Cost-Utility Analysis

Cost-Utility Analysis of Radiofrequency Ablation Among Facet Joint-Related Chronic Low Back Pain Patients in Thailand

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Background: Radiofrequency ablation (RFA) is a common secondary treatment recommended for facet joint-related chronic low back pain (CLBP). However, Thailand still lacks sufficient evidence of RFA's cost-effectiveness to support the decision to fund it.

Objective: To conduct a comparative economic evaluation of RFA and conservative treatment for CLBP patients over 16-month and 28-month time horizons in Thailand.

Study Design: A full economic evaluation encompassing measurements of both health utilities and health costs.

Setting: Data were collected from 3 university hospitals in Bangkok, Thailand: King Chulalongkorn Memorial Hospital, Siriraj Hospital, and Ramathibodi Hospital.

Methods: The cost-utility analysis, which used the Markov model, was developed according to the Thai health technology assessment guidelines and compared RFA and the best supportive care from the societal perspective. In the study, the population consisted of patients who had endured low back pain for more than 3 months despite receiving conservative treatment. The results were presented as an incremental cost-effective ratio (ICER) in Thai Baht (THB)/quality-adjusted life year (QALY). Scenario and sensitivity analyses were conducted.

Results: RFA was not cost-effective in Thailand when compared to conservative treatment, with a cost-effectiveness (CE) ratio of I$13,652 at all time horizons. The ICER of RFA was I$99,267 and I$52,380/QALY for the 16- and 28-month time horizons, respectively. In a scenario analysis in which RFA was repeated at 28 months and followed up to 52 months, the ICER was reduced to I$43,451. One-way sensitivity analysis showed that the ICER was most sensitive to the changes in utility parameters, the cost of RFA, and opportunity cost in the no-pain state.

Limitations: The study uses primary data to derive the utility value and determine the costs. However, the limitation includes a relatively small sample size and a short follow-up time for parameter inputs.

Conclusion: This study, the first economic evaluation of RFA for CLBP in Asia, showed that RFA was not cost-effective in Thailand. Price negotiation is recommended to make the intervention more cost-effective before it is included in the benefit package.

Key words: Low back pain, facet joint, radiofrequency ablation, cost-utility analysis, cost-effectiveness, low- and middle-income countries, quality-adjusted life year, Thailand

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Chronic low back pain (CLBP) is among the top 10 leading worldwide causes of years lost to disability (1). CLBP alone was responsible for a combined 65 million years of living with disability in 2017 (2). In Thailand, the 12-month prevalence of CLBP ranges between 20% and 56% (3-5), with an incidence of low back pain accounting for 33% of total back pain cases (3). CLBP not only impairs patients' quality of life but also exerts a substantial global economic burden by causing productivity losses through work-related absenteeism due to illness (6-9). Thus, the condition places immense strain on healthcare systems and societies, with productivity losses representing up to 80% of the total societal costs (10).

There is a need for access to effective CBLP treatments (11,12), and facet joint pain is one of the condition's leading causes, affecting up to 27%-41% of patients with CLBP (13). While conservative management for low back pain typically includes medications, physical therapies, and integrative treatments (exercise, heat or cold therapy, massage, acupuncture, nutrition, weight management, and sleep), international clinical practice guidelines (CPG) recommend nonsurgical interventional pain management strategies, such as radiofrequency ablation (RFA), as secondary treatment options (14,15) after 3 months of failed conservative treatment (16,17). Recent evidence demonstrates RFA's effectiveness in significantly reducing pain for up to one year, and the latest updated guidelines of the American Society of Interventional Pain Management recommend RFA for facet joint pain with a level of evidence II and a moderate strength of recommendation (13,18).

However, the high cost of RFA poses challenges to reimbursement due to the high burden of disease. In 2019, the Thai Association for the Study of Pain (TASP) proposed RFA for patients with CLBP as a potential treatment to include in the Universal Coverage Scheme (UCS), through the Universal Coverage Benefit Package (UCBP) process. RFA has demonstrated sufficient evidence of effectiveness, particularly for CLBP originating from facet joints (16,17,19). Currently, RFA for CLBP patients is not part of Thailand's UCS, and evidence of its cost-effectiveness is not available in the context of low- and middle-Income countries (LMICs). Therefore, to inform reimbursement decisions, this study aimed to compare the cost-utility of RFA for facet joint-related CLBP patients to that of conservative treatment in Thailand.

Methods

Study Design

This study followed Thailand's methodological guidelines for conducting a health technology assessment (HTA) (20). At the inception of the study in June 2021, following a consultation consisting of Thai clinical expert stakeholders, a cost-utility analysis was conducted from a societal perspective (21). The intervention under consideration was conventional RFA administered after a positive response to a diagnostic lumbar medial branch block (MBB) (Supplement 1). The decision to limit the number of diagnostic blocks to one was made in consultation with clinical experts and as reported in the literature (15). In our model, we assumed that all positive MBB patients would receive RFA. RFA was compared to usual care, referred to as "conservative treatment," which, according to the TASP guidelines, included pharmacological (pain medications, etc.) and nonpharmacological therapies (physiotherapy, guided exercise, etc.). The population consisted of patients with CLBP originating from lumbar facet joints that had persisted for more than 3 months despite receiving conservative therapy.

Given the time-limited nature of pain relief after RFA, typically spanning from 12 to 28 months (11,22,23), 2 time horizons were chosen to evaluate the cost-effectiveness at the base case. These horizons reflected the effectiveness of both RFA and the positive diagnostic block, which were agreed upon during the initial stakeholder meeting and based on existing evidence from the literature (15,24). The base case

assumed a single administration of intervention, with time horizons set at 16 and 28 months (25). Additionally, a scenario analysis considering a longer time horizon of 52 months (26) wherein a second RFA was given to patients was incorporated. The study adopted a cycle length of one month, to reflect the average follow-up time point for CLBP in Thailand.

The cost-effectiveness (CE) threshold of 160,000 Baht/QALY (I$13,652) was used in this study. Although the Thai HTA guideline recommended using a 3% discount rate for both costs and outcomes, this study did not apply the discount in the analysis due to the short time horizons. This decision was made because almost all cost parameters were obtained from either hospital databases or through data collection in the years of 2022 and 2023. The outcomes of the study were the length of life, measured in years, and the quality of life, measured in health utility. In addition, the Consolidated Health Economic Evaluation Reporting Standards 2022 (CHEERS 2022) (27) were followed. These standards are provided in Supplement 2.

The Markov model was adapted from a previous study by NICE (25). The model had 3 exclusive health states: pain, no pain (relief), and death. Patients have a probability of transitioning to either the "no pain" (P1) or "pain" state (P2) depending on the treatment efficacy seen in the first month after the intervention (Fig. 1). Patients who enter the "no pain" state can either remain there (P5) or transition to a state of pain remission (P3). Patients who receive RFA and transition to the "pain" state can persist in it (P6) if they do not recover, or they may move to the "no pain" state (P4) once the effects of RFA start to show. All patients could transition to the death state, based on general mortality probabilities.

