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Clinical and Cost-Effectiveness of Home-Based Rehabilitation Following Hip Fracture Surgery: A Real-World Comparative Study

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Research Article

Keywords: Hip fracture, Home-based rehabilitation, Cost-effectiveness analysis, Intermediate care

Posted Date: June 29th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-9755822/v1

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Additional Declarations: No competing interests reported.

Abstract

Introduction:

Hip fracture is a major health concern in aging societies. Intermediate care (IMC) policies have been implemented to promote continuity of care and enhance recovery after hospital discharge. However, its clinical and cost-effectiveness remain limited. Therefore, this study aimed to investigate the clinical and cost-effectiveness of home-based rehabilitation compared with facility-based rehabilitation following hip fracture surgery.

Methods

This prospective real-world comparative effectiveness study included a trial-based cost-effectiveness analysis conducted from a societal perspective. Clinical outcomes included the Short Physical Performance Battery (SPPB), gait speed, Barthel Index, Falls Efficacy Scale, and health-related quality of life measured using the EQ-5D-5L. Adherence and complications were compared between groups. The incremental cost-effectiveness ratio (ICER) was calculated to compare the costs and outcomes.

Results

A total of 48 patients were enrolled, including 32 in home-based rehabilitation group and 16 in facility-based rehabilitation group. Home-based rehabilitation group demonstrated significantly greater improvements in physical performance and activities of daily living than facility-based rehabilitation group. No significant differences were observed between groups in falls efficacy, gait speed, or utility scores. Adherence was significantly higher in the home-based rehabilitation group. No complications were observed in either group. Furthermore, home-based rehabilitation was cost-effective over the 6-month period at the accepted willingness-to-pay threshold.

Conclusion

Home-based rehabilitation following hip fracture surgery was clinically more effective than facility-based rehabilitation in improving physical performance and activities of daily living. It also achieved significantly higher adherence, with no complications observed in either group. From a societal perspective, home-based rehabilitation was cost-effective over a 6-month period.

Trial registration:

Thai Clinical Trials Registry (TCTR): TCTR20250527001. Registered on 27 May 2025.

1. Introduction

Hip fracture is a major concern in aging societies, with its incidence projected to substantially increase by 2050 (1). In Thailand, the incidence of hip fracture ranges from 201.2 to 611.5 per 100,000 population per year (2). Besides surgical care, postoperative rehabilitation is important to regain functional mobility, decrease complications and improve quality of life (3, 4). However, the ideal models for delivery of rehabilitation services remain disputed, particularly in resource-constrained and real-world contexts.

Conventionally, facility-based rehabilitation, using structured, supervised therapies in specialized settings is the typical care after hip fracture (5). However, this standard protocol may also present logistical issues such as transport barriers, increased caregiver burden and higher indirect expenses (5, 6), although it usually provides access to multidisciplinary treatment and equipment (7). On the other hand, home-based rehabilitation may provide a more accessible alternative, allowing for tailored interventions in the patient's own environment. This may promote task-specific training, compliance and integration of rehabilitation in regular activities (8–10). However, the comparative effectiveness of these two models remains inconclusive.

Previous studies comparing home-based versus facility-based rehabilitation have reported heterogenous results (11, 12). Some studies stated similar outcomes (13, 14) and others suggested a possible advantage for home-based programs (15–17). Importantly, many of these studies were conducted under controlled experimental conditions, which might limit their generalizability to routine clinical practice (16). Moreover, economic evaluations are often limited in scope, typically from a health care provider perspective (18). This design would lack of broader societal costs such as time for caregivers, transportation, and productivity losses. Thus, the real-world clinical and economic impact of rehabilitation delivery models after hip fracture remain insufficiently understood.

In Thailand, the intermediate care (IMC) policy was introduced to improve post-acute care and continuity of rehabilitation services after hospital discharge (6). This policy supports both home-based and facility-based services of rehabilitation, offering a natural context for evaluating their implementation in routine practice. However, there is a lack of empirical evidence assessing both clinical and economic outcomes within this policy framework.

Therefore, the aim of this study was to compare the clinical outcomes and cost-effectiveness of home-based versus facility-based rehabilitation following hip fracture within Thailand's intermediate care system.

2. Materials and methods

2.1 Study design and participants

This study employed a prospective real-world comparative effectiveness design with an embedded trial-based cost–effectiveness analysis conducted from a societal perspective. The study was carried out

within the context of Thailand's intermediate care (IMC) system, which supports post-acute rehabilitation following hospital discharge. Participants were recruited from a tertiary care hospital and followed for 6 months after discharge. The research protocol was approved by the Mahidol University Central Institutional Review Board (COA No. MU-CIRB 2025/107.0304) and conducted in accordance with the Declaration of Helsinki between April 2025 and April 2026.

Participants were eligible if they were aged ≥ 50 years, community-dwelling, diagnosed with a hip fracture (intra- or extracapsular), and had undergone first-time hip fracture surgery within the previous three months. All participants were required to be able to communicate in Thai. Exclusion criteria included pathological fractures (e.g., bone sarcoma or disease-related fractures), cognitive impairment (Montreal Cognitive Assessment–Thai version [MoCA-Thai] score ≤ 24, adjusted for educational level) (19), inability to ambulate at least 10 meters with or without a gait aid prior to the fracture, and neurological or other conditions affecting ambulation (e.g., stroke or Parkinson's disease). Participants were also excluded if they had medical conditions limiting physical exercise (e.g., unstable cardiac disease, active infection, or uncontrolled chronic conditions), severe osteoporosis, or poor nutritional status as defined by the European Society of Clinical Nutrition and Metabolism (i.e., weight loss > 5% within 6 months) (20).

