the analysis.

The intervention group received a comprehensive rehabilitation program including:

1. Multidisciplinary assessment and planning
   • Comprehensive assessment within 24 hours of enrollment by:
     - Rehabilitation physician
     - Rehabilitation nurses
     - Physical therapists
     - Occupational therapists
     - Speech therapists (when indicated)
     - Social workers
     - Nutritionists
2. Individualized rehabilitation planning
   • Structured goal-setting using the Canadian Occupational Performance Measure (COPM)[11]
   • Weekly multidisciplinary team meetings to review and adjust goals
   • Regular assessment of goal achievement using standardized outcome measures
3. Intensive rehabilitation program
   • 3-hour daily sessions, 5 days/week, including:
     - Task-specific training
     - Functional electrical stimulation
     - Virtual reality-based therapy
     - Group exercise sessions
     - Cognitive training when indicated
4. Caregiver education and support
   • Structured training program (2 hours/week)
   • Hands-on practice with supervision
   • Educational materials and videos
   • Peer support group sessions
5. Technology-enhanced home program
   Implementation timeline:
   - Initial setup: Week 1 of enrollment
   - Training period: Weeks 1-2 (2 sessions, 1 hour each)
   - Active usage period: Weeks 2-12
   Components:
   a) Custom smartphone application:
     - Exercise tracking with daily reminders
     - Progress monitoring through automated weekly reports
     - Direct messaging system with healthcare team (response within 24 hours)
     - Video-based educational resources
     - Automated appointment reminders
   b) Home-program structure:
     - Daily exercise modules (30-45 minutes)
     - Weekly progress uploads (photos/videos)
     - Bi-weekly virtual check-ins with a therapist
     - Monthly virtual group sessions

   Technical support:
   - Initial face-to-face training for patients and caregivers
   - Backup paper-based materials for technical difficulties

   Monitoring and compliance:
   - Weekly review of usage data
   - Follow-up calls for inactive users (>3 days)
   - Monthly satisfaction surveys
   - Technical issue logs and resolution times

   Prerequisites:
   - Smartphone ownership or provided tablet
   - Internet connectivity at home
   - Caregiver technical capability assessment

For patients without access to technology (n=X), modified paper-based home programs were provided with a telephone at the outset of follow-up.

All assessments were conducted by trained evaluators who were blinded to group allocation. Primary and secondary outcomes were measured at baseline, 12 weeks, and 6 months by different assessors than those providing treatment.

Measurement

Primary outcome: Barthel Index (BI) for functional independence

Secondary outcomes:

- Modified Rankin Scale (mRS)
- Stroke Impact Scale (SIS)
- Hospital Anxiety and Depression Scale (HADS)
- EuroQol 5-Dimension (EQ-5D)
- Modified Caregiver Strain Index (MCSI)
- Healthcare utilization and costs

Statistical analysis

Data analysis was performed using a software package. Between-group comparisons used independent t-tests for continuous data and chi-square tests for categorical data. Changes in outcomes over time were analyzed using linear mixed models to account for missing data and repeated measurements. Cost-effectiveness analysis was conducted from a healthcare system perspective.

Results

Between January 2020 and December 2021, 320 patients with subacute stroke were screened for eligibility. After applying selection criteria, 154 patients were included: 77 in the intervention group (2021 cohort) and 77 in the control group (2020 historical controls). The completion rates were 91.0% (70/77) for the intervention group and 88.0% (68/77) for the control group at 6-month follow-up. The most common reasons for dropout were relocation (n = 8) and medical complications unrelated to the intervention (n = 5). Analysis followed intention-to-treat (ITT) principles, with the last observation carried forward for missing data. (Figure 1)