A variety of approaches were used to synthesize parameter inputs (Table 1). Transitional probability values for different health states were derived from the literature review that reported numbers of successful cases of RFA treatment (28-31). All the studies incorporated were randomized control trials (RCTs), comparing RFA to sham treatments or to conservative standard care. Beta distributions were assigned to probability parameters, and the mean and standard error (SE) for each transition probability was calculated using fixed-effect alpha and beta values from the literature (28-31) to different follow-up time points of 3, 6, 9, 12, and 24 months.

Treatment efficacies were determined similarly to the transition probabilities, albeit while using alpha and beta values from the first 3-month follow-up point. The 3-month probabilities of treatment success were converted into monthly rates and subsequently monthly probabilities. Those values of the first month were used to represent the treatment efficacy. Baseline mortality was obtained from the 2014 report on Thailand's burden of diseases (Supplement 3) (32).

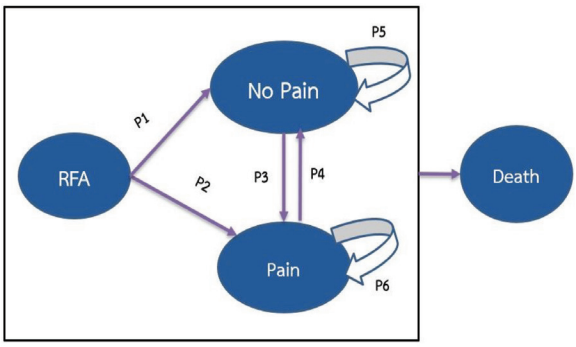

Fig. 1. *A Markov model illustrating the flow of the patients in each health state.*

Study Setting

The parameters of cost and health utilities were collected from 3 university hospitals in Bangkok, Thailand: King Chulalongkorn Memorial Hospital, Siriraj Hospital, and Ramathibodi Hospital. We interviewed a total of 64 eligible patients (31 patients in the RFA group and 33 patients in the conservative group) who met our inclusion criteria (Supplement 3).

To assess direct nonmedical costs, including the costs of travel, meals, and accommodation, we employed a Thai questionnaire for both patients and their accompanying relative(s) during each visit. The opportunity cost of taking work leave for the hospital visit was calculated based on absenteeism, using the Work Productivity and Activity Impairment Questionnaire: General Health V2.0 (WPAI-GH) (33).

Direct medical costs were retrieved from the hospitals' claim databases, using unique hospital numbers (HN) to match the recruited patients. The direct medical costs were disidentified and organized in an aggregate form, separated between main intervention costs per time (including RFA, MBB, and conservative treatment) and one-time procedural doctor fees. Other direct medical costs (e.g., follow-up and service fees, or other minor palliative care) were also included. The aggregate costs incurred during each hospital visit were assumed to represent the monthly direct medical

Table 1. *Summary of parameter inputs used in the analysis.*

Parameter	Mean	Standard Error	Distribution	References
Clinical parameters				
Prevalence of CLBP (age-standardized)	7.0%			(39)
Incidence of CLBP (age-standardized)	3.1%			(39)
Proportion of facet joint origin CLBP (within CLBP)	42%			(38)
Mortality rate of Thai population (age-specific)	Supplement 3			(29)
Probabilities of Changing Health States (RFA Treatment)				
Probability of pain relief at months one-3	0.200	0.012	Beta	(28-31)
Probability of pain relief at months 4-6	0.127	0.007	Beta	
Probability of pain relief at months 7-9	0.076	0.006	Beta	
Probability of pain relief at months 10-12	0.051	0.003	Beta	
Probability of pain relief at months 13-24	0.008	0.003	Beta	
Probability of returning to pain at months 1-3	0.108	0.021	Beta	
Probability of returning to pain at month 4-6	0.038	0.011	Beta	
Probability of returning to pain at months 7-12	0.018	0.006	Beta	
Probability of returning to pain at month 13-24	0.039	0.005	Beta	
Probabilities of Changing Health States (Conservative Treatment)				
Probability of pain relief at months one-3	0.147	0.011	Beta	(28-31)
Probability of pain relief at months 4-6	0.081	0.007	Beta	
Probability of pain relief at months 7-9	0.072	0.006	Beta	
Probability of pain relief at months 10-12	0.038	0.003	Beta	
Probability of pain relief at months 13-24	0.001	0.001	Beta	
Probability of returning to pain at months 1-3	0.216	0.023	Beta	
Probability of returning to pain at months 4-6	0.149	0.015	Beta	
Probability of returning to pain at months 7-12	0.101	0.009	Beta	
Probability of returning to pain at month 13-24	0.072	0.006	Beta	
Treatment Efficacy Parameters				
RFA success rate (measured after one month)	0.200	0.0345	Beta	(28-31)
Conservative treatment success rate (measured after one month)	0.147	0.0336	Beta	
Cost Parameters (I$, Year 2022-2023)				
Direct Medical Costs: Procedural Costs				
RFA (package including MBB and one-time doctor fee for the procedure), price/time	4,897	400	Gamma	Hospital databases
Conservative treatment, price/time	515	40	Gamma	
Direct Medical Costs: Additional Treatments/Services				
Medical expenses incurred by patients in pain state (e.g., follow-up visits, medications, etc.) after the procedure	258	75	Gamma	Hospital databases
Medical expenses incurred by patients in pain relief state (e.g., doctor visits, medications, etc.)	128	31	Gamma	
Direct Nonmedical Costs of Patients: Travel, Food, Accommodation (If Any)				
Incurred cost in pain state	32	32	Gamma	Primary data collection
Incurred cost in pain relief state	15	15	Gamma	
Direct Nonmedical Costs of Patients' Relative(s): Travel, Food, Accommodation (If Any)				
Incurred cost in pain state	38	10	Gamma	Primary data collection
Incurred cost in pain relief state	33	8	Gamma	

Table 1 cont. *Summary of parameter inputs used in the analysis.*

Parameter	Mean	Standard Error	Distribution	References
Opportunity Costs from Taking Work Leave for Hospital Visit				
Patients in a pain state	89	55	Gamma	Primary data collection
Patients in a pain relief state	198	90	Gamma	
Utility Parameters				
Pain state (n = 35)	0.64	0.03	Beta	Primary data collection
Pain relief state (n = 29)	0.74	0.04	Beta	

Note: The criterion for declaring that patients were in the pain state was a pain score of 4 or above (out of 10). Thailand's CE threshold is approximately I$13,652 per QALY gained. All costs are converted to I$ using the PPP conversion rate of I$1 = THB 11.72.

costs of patients, respectively to their health state (a patient pain score above 4 out of 10 was considered a pain state). If applicable, all costs were converted to 2022 values using the Thai consumer price index and presented in Thai Baht (THB). To ensure comparability, all THB values are hereby converted to international dollars, using purchasing power parity at a conversion rate of THB 11.7236 = 1 international dollar (Intl $) in 2022 (34).

The utility values representing patients' health states were derived from primary data collected using the EQ-5D-5L (Thai version) (35). The same cohort as the cost parameter data collection was recruited (n = 64), although the utility score was collected based on patient health states, using the NRS pain score at the time data were collected (i.e., pain if NRS ≥ 4 and no pain if NRS < 4). The quality of adjusted life years (QALYs) were calculated using the following formula:

QALY = years of life × health utility

The incremental cost-effectiveness ratios (ICERs) represent the average incremental cost in relation to one additional unit of the measure of effect, which in this case is the QALY. ICERs were calculated by dividing the difference in total adjusted costs by the difference in total adjusted QALYs. The ICER values of RFA relative to conservative treatment were compared to the CE threshold to determine whether RFA was cost-effective (ICER below the threshold).