Participants were allocated to either home-based or facility-based rehabilitation according to real-world accessibility and contextual factors, including geographic location, patient preference, and caregiver availability. This pragmatic allocation reflects routine clinical practice under the IMC policy in the Thai healthcare system. Baseline characteristics between groups were assessed to evaluate comparability and to inform interpretation of outcomes. To address potential selection bias, baseline characteristics were carefully compared between groups, and statistical adjustment was applied in subsequent analyses. The procedure was presented in Fig. 1.

2.2 Intervention

Participants in both groups received rehabilitation programs developed through expert consensus using a Delphi approach to ensure consistency in core components. The program consisted of progressive strengthening exercises, weight-bearing activities, balance training, functional mobility training, patient education, as well as home hazard evaluation and adjustment. The program was individualized based on each participant's physical status and functional capacity.

For the home-based rehabilitation group, the intervention was delivered by a licensed physical therapist through one home visit per week over an 8-week period (total of 8 sessions). Each session lasted approximately 60 minutes and included supervised exercise, monitoring of performance, and progression of the program as appropriate. Participants were also provided with a logbook containing prescribed exercises and written instructions to support adherence and independent practice between sessions.

Participants in the facility-based rehabilitation group received rehabilitation according to the standard protocol for hip fracture rehabilitation at the hospitals where they underwent surgery. All sessions were supervised by a licensed physical therapist. Following discharge, participants attended outpatient rehabilitation sessions once per week for 8 weeks (total of 8 sessions). Each session lasted approximately 60 minutes and included supervised exercise and progression of the program as appropriate to their physical and functional status.

2.3 Outcome measures

Demographic and clinical data were collected, including age, sex, time since hospital discharge (days), fracture type, comorbidities, type of surgery, and cognitive score. Clinical outcomes were assessed at baseline (post-discharge), post-intervention (8-weeks), and at 6 months follow-up.

Primary outcome was Short Physical Performance Battery (SPPB) which assesses lower extremity function in older adults, including balance, gait speed, and chair rise. Scores range from 0 to 12, with higher scores indicating better performance (21). The SPPB has demonstrated good validity and reliability (ICC = 0.88–0.92) (22).

Secondary outcomes included gait speed (m/s), Barthel Index, Falls Efficacy Scale–International (FES-I), utility score, program adherence, and healthcare costs. Gait speed was assessed using a 3-meter walk test at usual pace and expressed in meters per second (m/s), with higher values indicating better mobility (12). The Barthel Index assesses activities of daily living across 10 items, with total scores ranging from 0 to 100, where higher scores indicate greater independence. The instrument has demonstrated good reliability (ICC = 0.714) (23, 24). Fall efficacy was measured using the Thai version of the Falls Efficacy Scale–International (FES-I), which includes 16 items scored on a 4-point Likert scale, with total scores ranging from 16 to 64. Higher scores indicate greater fear of falling. The instrument has shown moderate test–retest reliability in individuals with hip fractures (ICC = 0.72) (25, 26). Health-related quality of life was assessed using the EQ-5D-5L questionnaire, which includes five domains: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. Utility scores were derived using the Thai value set (27). Program adherence was also assessed using a logbook, with participants reporting their home exercise performance at each visit. Adherence was calculated as the percentage of completed exercises relative to the prescribed program.

Economic evaluation was conducted from a societal perspective, incorporating both direct and indirect costs. Direct medical costs included healthcare services and rehabilitation-related expenses based on the unit cost that was established by the Ministry of Public Health in 2023 (28). Indirect costs included transportation and caregiver time. All costs were collected prospectively over the 6-month study period and reported in Thai Baht (THB). Effectiveness was assessed in terms of quality-adjusted life years (QALYs), which were estimated using the area under the curve (AUC) approach based on utility values collected at several time points. Utility values were derived from the EQ-5D-5L questionnaire, and QALYs were calculated by integrating utility scores over the study duration (29).

2.4 Sample size calculation

The sample size was calculated for a longitudinal design with two groups and repeated measurements using G*Power software (repeated measures ANOVA, within–between interaction). Based on an effect size of 0.17 from a previous study, a significance level of 0.05, and a power of 80%, the required sample size was 58 participants (10). Allowing a 10% dropout rate, the final sample size was set at 64 participants (32 per group).

2.5 Statistical analysis

The statistical analysis was performed using SPSS software (IBM SPSS Statistics V23.0 for Windows, SPSS Inc., USA). Data normality was assessed using the Shapiro–Wilk test. Descriptive statistics were used to summarize baseline characteristics. Baseline characteristics were compared between groups using the independent samples t-test for normally distributed continuous variables and the Mann–Whitney U test for non-normally distributed variables. Categorical variables were analyzed using the χ^2 test or Fisher's exact test, as appropriate.