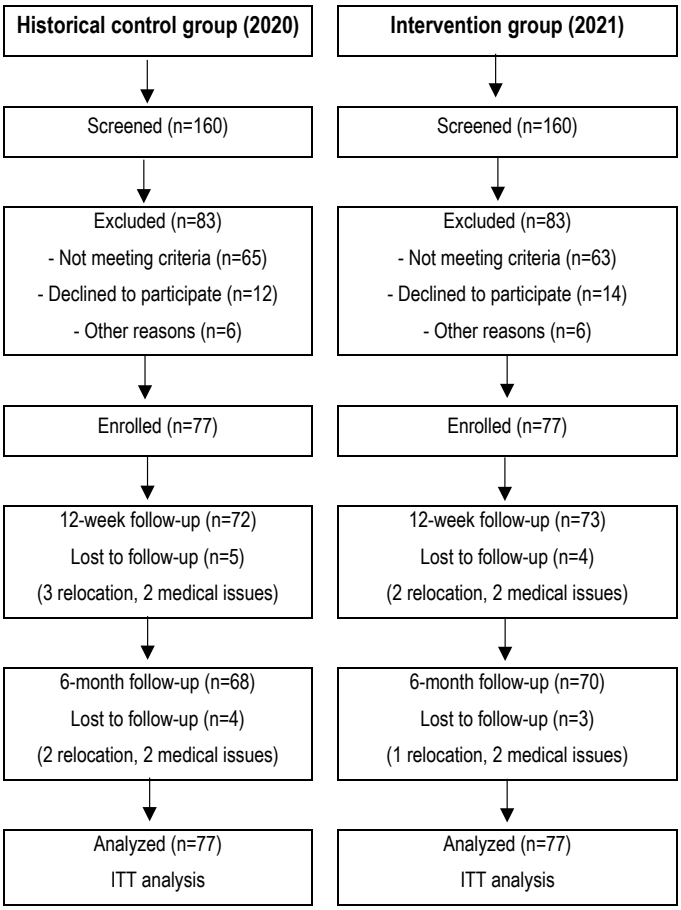

Figure 1. Study flow diagram

Table 1. Baseline demographic and clinical characteristics of study participants

Characteristic	Intervention group (n = 77)	Control group (n = 77)	*p*-value
Age (years)[1]	65.3 (10.2)	66.1 (9.8)	0.621[4]
Male gender[2]	42 (54.5)	40 (51.9)	0.743[5]
Days since stroke onset[1]	28.4 (5.6)	27.9 (5.8)	0.582[4]
Education level[2]			0.892[5]
Primary or lower	45 (58.4)	43 (55.8)	
Secondary	20 (26.0)	22 (28.6)	
Tertiary	12 (15.6)	12 (15.6)	
Stroke type[2]			0.865[5]
Ischemic	61 (79.2)	62 (80.5)	
Hemorrhagic	16 (20.8)	15 (19.5)	
Initial NIHSS score[3]	8 (5-12)	7 (5-11)	0.723[6]
Initial mRS score[3]	3 (2-4)	3 (2-4)	0.891[6]
Baseline BI score[1]	45.6 (15.3)	46.2 (14.9)	0.798[4]
Living situation[2]			0.815[5]
With family	68 (88.3)	67 (87.0)	
Alone	9 (11.7)	10 (13.0)	

[1]Mean (SD), [2]number (percentage), [3]median (IQR), [4]Independent t-test, [5]Chi-square test, [6]Mann-Whitney U test.

NIHSS, National Institutes of Health Stroke Scale; mRS, modified Rankin Scale; BI, Barthel Index; IQR, interquartile range; SD, standard deviation.

Table 1 presents the baseline demographic and clinical characteristics. At baseline, there were no significant differences between groups in age, gender, stroke type, stroke severity, or functional status.

Table 2 demonstrates significant improvements across all secondary measures in the intervention group compared to controls. The Stroke Impact Scale showed substantial gains at 12 weeks (mean difference: 26 points, $p < 0.001$) and 6

Table 2. Barthel Index scores across evaluation time points

Time point	Intervention group (n = 77)	Control group (n = 77)	Mean difference (95%CI)	*p*-value
Baseline	45.6 (15.3)	46.2 (14.9)	-0.6 (-5.2 to 4.0)	0.798
12 weeks	72.8 (18.6)	61.4 (17.2)	11.4 (6.8 to 16.0)	<0.001
6 months	78.5 (19.2)	65.7 (18.1)	12.8 (7.9 to 17.7)	<0.001