Uncertainty Analysis

Parameter uncertainty was assessed through deterministic one-way sensitivity analysis (OSA) to identify the most influential parameters. The results were ranked in a tornado diagram. A probabilistic sensitivity analysis (PSA) with 1,000 Monte Carlo simulations (second order) was run for 95% confidence that the median was among the 49th and 51st percentile (36). The median was presented as the cost-effectiveness acceptability curves, indicating probabilities that RFA was cost-effective compared to conservative treatment at different CE thresholds.

Threshold Analysis

A threshold analysis was also performed to compare different purchasing prices of RFA intervention (including MBB) and determine at which price RFA could become cost-effective.

Expected Value of Perfect Information (EVPI)

Due to some data limitations, it was important to assess whether additional data/information collection would be warranted before making a policy decision based on the results of this study. Expected (monetary) value of perfect information (EVPI) analyses were performed to estimate the value of acquiring further data/information (37) at a given CE threshold. This study performed both a full EVPI (all parameters considered simultaneously) and a partial EVPI (one parameter was considered at a time) analysis. The total number of patients eligible for RFA was estimated from the prevalence of facet joint-related CLBP using a previous local study and the Global Burden of Disease database (37, 38). Using the Thai CE threshold, a 100-time simulation was run for the full EVPI analysis. In the partial analysis, 100 cycles were set for the inner and outer loops at the threshold with the maximum EVPI to identify which parameter (among those identified by the OSA) had the highest EVPI.

Model Validation

Face validation was ensured through 2 stakeholder meetings. The first meeting was conducted in June 2021, at the beginning of the study, to confirm its methodological approach and review its scope (population, intervention, comparison, outcome [PICO]), model structure, time horizon, cycle length, and potential sources of input parameters. The stake-

holders reconvened in March 2023, toward the end of the study, to verify the parameters used, validate the preliminary results, and fine-tune policy recommendations. The internal validity of the formulas and methods for calculating cohort numbers in economic models was also examined.

Results

Base Case Analysis

As shown in Table 2, the health benefits of RFA were illustrated in terms of pain relief and increased QALY gained. With the higher efficacy, there were greater proportions of patients who recovered from pain or remained in the pain relief state after receiving RFA, compared to receiving conservative treatment. However, these benefits were marginal compared to the incremental costs incurred, which resulted in estimated ICER values of I$99,267 (THB 1,16,3413) and I$52,380 (THB 613,879)/QALY for the 16- and 28-month time horizons, respectively. Because only one RFA procedure per patient was assumed in the base case, the incremental costs were not increased with longer time horizons. Instead, the overall costs were lower, since RFA reduced related expenses, including travel and additional treatments, over the long term.

Scenario Case

In the scenario case, patients who were in the pain state at the 28th month were allowed to undergo a repeat RFA procedure. During the time horizon of 52 months, greater health benefits associated with RFA were observed, with 54% of the patients recovering from pain. However, RFA in the scenario case yielded an ICER value of I$43,451 (THB 509,248)/QALY, which was lower than the 2 in the base case.

Uncertainty Analysis

Results from the probabilistic sensitivity analysis (PSA) were presented as the cost-effectiveness acceptability curves (Figs. 2-4). With an average price of I$4,897/time (including RFA, MBB, and procedural doctor fee) at the Thai CE threshold, RFA was unlikely to be cost-effective at the base case (16- and

Table 2. *Health outcomes and incremental cost-effectiveness ratio for conventional RFA (probabilistic analysis).*

	Conservative Treatment (Current Practice)	RFA
Base Case		
Proportion of patients in pain state at 16 months (%)	69.4	45.1
Proportion of patients in pain relief state at 16 months (%)	30.3	54.6
Proportion of patients in dead state at 16 months (%)	0.3	0.3
Incremental QALY	-	0.04
Incremental cost (I$)	-	4,007
ICER (I$/QALY gained)	-	99,267
Proportion of patients in pain state at 28 months (%)	75.3	48.4
Proportion of patients in pain relief state at 28 months (%)	24.4	51.4
Proportion of patients in dead state at 28 months (%)	0.3	0.3
Incremental QALY	-	0.07
Incremental cost (I$)	-	3,728
ICER (I$/QALY gained)	-	52,380
Scenario Case (Repeat RFA)		
Proportion of patients in pain state at 52 months (%)	70.5	45.4
Proportion of patients in pain relief state at 52 months (%)	29.2	54.3
Proportion of patients in dead state at 52 months (%)	0.3	0.3
Incremental QALY	-	0.12
Incremental cost (I$)	-	5,139
ICER (I$/QALY gained)	-	43,451

Note: Starting age of the cohort was 35 years old; QALY: quality-adjusted life-years; ICER: incremental cost-effectiveness ratio. Societal perspective was used for the analysis; ICER values were reported from probabilistic analyses; Thailand CE threshold was approximately I$13,652 per QALY gained.
The values in this table have been converted from THB to I$ using the PPP conversion rate of I$1 = THB 11.72.

28-month time horizon) or in a scenario involving a repeat RFA procedure (52-month time horizon). However, RFA had a 50% probability of being cost-effective at 28 months, in a scenario in which the Thai cost-effectiveness threshold was increased fourfold. Similarly, results from the OSA (Fig. 5) suggested that there was no parameter for which RFA might become cost-effective (altered ICER to I$13,652/QALY) at each time horizon. Across all time horizons, the utility values of the pain and no-pain health states emerged as the top 2 parameters most capable of altering RFA's ICER values. It is noteworthy that over a short time horizon of 16 months, the cost of RFA ranked third among the most influential parameters on the ICER values. However, at longer time horizons (28 and 52 months), the opportunity cost of remaining in the no-pain state superseded the cost of RFA, becoming the parameter with the third greatest effect on the ICER values of RFA.

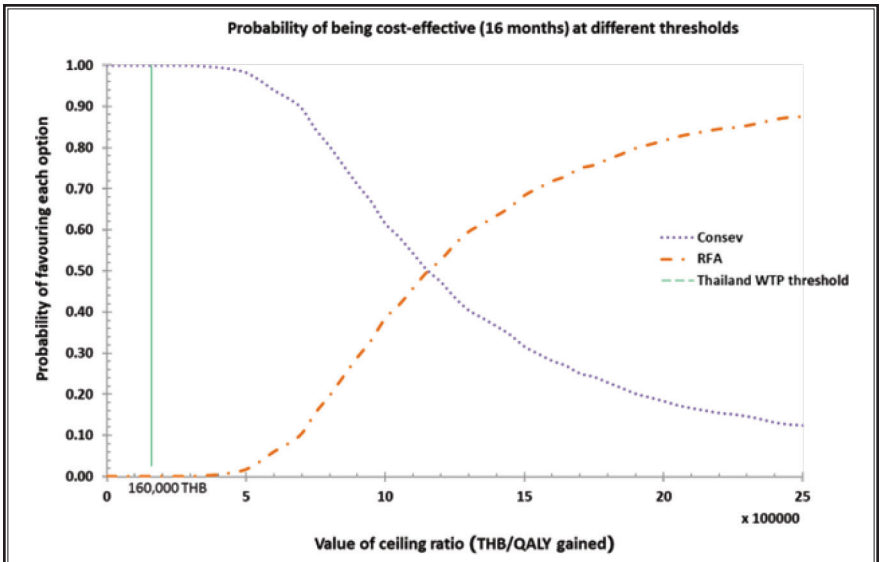

Fig. 2. *Cost-effectiveness acceptability curve of different thresholds at a 16-month time horizon.*
†All the values presented in the graph are in THB (one THB = I$11.72).