Missing data were addressed using a multiple imputation by chained equations (MICE) under the assumption of missing at random. Five imputed datasets were created, incorporating all variables included in the final analysis. Each dataset was analyzed independently, and the estimates were combined using Rubin's rules.

The Short Physical Performance Battery (SPPB) score, gait speed, Barthel Index, fall efficacy score, and utility score were analyzed using a linear mixed model (LMM). The model included fixed effects for group, time, and group-by-time interaction, while participants were treated as random effects to account for within-subject correlations across repeated measurements. Age, sex, and type of fracture were included as covariates in the model (30). Adjusted mean differences with 95% confidence intervals were estimated, and statistical significance was set at $p < 0.05$.

A cost-effectiveness analysis was conducted from a societal perspective over a 6-month time horizon, corresponding to the study follow-up period. The incremental cost-effectiveness ratio (ICER) was calculated to compare the costs and outcomes between the intervention and control groups. Uncertainty surrounding the ICER was evaluated using a non-parametric bootstrap method based on the original dataset, with 2,000 bootstrap replications performed to estimate the joint distribution of incremental costs and QALYs. The bootstrap results were illustrated on a cost-effectiveness plane using an ICER scatter plot. In addition, a cost-effectiveness acceptability curve (CEAC) was generated to demonstrate the probability that the intervention would be considered cost-effective across a range of willingness-to-pay thresholds. A willingness-to-pay threshold of 160,000 Thai Baht per QALY gained was applied (31). The 6-month evaluation period was considered appropriate for capturing the short-term effects of the rehabilitation intervention.

3. Results

3.1 Participants

The baseline characteristics of participants was illustrated in Table 1. A total of 48 participants were included, with 32 in the home-based rehabilitation group and 16 in the facility-based rehabilitation group. The mean age was 78.0 ± 9.52 years in the home-based group and 76.88 ± 10.29 years in the facility-based group ($p = 0.709$). The majority of participants were female in both groups (68.8% vs 75.0%, $p = 0.653$).

There were no significant differences between groups in time since hospital discharge (6.91 ± 3.02 vs 7.38 ± 3.90 days, $p = 0.648$), fracture type distribution ($p = 0.683$), or type of surgery ($p = 0.919$). Similarly, comorbidities, including hypertension, dyslipidemia, diabetes mellitus, and thyroid disorders, were comparable between groups (all $p > 0.05$). Lastly, Cognitive function, measured by the MoCA score, was also similar between groups (median [IQR]: 25.0 [24.25–29.0] vs 25.0 [24.25–29.0], $p = 0.444$).

Table 1
Baseline characteristics of participants

Variables	Home-based rehabilitation group (n = 32)	Facility-based rehabilitation group (n = 16)	p-value
Age (years), mean ± SD	78.0 ± 9.52	76.88 ± 10.29	0.709[a]
Sex, n (%)			
- Male	10 (31.2)	4 (25.0)	0.653[b]
- Female	22 (68.8)	12 (75.0)	
Number of days after discharge	6.91 ± 3.02	7.38 ± 3.90	0.648 [a]
Fracture types, n (%)			
- Neck of femur fracture	16 (50.0)	7 (43.8)	0.683[b]
- Intertrochanteric fracture	16 (50.0)	9 (56.3)	
Types of surgery, n (%)			
- Total hip arthroplasty	9 (28.1)	4 (25.0)	0.919[b]
- Hemi hip arthroplasty	7 (21.9)	3 (18.8)	
- Internal fixation	16 (50.0)	9 (56.3)	
Comorbidities, n (%)			
- Hypertension (HT)	23 (71.9%)	14 (87.5%)	0.293[c]
- Dyslipidemia (DLP)	15 (46.9%)	5 (31.3%)	0.213[c]
- Diabetes mellitus (DM)	6 (18.8%)	4 (25.0%)	0.712[c]
- Thyroid disorder	1(3.1)	1 (6.3%)	1.000[c]
Cognitive score (points), median (IQR)	25.00 (24.25–29.5)	25.00 (24.25-29.0)	0.444[d]

[a] Independent sample t-test, [b] Pearson Chi-Square test, [c] Fisher's Exact Test, [d]Mann-Whitney U test

3.2 Clinical outcomes

Repeated measures analysis using a Linear Mixed Model demonstrated significant time effects for all clinical outcomes (all $p < 0.001$), indicating improvements over the 6-month follow-up period in both rehabilitation groups. Significant group-by-time interactions were observed for the Short Physical

Performance Battery (SPPB) score (p = 0.031) and Barthel Index (p = 0.003), suggesting greater functional improvement in the home-based rehabilitation group compared with the facility-based rehabilitation group. The adjusted mean SPPB score in the home-based rehabilitation group increased from 3.84 at baseline to 7.56 at follow-up, whereas the facility-based rehabilitation group improved from 3.63 to 6.00. Likewise, the adjusted mean Barthel Index increased from 54.38 to 85.31 in the home-based rehabilitation group and from 55.94 to 79.38 in the facility-based rehabilitation group.

Although gait speed, fall efficacy score, and utility score improved over time in both groups, the group-by-time interactions were not statistically significant, indicating comparable changes between groups for these outcomes (p = 0.087, 0.821, and 0.328, respectively) (Table 2) (Fig. 2).