All values are presented as mean (SD). CI, confidence interval

Table 3. Secondary outcome measures across different time points

Outcome measure	Time point	Intervention group	Control group	Mean/median difference	*p*-value
SIS score[1]	Baseline	112 (95-130)	114 (97-132)	-2 (-8 to 4)	0.823
	12 weeks	168 (145-189)	142 (122-162)	26 (18 to 34)	<0.001
	6 months	182 (158-201)	151 (130-172)	31 (22 to 40)	<0.001
HADS score[1]	Baseline	16 (12-20)	15 (11-19)	1 (-2 to 4)	0.652
	12 weeks	10 (6-14)	13 (9-17)	-3 (-5 to -1)	0.003
	6 months	8 (4-12)	12 (8-16)	-4 (-6 to -2)	<0.001
EQ-5D index[2]	Baseline	0.45 (0.15)	0.46 (0.14)	-0.01 (-0.05 to 0.03)	0.624
	12 weeks	0.72 (0.18)	0.57 (0.16)	0.15 (0.08 to 0.22)	<0.001
	6 months	0.78 (0.19)	0.61 (0.17)	0.17 (0.10 to 0.24)	<0.001
MCSI score[2]	Baseline	13.5 (4.2)	13.2 (4.1)	0.3 (-1.0 to 1.6)	0.658
	12 weeks	7.1 (3.8)	11.4 (4.0)	-4.3 (-5.6 to -3.0)	<0.001
	6 months	6.4 (3.6)	10.8 (3.9)	-4.4 (-5.7 to -3.1)	<0.001

[1]Median, [2]mean

SIS, Stroke Impact Scale; HADS, Hospital Anxiety and Depression Scale; EQ-5D, EuroQol 5-Dimension; MCSI, Modified Caregiver Strain Index. SIS and HADS values are presented as median (IQR); EQ-5D and MCSI values are presented as mean (SD)

Table 4. Patient and caregiver satisfaction scores at 12 weeks

Domain	Intervention group Mean (SD)	Control group Mean (SD)	Mean difference (95%CI)	*p*-value
Overall satisfaction	4.2 (0.6)	3.5 (0.7)	0.7 (0.5 to 0.9)	<0.001
Treatment process	4.1 (0.6)	3.4 (0.7)	0.7 (0.5 to 0.9)	<0.001
Staff communication	4.3 (0.5)	3.6 (0.6)	0.7 (0.5 to 0.9)	<0.001
Facility and equipment	4.0 (0.7)	3.7 (0.6)	0.3 (0.1 to 0.5)	0.003
Home program support	4.4 (0.5)	3.3 (0.8)	1.1 (0.9 to 1.3)	<0.001
Caregiver support	4.3 (0.6)	3.2 (0.7)	1.1 (0.9 to 1.3)	<0.001

SD, standard deviation; CI, confidence interval

months (mean difference: 31 points, $p < 0.001$). Similarly, the intervention group exhibited more significant reductions in anxiety and depression on the HADS, with significant differences at both time points ($p = 0.003$ and $p < 0.001$, respectively). Quality of life measured by EQ-5D improved markedly in the intervention group (0.45 to 0.78) compared to controls (0.46 to 0.61), with a significant between-group difference ($p < 0.001$). Caregiver burden decreased more substantially in the intervention group, with MCSI scores dropping from 13.5 to 6.4 compared to 13.2 to 10.8 in controls ($p < 0.001$).

Table 3 presents our primary outcome measure results. While baseline scores were comparable between groups (mean (SD) of BI score of intervention and control groups were 45.6 (15.3) and 46.2 (14.9), respectively with $p = 0.798$), the intervention group showed significantly greater improvement at 12 weeks (mean (SD) of the improvement in intervention and control groups were 72.8 (18.6) and 61.4 (17.2) with mean difference = 11.4, 95%CI: 6.8-16.0, $p < 0.001$). This improvement was maintained and slightly increased at 6 months (mean (SD) of the improvement in intervention and control groups were 78.5 (19.2) and 65.7 (18.1) with mean difference = 12.8, 95%CI: 7.9-17.7, $p < 0.001$), demonstrating clinically meaningful and sustained functional independence gains

All outcome measures used validated Thai versions and were administered by trained research assistants. Due to stroke-related communication impairments (mild-moderate dysarthria or mild expressive aphasia) that developed during the study period, 15 participants (8 in the intervention group, 7 in the control group) required assistance from their primary caregivers to clarify their responses. This assistance was limited to clarifying the patient's intended responses without

answering on their behalf. The need for caregiver assistance was documented and analyzed to ensure it did not significantly impact the outcome measures.