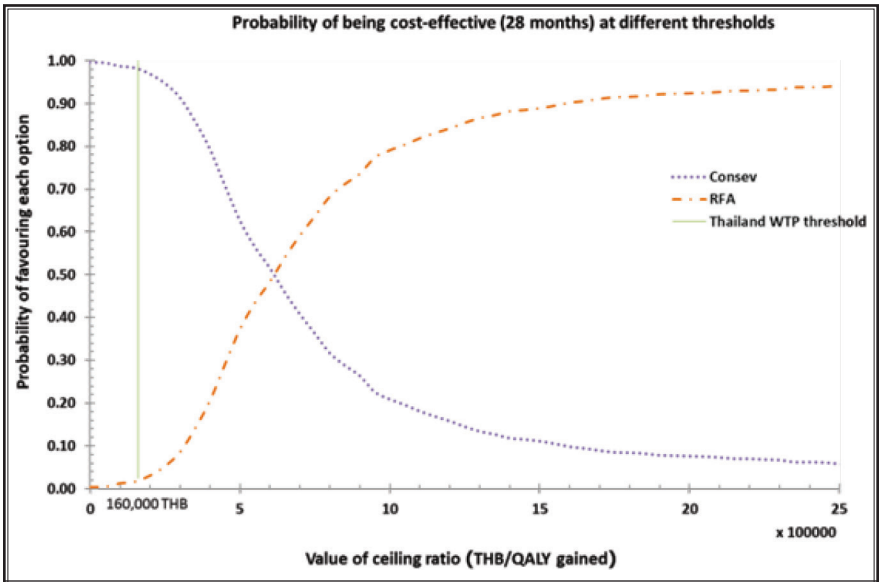

Fig. 3. *Cost-effectiveness acceptability curve of different thresholds at a 28-month time horizon.*
†All the values presented in the graph are in THB (one THB = I$11.72).

Threshold Analysis

Threshold analysis for the RFA cost was conducted, since it was one of the parameters that influenced the ICER value of RFA in the base case. At the CE threshold, the average price of RFA intervention should be lowered to I$1,158 and I$1,779 THB for the procedure to have a 50% chance of being cost-effective at 16- and 28-month time horizons, respectively.

Expected Value of Perfect Information (EVPI) Analysis

At the Thai CE threshold of I$13,652, the population EVPI for the base case ranges from I$1.6 million to I$35.9 million at the respective time horizons of 16 and 28 months (Supplement 4). For repeat RFA with a time horizon of 52 months, the population EVPI is equivalent to I$76.3 million. The partial EVPI at the current CE threshold indicates that acquiring addi-

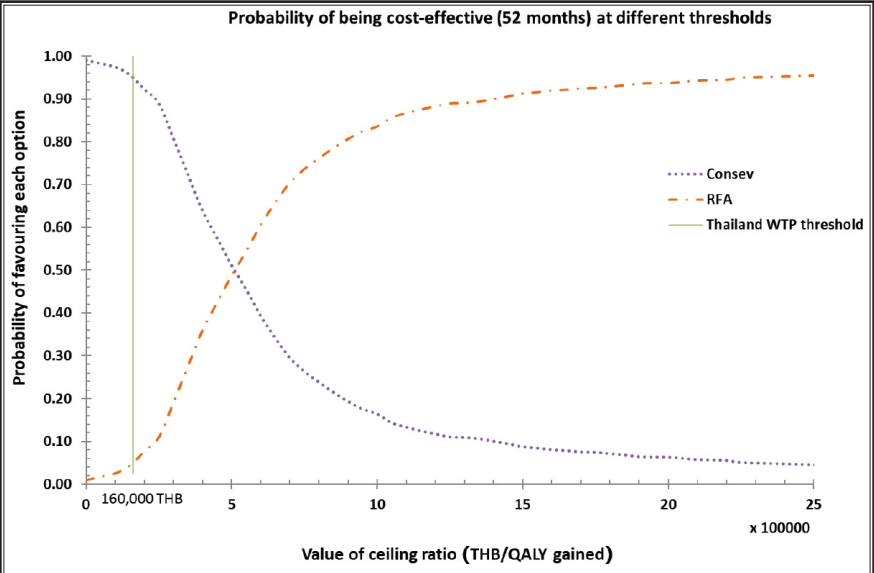

Fig. 4. *Cost-effectiveness acceptability curve of different thresholds at a 52-month time horizon (repeated RFA).*
†All the values presented in the graph are in THB (one THB = I$11.72).

tional information, particularly for parameters most sensitive in OSA, such as utility values and the opportunity cost associated with the health states of pain and no pain, would yield no added value across all time horizons. However, when the CE threshold was increased threefold to I$42,662 for the time horizons of 28 and 52 months, the greatest uncertainty lay in the opportunity costs of patients in a no-pain state and the utility values of patients experiencing pain. These uncertainties amounted to a respective I$248.4 million and I$202.8 million at 52 months and a respective I$34.4 million and I$45.2 million at 28 months. In contrast, for the base case scenario at the 16-month time horizon, even with the increased CE threshold, the partial EVPI for selected parameters remained zero (Supplement 5).

Discussion

This study represents the first attempt to assess the comparative cost-effectiveness of RFA and conservative treatment for facet joint-related CLBP patients within the Southeast Asian region and the context of an LMIC. Our findings from the base case analysis, considering both 16-month and 28-month time horizons, indicate that RFA, at the current Thai CE threshold of I$13,652, is unlikely to be cost-effective.

When we extended the time horizon to 28 months, a slight decrease in RFA's ICER value was estimated, although it did not become cost-effective compared to conservative treatment. This shift was primarily attributed to the reduction in other direct medical and nonmedical costs associated with the implementation of RFA. This study did not adopt a lifetime horizon in its analysis, primarily because the interventions and the pain condition had no impact on patients' mortality, and the outcomes eventually converged in terms of the patients' pain states, costs, and health effects (25). Additionally, the decision to use 2 time horizons in our base cases was informed by the limited evidence on the extended effectiveness of RFA and expert consultation during stakeholder meetings (28-31).

A scenario analysis that used a 52-month time horizon and allowed patients who had persisted in the pain state at the 28th month to undergo a repeat RFA indicated a higher incremental QALY gain (0.12) than the base case. However, the resulting ICER value remained above the Thai CE threshold (I$43,451) and was thus not cost-effective. This time horizon was used as a scenario case rather than a base case because relatively few proportions of patients undergo repeat RFA, and the treatment effectiveness of repeat RFA is unclear. Besides, there is limited evidence on how often the RFA can be repeated in a lifetime to the point of it serving the intended purpose.