Table 2
Estimated marginal means of clinical outcomes over time between the home-based and facility-based rehabilitation groups

Clinical outcomes	Time point	Groups		Time effect	Group x Time
		Home-based rehabilitation	Facility-based rehabilitation	p-value	p-value
Short Physical Performance Battery (score)	Baseline	3.84 (3.08–4.61)	3.63 (2.55–4.70)	< 0.001	0.031*
	Post	6.47 (5.71–7.23)	5.31 (4.24–6.39)		
	Follow-up	7.56 (6.80–8.32)	6.00 (4.92–7.08)		
Gait speed (m/s)	Baseline	0.31 (0.25–0.38)	0.30 (0.22–0.39)	< 0.001	0.087
	Post	0.51 (0.45–0.57)	0.41 (0.32–0.50)		
	Follow-up	0.59 (0.53–0.65)	0.48 (0.39–0.56)		
Barthel index (score)	Baseline	54.38 (47.59–61.16)	55.94 (46.32–65.54)	< 0.001	0.003*
	Post	82.97 (76.18–89.76)	74.69 (65.09–84.29)		
	Follow-up	85.31 (78.53–92.10)	79.38 (69.78–88.97)		
Fall efficacy (score)	Baseline	52.38 (48.15–56.60)	55.50 (49.53–61.47)	< 0.001	0.821
	Post	34.88 (30.65–39.10)	39.19 (33.22–45.16)		
	Follow-up	33.31 (29.09–37.53)	36.38 (30.41–42.34)		
Utility (score)	Baseline	0.534 (0.457–0.612)	0.530 (0.421–0.639)	< 0.001	0.328
	Post	0.783 (0.706–0.860)	0.712 (0.603–0.821)		
	Follow-up	0.818 (0.741–0.895)	0.784 (0.675–0.893)		

Data were presented with estimated marginal mean and 95% confidence intervals.

Data were analyzed using a Linear Mixed Model adjusted for age, sex, and type of fracture. Fixed effects included group, time, and group-by-time interaction, with participants treated as random effects.

3.3 Cost-effectiveness analysis

The home-based rehabilitation group demonstrated lower total costs than the facility-based rehabilitation group (103,230.6 vs 128,565.9 THB) while achieving greater health benefits in terms of QALYs (0.37 vs 0.31). Cost details were provided in Table S1. The analysis showed an incremental cost of − 25,335.3 THB and an incremental gain of 0.06 QALYs. Consequently, the incremental cost-effectiveness ratio (ICER) was estimated at − 422,255 THB per QALY gained (Table 3).

Table 3
Sensitivity analysis of cost effectiveness

Groups	Costs (THB)	QALYs	Incremental costs (THB)	Incremental QALYs	ICER (THB/ QALYs)
Home-based rehabilitation	103,230.6	0.37	-25,335.3	0.06	-422,255
Facility-based rehabilitation	128,565.9	0.31			

The cost-effectiveness scatter plot demonstrated that most bootstrap replications were clustered in the southeast quadrant, indicating that the intervention was both less costly and more effective than the comparator. However, a limited number of simulations were observed in the other quadrants, suggesting some uncertainty in the economic evaluation model (Fig. 3).

The cost-effectiveness acceptability curve (CEAC) demonstrated that, at a willingness-to-pay threshold of 160,000 THB per QALY gained, the probability of home-based rehabilitation being cost-effective was 88.8% (Fig. 4).

3.4 Adherence and complications

The median exercise adherence from baseline to post-intervention was significantly higher in the home-based group compared to the facility-based group (90.50% [80.25–95.75] vs. 82.00% [72.75–89.75]; p = 0.038). Similarly, from post-intervention to the 6-month follow-up, adherence remained significantly higher in the home-based group (80.00% [74.25–85.50] vs. 73.00% [62.75–80.00]; p = 0.013). No complications or adverse events were observed in either group during the study period (Table 4).

Table 4
Adherence and complications outcomes

Outcome	Time point	Home-based rehabilitation	Facility-based rehabilitation	p-value‡
Exercise adherence	Baseline - Post intervention	90.50 (80.25–95.75)	82.00 (72.75–89.75)	0.038*
	Post intervention - Follow-up	80.00 (74.25–85.50)	73.00 (62.75–80.00)	0.013*
Complications	During intervention	0	0	-

Data presented as median ($IQR_{25,75}$)., *Significant at p-value < 0.05, ‡Between-group comparisons at each time point were performed using the Mann–Whitney U test.

4. Discussion

This study examined the clinical and cost efficiency of home-based rehabilitation compared to facility-based rehabilitation following hip fracture surgery within a practical health service model. The results showed that the progressive strengthening exercises, balance and weight-bearing training, functional training, and patient education that comprised the home-based rehabilitation group had significantly greater improvements in physical performance and activity daily living than the facility-based rehabilitation group. However, no significant difference in fall efficacy, gait speed, and health utility were observed between groups. Furthermore, the home-based rehabilitation group showed higher adherence rates and better cost-effectiveness outcomes, with lower overall costs and greater QALY gains. These findings suggested that home-based rehabilitation may be a clinically successful and cost-beneficial alternative to facility-based rehabilitation in older adults recovering from hip fracture surgery.