Discussion

This study aimed to evaluate the effectiveness of a comprehensive rehabilitation service model for patients with subacute stroke. The prospective cohort design with historical controls was chosen to address scientific rigor and ethical concerns regarding access to potentially beneficial interventions.[11] This design ensured that all patients admitted after the implementation received the enhanced intervention, aligning with emerging evidence that supported intensive rehabilitation during the subacute phase.[2]

The intervention group demonstrated significantly improved functional independence, with mean Barthel Index increases exceeding the minimal clinically significant difference of 10 points.[12] However, these improvements must be interpreted within natural recovery and neuroplasticity. The subacute phase (2-6 weeks post-stroke) represents a period of enhanced endogenous plasticity, characterized by increased expression of growth-promoting factors and heightened neural reorganization.[2] The intensive rehabilitation program may have optimized this natural recovery window through activity-dependent plasticity enhancement, environmental enrichment, and synchronized timing of interventions with spontaneous recovery processes.[11]

The improvements in quality of life and psychological well-being align with recent evidence supporting holistic rehabilitation approaches.[8] The significant reduction in caregiver burden (MCSI score difference -6.4) suggests that structured caregiver education and support systems are crucial components of effective rehabilitation models.[6] Integrating technology-assisted monitoring and communication platforms further enhanced care coordination and treatment adherence.[10]

Our study demonstrated significant improvements in functional outcomes in the intervention group compared to the control group. However, we must note some limitations in our study design and analysis. We did not perform subgroup analyses to identify factors that might have influenced treatment outcomes, such as initial stroke severity, socioeconomic status, and level of caregiver support. Future studies should consider investigating these factors to help identify which patient populations might benefit most from this comprehensive rehabilitation program. Additionally, research examining the effectiveness of this program in patients with more severe impairments (NIHSS >15) would be valuable, as our inclusion criteria limited our study to those with moderate impairment levels.[13]

The community support component proved particularly important for sustaining improvements. Mobile rehabilitation units, telemedicine follow-up, community health worker training, and enhanced social service coordination may help address barriers to care access, especially in rural areas.[14] Integrating these services with existing healthcare infrastructure appears crucial for program sustainability.

Preliminary cost analysis suggests potential long-term economic benefits through reduced readmission rates and lower long-term care expenses.[15] However, the initial implementation costs, including staff training and technology infrastructure, require careful consideration. Future research should include comprehensive cost-effectiveness analysis and budget impact studies to inform scaling decisions.[5]

Several limitations warrant consideration. Historical controls such as differences in environmental factors, potential variations in standard care practices over time, and possible documentation inconsistencies may have introduced temporal bias, although baseline characteristics were similar between groups.[16] The resource-intensive nature of the intervention may challenge scalability, particularly in settings with limited rehabilitation personnel. Additionally, the 6-month follow-up period may not capture the entire trajectory of recovery.[17]

Future research should focus on three key areas. First, long-term follow-up studies (12-24 months) are needed to evaluate sustained benefits. Second, implementation research should examine adaptation strategies for resource-limited settings.[18] Finally, technology development should enhance telemedicine platforms and automated progress tracking systems.[10]

In conclusion, this comprehensive rehabilitation model significantly improves stroke outcomes. The findings suggest that intensive, technology-enhanced rehabilitation, combined with structured caregiver support, can significantly improve functional independence and quality of life.[19] Future efforts should focus on optimizing care for challenging cases and ensuring sustainable implementation across diverse healthcare settings.[20]

Conclusions

This study demonstrates that a comprehensive rehabilitation service model improved outcomes in patients with subacute stroke. The intervention, combining intensive, multidisciplinary rehabilitation, structured caregiver training, and technology-assisted monitoring, resulted in clinically significant improvements in functional independence (mean Barthel Index difference 11.4, 95%CI: 6.8-16.0) compared to historical controls. Secondary benefits included enhanced quality of life, reduced caregiver burden, and decreased depressive symptoms, with improvements sustained at the 6-month follow-up.

While implementation requires considerable resources and organizational change, the potential benefits of improved patient outcomes and reduced long-term care needs suggest this model could be cost-effective in tertiary care settings. Future research should focus on adaptation strategies for

resource-limited environments and long-term cost-effectiveness analysis.

Acknowledgment

We would like to express our sincere gratitude to the rehabilitation staff at Uttaradit Hospital for their dedication throughout the implementation of this project. Special thanks to our research assistants for their meticulous data collection, and to the stroke patients and their families who participated in this study.

Conflict of interest declaration

The authors confirm that there are no known conflicts of interest associated with this publication, and no significant financial support has been received that could have influenced the results or conclusions of this work.

Funding

This study received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Data availability

The data that support the findings of this study are available on request from the corresponding author, Dr. Seubtrakul Tantalanukul. The data are not publicly available due to privacy and ethical restrictions, as they contain personal health information obtained from hospital medical records and patient-reported outcome measures. Access to anonymous data may be granted upon reasonable request and subject to approval by the institutional ethics committee.

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