The OSA revealed that at all time horizons, the major drivers were the utility values of pain and opportunity cost in no-pain state. Interestingly, while the cost of RFA emerged as the third most influential factor over a shorter time horizon, opportunity costs in the no-pain state and other direct medical costs exhibited a greater influence on the shifting ICER value over longer periods (28 and 52 months). This finding was partly due to the difference in the proportion of RFA patients who remained in the no-pain state as compared to those who stayed there after receiving conservative treatment. Contrary to general expectations, patients in the pain state tended to have a lower opportunity cost related to work absenteeism than did those in the no-pain

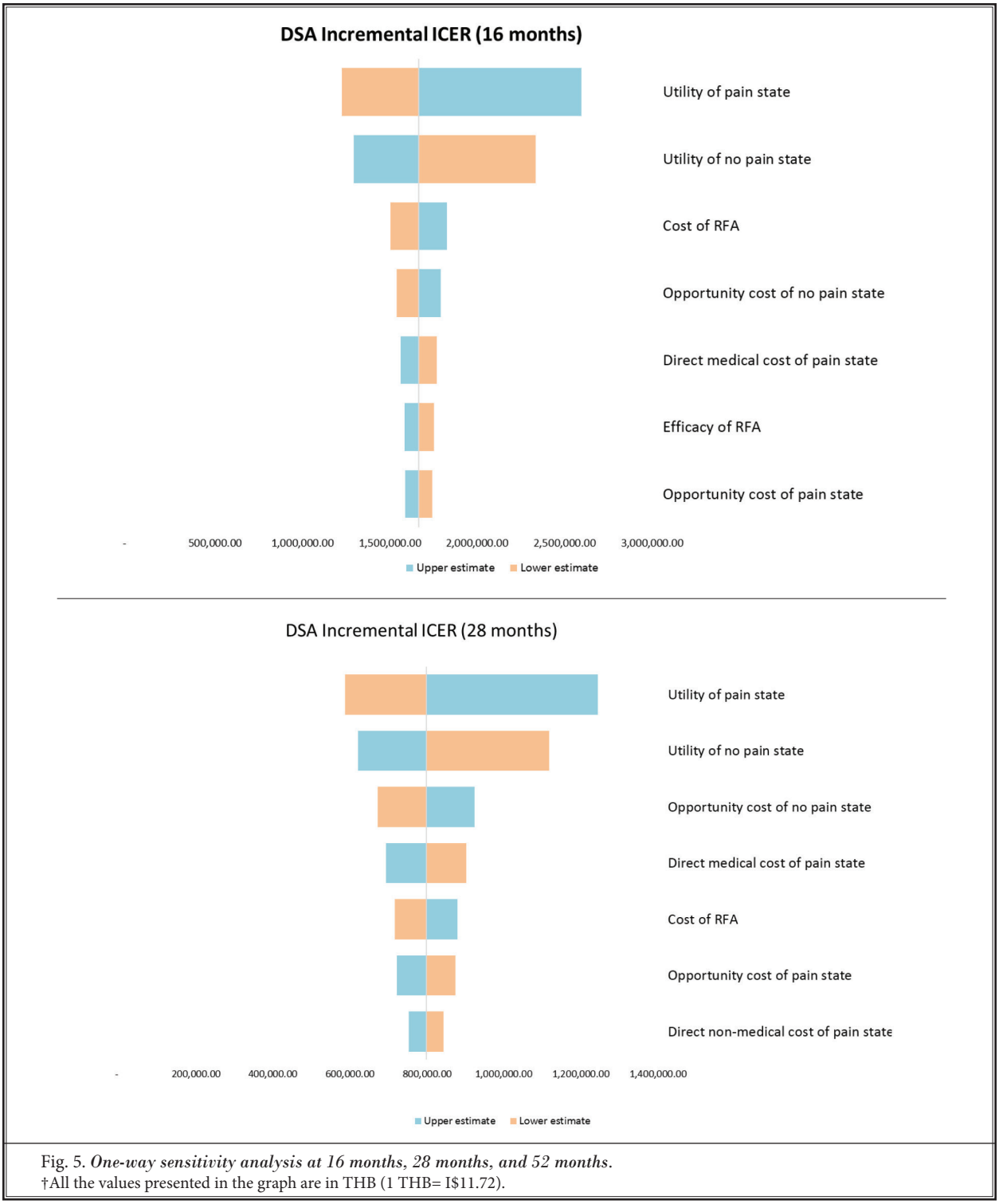

Fig. 5. *One-way sensitivity analysis at 16 months, 28 months, and 52 months.*
†All the values presented in the graph are in THB (1 THB= I$11.72).

state, though this was because our sample comprised a notable number of patients in the pain state who had no working hours due to factors such as unemployment or retirement. We also found that many of the patients in the pain state had pain scores of approximately 5 to 6 points out of 10, reflecting a relatively low severity

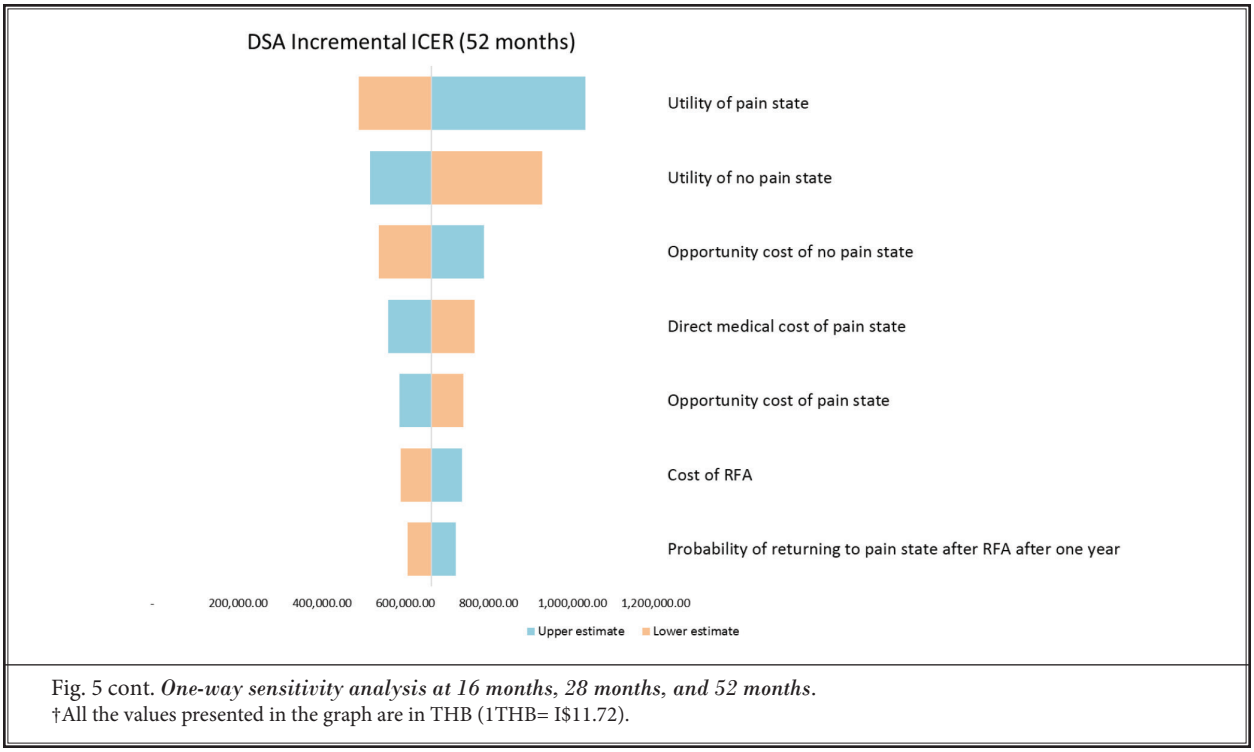

Fig. 5 cont. ***One-way sensitivity analysis at 16 months, 28 months, and 52 months.***
†All the values presented in the graph are in THB (1THB= I$11.72).

of the condition, which might not have affected their absenteeism significantly.