One of the key findings of this study was the superior improvement in physical performance outcomes observed in the home-based rehabilitation group, particularly in SPPB scores. These findings are clinically important because physical performance and mobility recovery are strongly associated with long-term independence, fall risk reduction, and survival following hip fracture. According to previous research, the home-based rehabilitation approach significantly enhanced mobility and functional results, especially as determined by the SPPB score (8, 10). A retrospective study conducted in Thailand also revealed that a home exercise program directed by physical therapist substantially improved physical performance following a hip fracture (32). The observed improvements may reflect the contextual relevance of rehabilitation delivered within the actual living environment of the patient.

The superior physical and functional independence outcomes observed in the home-based rehabilitation group may be explained by principles of task-specific and context-dependent motor learning (33, 34). Rehabilitation performed within the home environment may facilitate greater transfer of training to real-

life activities of daily living, which may enhance functional recovery and promote independence (7, 35). More frequent practice in their own homes may help them achieve long-term improvements in mobility. In addition, home-based rehabilitation may encourage greater caregiver participation and reinforcement of therapeutic activities outside formal treatment sessions. These factors may contribute to the greater increases in BI scores observed in the home-based rehabilitation group during the follow-up period.

In contrast, fall efficacy did not differ significantly between groups. This suggests that improvements in physical performance alone may not be sufficient to enhance confidence in avoiding falls. This finding is consistent with a previous study reporting no superiority of home-based rehabilitation over usual care in improving fall efficacy (36). Fall efficacy is influenced not only by physical function but also by psychological factors such as anxiety and prior fall experience (37, 38). Therefore, physical rehabilitation alone, whether delivered at home or in a facility, may not produce superior improvement in this outcome.

Moreover, gait speed and utility scores also showed no significant differences between the two groups in this study. Consistently, previous studies found no significant differences in usual gait speed between home-based rehabilitation and conventional care (39–41). One possible explanation is that both groups received strengthening exercises and functional training, particularly ambulation training, which may similarly improve walking ability (42, 43).

Importantly, improvements in physical performance (SPPB), gait speed, activities of daily living (Barthel Index), and fall efficacy exceeded the minimal clinically important difference (MCID) in both groups, indicating that both interventions provided clinically meaningful benefits (23, 44–46). However, the greater magnitude of improvement in SPPB and BI were observed in the home-based rehabilitation group suggests additional benefits beyond facility-based care .

The findings on adherence are noteworthy. The better clinical results seen in the present trial might be associated with higher adherence rate of the home-based rehabilitation group compared with the facility-based group. This result was consistent with the previous findings of a randomized controlled trial which demonstrated that a home-based program delivered via a DVD format improved adherence compared with usual care (10). The greater adherence may be attributable to lesser transportation burden, lower physical and logistical barriers to participation, and more convenience for older persons with mobility restrictions. The complementary strategies such as exercise logbooks could also promote self-monitoring, as well as training in real-life contexts may improve patient engagement and caregiver involvement (47–49). However, adherence declined in both groups after the intervention period, possibly due to increased independence, reduced perceived need for continued exercise, and the absence of direct supervision (50).

No adverse events were observed during either the intervention or follow-up periods, supporting the safety of both rehabilitation approaches. Although mild and transient symptoms have been reported in previous studies, these were not classified as complications in the present study (51, 52).

From an economic perspective, the findings of this study are especially pertinent. This result contrasts with previous studies conducted in health care perspective which reported no cost-effectiveness of home-based programs compared with usual care (36, 53, 54). One possible explanation was that previous study reported increased costs associated with transportation and travel time required for physical therapists to deliver interventions in patients' homes (54). With lower overall health care costs and more QALY improvements than facility-based rehabilitation, home-based rehabilitation was economically dominant from a societal standpoint. There is limited evidence regarding the economic benefits of home-based rehabilitation following hip fracture, particularly in Southeast Asian healthcare systems. Existing studies from high-income countries suggest that community- and home-based rehabilitation may improve accessibility and may be cost-effective; however, the evidence remains limited and context-specific (55, 56). Therefore, the current results offer important evidence for the potential cost-effectiveness of home-based rehabilitation delivery in healthcare settings with limited resources and in aging populations. There is a good chance that home-based rehabilitation is cost-effective for a variety of willingness-to-pay thresholds, according to the favorable cost-effectiveness acceptability results.

A key strength of this study is the comprehensive home-based rehabilitation program, which incorporated both structured exercise training and environmental modification in real-life settings, alongside a multidimensional assessment of clinical outcomes, adherence, safety, and cost. These features enhance the clinical relevance and applicability of the findings. In addition, the intervention demonstrated cost-effectiveness from a societal perspective by accounting for the burden on both patients and caregivers.

4.1 Implications for practice and policy

The findings of this study have important implications for clinical practice and health policy. They support the integration of home-based rehabilitation into routine post-discharge care pathways to enhance continuity of care and improve functional recovery in patients with hip fracture. Delivering rehabilitation in a real-life and familiar environment may facilitate better functional recovery compared with facility-based settings. From a policy perspective, the implementation of home-based rehabilitation should be considered as part of transitional care models, particularly for older adults following hip fracture surgery, to improve accessibility and continuity of rehabilitation services.

5. Limitations

Despite these constructive findings, several limitations should be acknowledged. First, the study employed a quasi-experimental design without random allocation, which may introduce residual confounding despite statistical adjustment. Although baseline characteristics were generally comparable between groups and linear mixed-effects models were applied to control for important covariates, unmeasured differences may still have influenced outcomes. Second, generalizability to larger populations and healthcare contexts may be limited due to the relatively small sample size and

single-center setting. Additionally, there was an unequal sample size between the two groups since patients needed caregiver help for transportation, which made it difficult for them to undergo facility-based rehabilitation. This may have introduced group imbalance, despite the fact that it reflects real-world constraints and socioeconomic factors in clinical practice. Also, the study population excluded patients with cognitive impairment, significant comorbidities, and those who did not undergo surgical treatment, which may further limit applicability to the broader hip fracture population. Third, adherence measurements relied partly on self-reported participation records, which may be subject to reporting bias. In addition, while no serious adverse events related to the rehabilitation interventions were reported during the study period, larger studies with longer follow-up durations are warranted to further evaluate long-term safety and sustainability. Finally, although cumulative QALY estimates favored the home-based rehabilitation group, differences in utility scores over time did not consistently reach statistical significance, suggesting that larger studies may be needed to confirm health utility differences more definitively.

6. Future directions

Future research should include larger multicenter randomized or pragmatic implementation studies to further evaluate the long-term effectiveness, scalability, and economic sustainability of home-based rehabilitation models following hip fracture surgery. Additional investigation into patient selection criteria, caregiver involvement, technology-assisted home rehabilitation, and implementation within different healthcare systems may further optimize rehabilitation delivery strategies for older adults recovering from hip fracture.

7. Conclusion

In conclusion, home-based rehabilitation following hip fracture surgery was associated with superior improvements in physical performance, functional independence and adherence compared with facility-based rehabilitation in this real-world comparative study. Moreover, home-based rehabilitation demonstrated cost-effectiveness over a 6-month period from a societal perspective. These findings support the potential role of home-based rehabilitation as a clinically effective and economically advantageous rehabilitation strategy for older adults recovering from hip fracture surgery, particularly within healthcare systems facing increasing demand for accessible and sustainable rehabilitation services.

Abbreviations

ADL
Activities of daily living
AUC
Area under the curve
BI

Barthel Index
CEAC
Cost-effectiveness acceptability curve
EQ-5D-5L
EuroQol five-dimensional five-level questionnaire
FES-I
Falls Efficacy Scale-International
ICER
Incremental cost-effectiveness ratio
IMC
Intermediate care
LMM
Linear mixed model
QALY
Quality-adjusted life year
SPPB
Short Physical Performance Battery
THB
Thai Baht

Declarations

Ethics approval and consent to participate

The study was conducted in accordance with the Declaration of Helsinki and was approved by the Mahidol University Central Institutional Review Board (COA No. MU-CIRB 2025/107.0304). Written informed consent was obtained from all participants prior to enrollment.

Consent for publication

Not applicable.

Generative AI Statement

During the preparation of this manuscript, the authors used ChatGPT (OpenAI) to improve language and readability. The authors reviewed and edited the content and took full responsibility for the content of the publication.

Competing interests

The authors declare that they have no competing interests.

Supplementary_Material

Supplementary files for this article include the separately uploaded document “Supplementary_Material”

Funding

This research was supported by the 60th Year Supreme Reign of His Majesty King Bhumibol Adulyadej Scholarship for the 2022 academic year, awarded by the faculty of graduate studies, Mahidol University.

Author Contribution

RJ conceived and designed the study, collected the data, performed the statistical analyses, interpreted the results, and drafted the manuscript. MV contributed to study supervision, interpretation of data, and critical revision of the manuscript. WK, PL, and PP contributed to data interpretation and critical revision of the manuscript. All authors read and approved of the final manuscript.

Acknowledgement

The authors would like to express their sincere gratitude to all patients and their caregivers for participating in this study. We also thank the rehabilitation staff and multidisciplinary healthcare team for their valuable support in data collection and patient care. In addition, we acknowledge the institutional support provided by our affiliated hospital and university, which made this research possible.

Data Availability

The datasets generated and analyzed during the current study are available from the corresponding author on reasonable request.