RFA's current price is I$4,897 per procedure, so the inclusion of RFA in the UCBP could have significant budget implications due to the high incidence of CLBP patients (38). Therefore, for the payer—i.e., the National Health Security Office (NHSO)—negotiating to reduce the procurement cost by 78% (I$1158) could yield greater long-term benefits. The negotiated price would not only improve patient access but could generate economies of scale, justifying the impact on the budget.

Our findings contrast with the study by NICE (39), which concluded that RFA was cost-effective in their base case and sensitivity analysis. However, the NICE study's main limitation regarding utility score and effectiveness data was addressed in our study, including collecting patients' primary cost-utility data from them directly and selectively incorporating RCTs that aligned with Thai clinical recommendations. Although the MINT trial (40), like our study, concluded that RFA was not cost-effective, those results needed to be interpreted with caution (41). The limitations of the MINT trial, such as the patient selection process, RFA process, and data collection, were addressed in our study by adhering to the best practices for RFA according to Thai clinical settings and protocol.

The strength of this study lies in the primary data collection, in which we gathered utility and cost data directly from patients across 3 major tertiary care hospitals in Thailand. We minimized recall bias by acquiring data within a 3-month window during patient follow-up. By adopting a societal perspective, patients' time was valued irrespective of their employment status. Moreover, the selection process in our clinics adhered strictly to the international guidelines (16,17,42) and was supervised by clinical experts, enhancing the generalizability of our results beyond the Thai context. Secondly, adhering to Thai HTA methodological guidelines and incorporating stakeholders' opinions from design to validation ensured the study's relevance and alignment with the Thai healthcare system. Given the uncertainty of the evidence of clinical effectiveness and a lack of consensus on clinical guidelines, this step was particularly important.

However, this study has its limitations. These include, firstly, its relatively small sample size, primarily because of the limited number of patients receiving RFA in current clinical practice. This dearth is largely due to RFA's currently nonreimbursable status under the UCS. Secondly, the timing of the data collection, which took place shortly after the COVID-19 pandemic, might have further impacted patient participation. Indeed, as suggested by the EVPI, the cost of research is high, ranging

from I$1.6 million to I$35.9 million to I$76.3 million at 16- 28-, and 52-month time horizons. The cost of reducing the uncertainty of RFA's outcomes if the procedure were to be included the health benefit package at the current Thai CE threshold would also be high. While EVPI is not prescriptive, the partial EVPI suggests that the greatest value lies in obtaining more information specifically on opportunity cost in the no-pain state and utility value in the pain state at longer time horizons of 28 and 52 months. Learning more about these parameters will present us with additional values informing decisions on RFA policy. Secondly, there has been an ongoing debate on diagnostic criteria, particularly on the ideal cutoff for designating a block as positive and the optimal number of blocks that should be performed with no consensus achieved (43-46). While stringent diagnostic criteria such as 80% cutoff and the use of double diagnostic bocks have been associated with a high success rate for RFA, the increased false negative rate and higher cost of intervention may potentially limit RFA's inclusion in the health benefits package (15,24,45). Thus, based on the recommendations from Cohen et al (15) and stakeholder consultations on current practice in Thailand, our study opted to include RFA after a single diagnostic MBB block at a cutoff threshold of 50%. Nonetheless, to assess the completeness of this assumption, a scenario analysis was performed (Supplement 6) that compared our findings using a single diagnostic block with those obtained using a double diagnostic block prior to RFA intervention. Naturally, the overall cost of intervention would be higher with the latter option (i.e., RFA after a double diagnostic block) due to the additional MBB block, and yet our results were comparable in terms of ICERs.

Although RFA is not cost-effective in the base case (16 months and 28 months) or the scenario case (52 months), there is merit in delving into applications of RFA for other indications, such as knee osteoarthritis. Negotiations to lower RFA procurement costs could facilitate its broader implementation, yielding economies of scale and scope, thus enhancing patient access. Future research should consider the potential opportunity costs from the health care system's perspective and further investigate RFA's capacity to reduce medically unnecessary low-back surgeries, thereby maximizing its value within the Thai health care context and minimizing the opportunity cost of RFA. The necessity of surgeries on the low back is a concern frequently raised by clinicians and reported in the literature (47). This aspect is particularly important in the context of the Thai health system, since patients with CLBP may also be referred for back surgery, which is reimbursable under the UCS, while RFA is not. Therefore, further investigations should endeavor to explore this dimension to gain a better understanding of the true value of RFA.

Conclusion

In conclusion, the study evaluated the cost-effectiveness of RFA for facet joint-related CLBP in Thailand and found that the procedure was unlikely to be cost-effective at the current CE threshold. However, on the conditions that pain relief was sustained and the cost of the intervention was lowered, the possibility that RFA could become more cost-effective increased, since RFA helped reduce other medical and nonmedical costs in the long term. The study also highlighted the importance of considering utility values, opportunity costs, and direct medical costs when evaluating the cost-effectiveness of RFA. Additionally, the study recognized that RFA therapy resulted in better health outcomes than did the current standard treatment and that RFA helped reduce the budget burden of medical expenses from pain and potentially unnecessary back surgeries. Hence, RFA should be considered for incorporation into the Thailand health benefit package. Given the current price of RFA intervention, the Thai public payer, NHSO, should further negotiate with hospitals and private companies to reduce the purchasing price of RFA machines and the intervention cost, making the procedure more cost-effective and lowering the overall budget impact. Ongoing effectiveness evaluation, data collection and monitoring, and accessibility of RFA measures are also recommended for further studies.

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Author Declarations

Ethics Approval

Ethical approvals were received from the data collection sites, the Ethics Committee of the Faculty of Medicine, Chulalongkorn University (COA No. 1693/2022) and the Ethics Committee of Multicenter Research Mahidol University (COA. MURA2022/718).

Consent to Participate

All patients were informed of the benefits and risks of taking part in the study. Written consent was provided by each patient before enrollment.

Author Contributions

Conceptualization: YT, DB, MS, PC, PE, KP, SN. Methodology: MS, DB, PC, PE, KP, SN. Formal analysis and investigation: MS, CP, DB, PC, PE, KP, SN. Original draft preparation: MS DB, MK, MN, CP. Review and editing: all co-authors. Funding acquisition: YT. Project administration: MK, MS, CP, MN, DB. Supervision: YT.

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Supplement 1

RFA Intervention

The proposed intervention was conventional RFA after a positive response to a diagnostic block of MBB. RFA was an outpatient procedure performed generally under local anesthesia with or without mild sedation. Before the actual treatment began, the site of injection was confirmed using an imaging guidance represented by fluoroscopy. Alternatively, in more advanced centers, the imaging used was CT-guided. An 18–22-gauge RF cannula with a 10 mm active tip was then advanced toward the confirmed site for the application of RFA. The temperature recommendation used in conventional RFA was 80° C, applied for 90-180 seconds (48). The patient was observed for immediate follow-up and discharged from the clinic within 2 hours. The pain relief typically lasted from 3-12 months after the application of RFA, and if needed, the process was repeated in case of future pain complaint (49).

Conservative Treatment (Comparator)

The comparator was conservative treatment, which could include pharmacological (pain medications, etc.) and non-pharmacological therapies (physiotherapy, guided exercise, etc.). However, nonconservative treatments, such as spinal fusion surgery, were not considered.

Supplement 2. *CHEERS 2022 Checklist*

Topic	No.	Item	Location where item is reported
Title			
	1	Identify the study as an economic evaluation and specify the interventions being compared.	Title Page
Abstract			
	2	Provide a structured summary that highlights context, key methods, results, and alternative analyses.	Abstract
Introduction			
Background and objectives	3	Give the context for the study, the study question, and its practical relevance for decision making in policy or practice.	Introduction
Methods			
Health economic analysis plan	4	Indicate whether a health economic analysis plan was developed and where available.	Methods
Study population	5	Describe characteristics of the study population (such as age range, demographics, socioeconomic, or clinical characteristics).	Supplemental files
Setting and location	6	Provide relevant contextual information that may influence findings.	Methods
Comparators	7	Describe the interventions or strategies being compared and why chosen.	Methods
Perspective	8	State the perspective(s) adopted by the study and why chosen.	Methods
Time horizon	9	State the time horizon for the study and why appropriate.	Methods (parameters and outcome measurement)
Discount rate	10	Report the discount rate(s) and reason chosen.	Methods (parameters and outcome measurement)
Selection of outcomes	11	Describe what outcomes were used as the measure(s) of benefit(s) and harm(s).	Methods (parameters and outcome measurement)
Measurement of outcomes	12	Describe how outcomes used to capture benefit(s) and harm(s) were measured.	Methods (parameters and outcome measurement)
Valuation of outcomes	13	Describe the population and methods used to measure and value outcomes.	Methods (parameters and outcome measurement)
Measurement and valuation of resources and costs	14	Describe how costs were valued.	Table 1 summary of parameter inputs used in the analysis.
Currency, price date, and conversion	15	Report the dates of the estimated resource quantities and unit costs, plus the currency and year of conversion.	Methods (parameters and outcome measurement)
Rationale and description of model	16	If modelling is used, describe in detail and why used. Report if the model is publicly available and where it can be accessed.	Methods (model structure)
Analytics and assumptions	17	Describe any methods for analyzing or statistically transforming data, any extrapolation methods, and approaches for validating any model used.	Methods
Characterizing heterogeneity	18	Describe any methods used for estimating how the results of the study vary for subgroups.	Not applicable
Characterizing distributional effects	19	Describe how impacts are distributed across different individuals or adjustments made to reflect priority populations.	Not applicable
Characterizing uncertainty	20	Describe methods to characterize any sources of uncertainty in the analysis.	Methods (uncertainty analysis)
Approach to engagement with patients and others affected by the study	21	Describe any approaches to engage patients or service recipients, the general public, communities, or stakeholders (such as clinicians or payers) in the design of the study.	Methods (model validation)
Results			
Study parameters	22	Report all analytic inputs (such as values, ranges, references) including uncertainty or distributional assumptions.	Results

Supplement 2 cont. *CHEERS 2022 Checklist*

Topic	No.	Item	Location where item is reported
Summary of main results	23	Report the mean values for the main categories of costs and outcomes of interest and summarize them in the most appropriate overall measure.	Results
Effect of uncertainty	24	Describe how uncertainty about analytic judgments, inputs, or projections affects findings. Report the effect of choice of discount rate and time horizon, if applicable.	Results
Effect of engagement with patients and others affected by the study	25	Report on any difference patient/service recipient, general public, community, or stakeholder involvement made to the approach or findings of the study	Conflict of interest
Discussion			
Study findings, limitations, generalizability, and current knowledge	26	Report key findings, limitations, ethical or equity considerations not captured, and how these could affect patients, policy, or practice.	Discussion
Other relevant information			
Source of funding	27	Describe how the study was funded and any role of the funder in the identification, design, conduct, and reporting of the analysis	Funding
Conflicts of interest	28	Report authors' conflicts of interest according to journal or International Committee of Medical Journal Editors requirements.	Conflict of interest

From: Husereau D, Drummond M, Augustovski F, et al. Consolidated Health Economic Evaluation Reporting Standards 2022 (CHEERS 2022) explanation and elaboration: A report of the ISPOR CHEERS II Good Practices Task Force. *Value Health* 2022; 25.

Supplement 3

Study Population

The study included individuals with chronic low back pain (CLBP) that originated in the facet joint and had not been resolved with noninvasive treatments.

The inclusion criteria required that patients:

1. were 18 years of age or older,
2. had suffered from CLBP for more than 3 months—axial back pain without radicular pain or leg pain,
3. had a mean pain score of at least 4 (out of 10) if measured via visual analog scale (VAS) or numeric rating scale (NRS),
4. exhibited a pain reduction of more than 50% as a response to a diagnostic medial branch block (MBB), and
5. had failed conservative treatment for more than 3 months.

The exclusion criteria were as follows:

1. pregnancy,
2. mental illness,
3. the taking of anticoagulant medication or presence of abnormal blood-clotting tendencies, and
4. having refused or withdrawn from the study.

Please note that all patients were informed of the benefits and risks of taking part in the study. Written consent was provided by each patient before enrollment.

Overview of patient characteristics during primary data collection.