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Figures

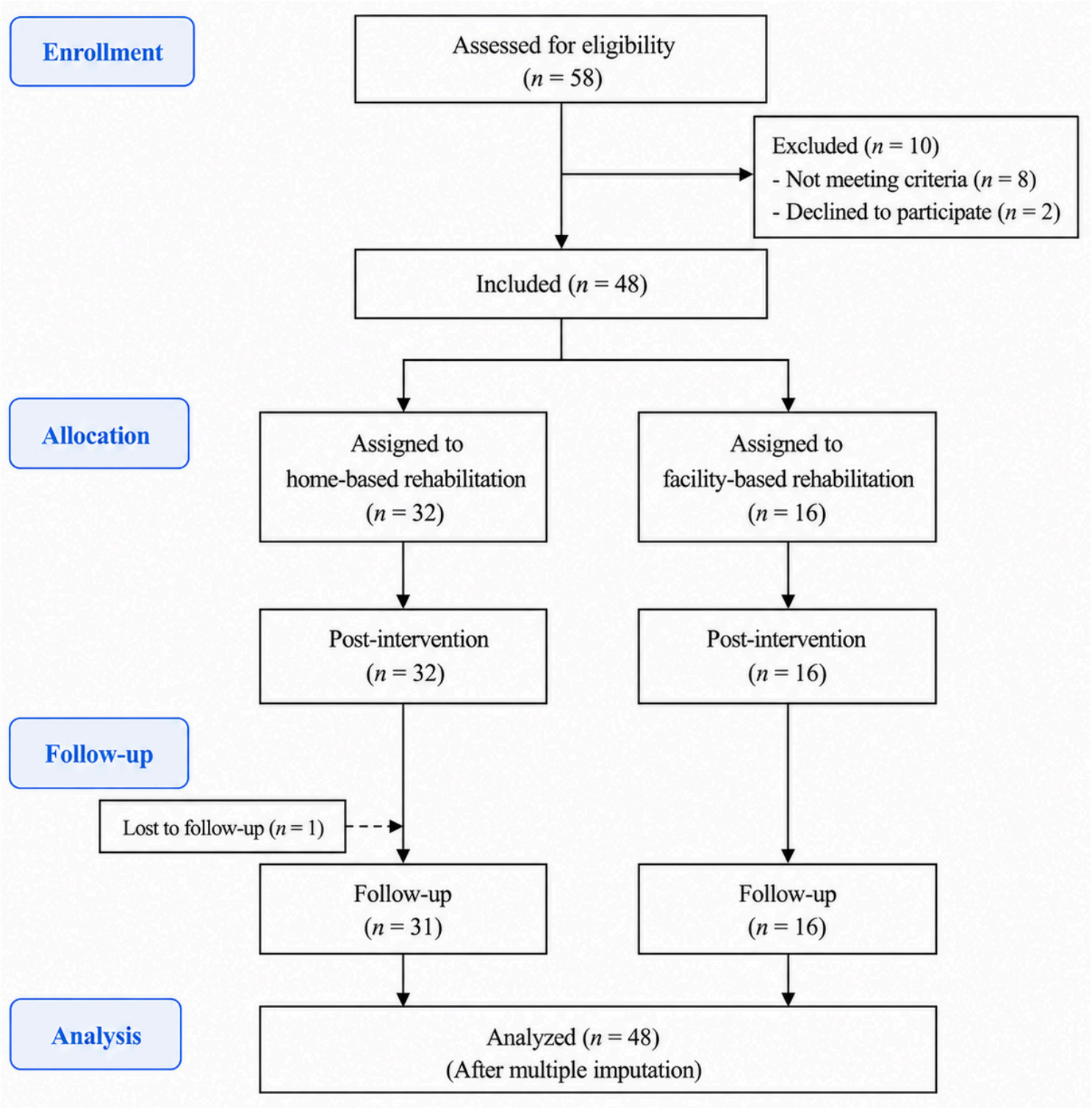


Figure 1

Procedure of study

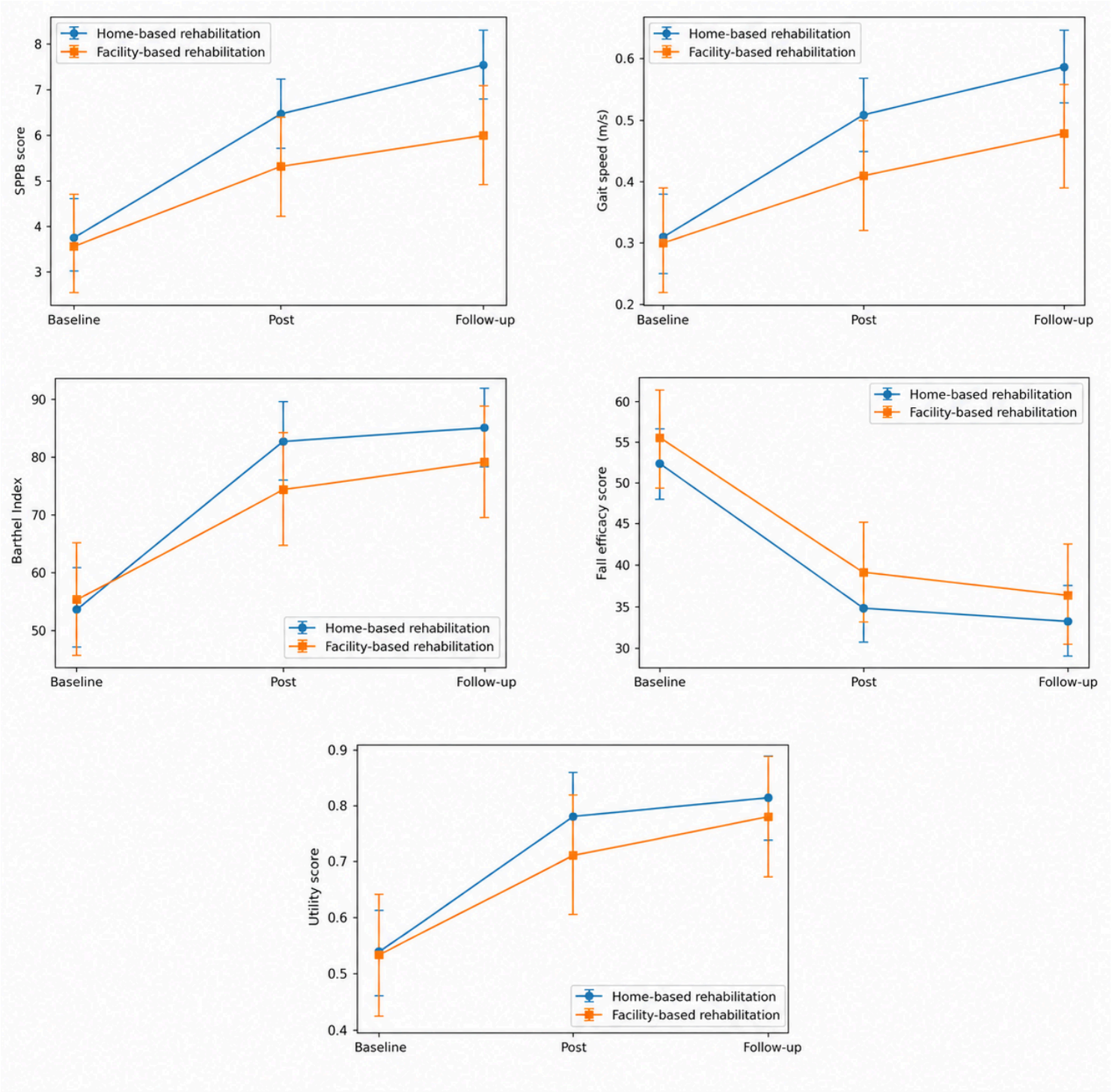


Figure 2

Estimated marginal means with 95% confidence intervals for clinical outcomes across baseline, post-intervention, and follow-up assessments in home-based and facility-based rehabilitation groups.

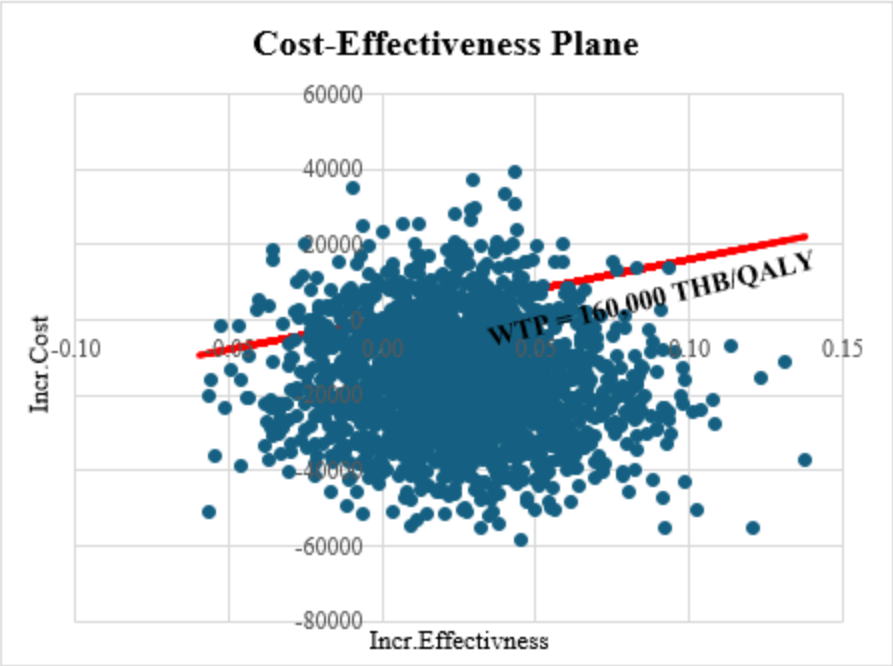


Figure 3

Cost-effectiveness scatter plot

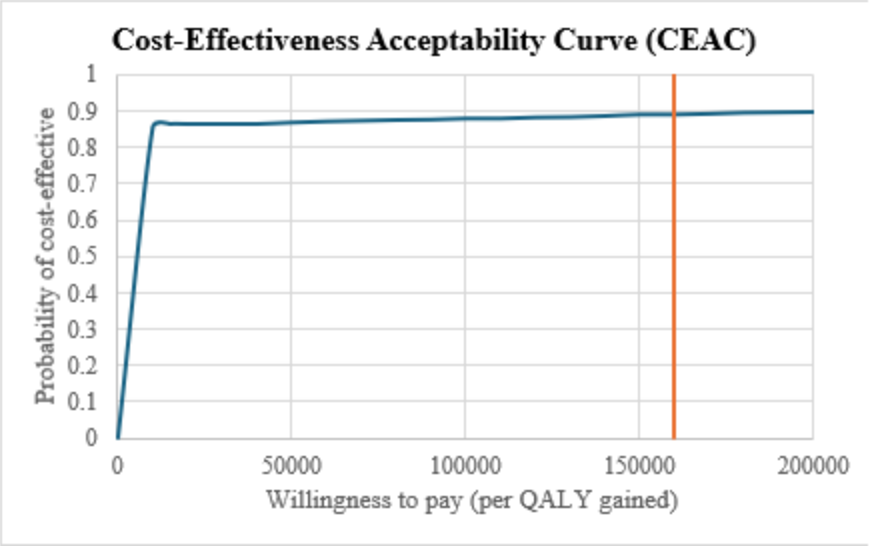


Figure 4

Cost-Effectiveness Acceptability Curve (CEAC)

Supplementary Files

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