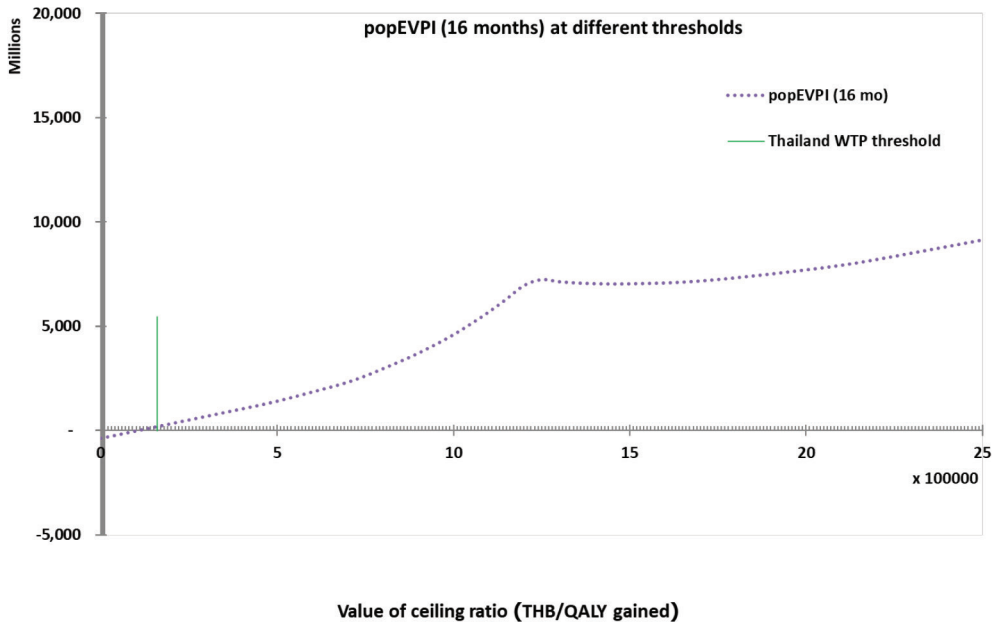
Characteristics	RFA Treatment Group	Conservative Group
Number of patients	N: 31	N: 33
Age		
< 35	2	2
35-40	2	2
41-45	3	-
46-50	2	2
51-55	2	1
56-60	-	6
61-65	2	5
66-70	5	3
>70	13	12
Average age (years ± SD)	62.4 ± 16.4	62.7 ± 15.7
Gender		
Female: Male	53:11	
Household Income		
< 10,000 Baht	5	4
10,000 – 20,000 Baht	4	6
20,001 – 30,000 Baht	4	6
30,001 – 40,000 Baht	2	2
40,001 – 50,000 Baht	4	5
50,000 Baht	15	12
Time-point pain score* Mean score	4.38	5.15
Health Benefit Package		
CSMBS	15	18
SSS	5	3
UCS	8	11
Self-pay	3	1

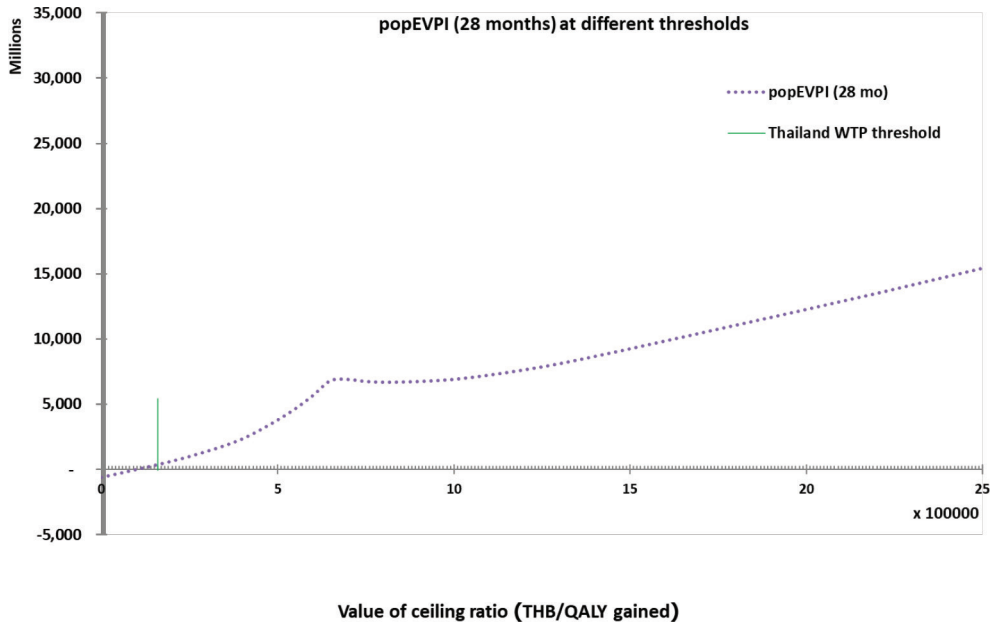
Note: *Pain score was measured on the numerical rating scale (NRS) upon the day the patient visited doctors. CSMBS = Civil Servant Medical Benefit Scheme; SSS = Social Security Scheme; UCS = Universal Coverage Scheme.

Supplement 4. *Age-adjusted mortality rate for the general population (data from 2014).*

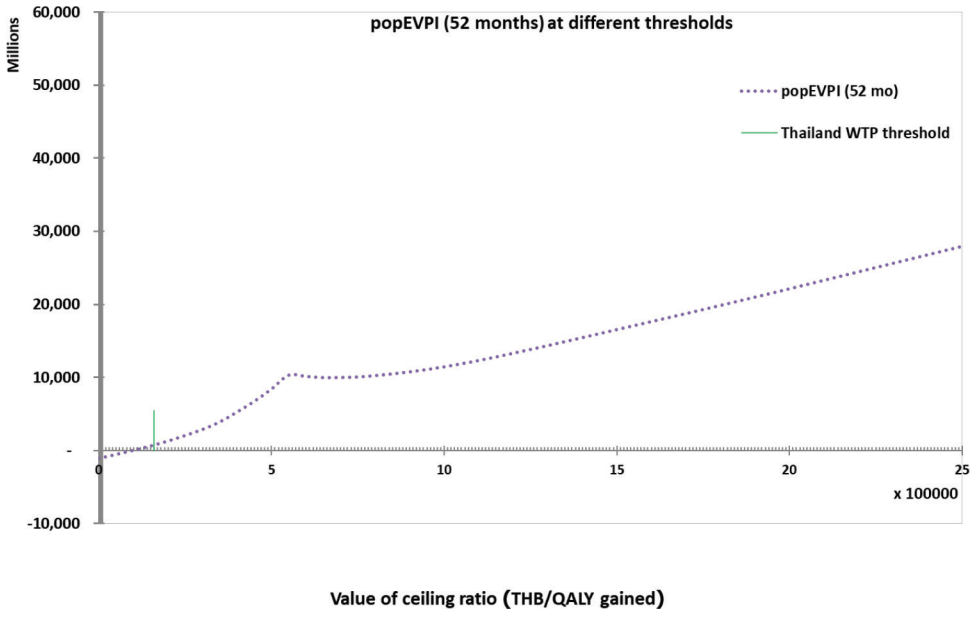
Age Interval	Age-Adjusted Mortality Rate		
	M	F	Total
0	0.01024	0.00869	0.00949
1-4	0.00089	0.00068	0.00079
5-9	0.00042	0.00032	0.00037
10-14	0.00059	0.00037	0.00048
15-19	0.00161	0.00056	0.00110
20-24	0.00189	0.00060	0.00126
25-29	0.00228	0.00077	0.00153
30-34	0.00297	0.00109	0.00204
35-39	0.00419	0.00153	0.00285
40-44	0.00542	0.00219	0.00377
45-49	0.00709	0.00310	0.00503
50-54	0.00952	0.00441	0.00686
55-59	0.01307	0.00662	0.00967
60-64	0.01679	0.00932	0.01279
65-69	0.02400	0.01486	0.01905
70-74	0.03620	0.02453	0.02975
75-79	0.05360	0.03932	0.04541
80-84	0.08002	0.06400	0.07048
85-89	0.14392	0.13068	0.13572

From: The age-specific general mortality was derived from the 2014 lifetable generated by the Burden of Disease Research Program Thailand (BOD Thailand http://bodthai.net/), a project of the International Health Policy Program, in collaboration with the Ministry of Public Health. The program was funded by the ThaiHealth Promotion Foundation (50).

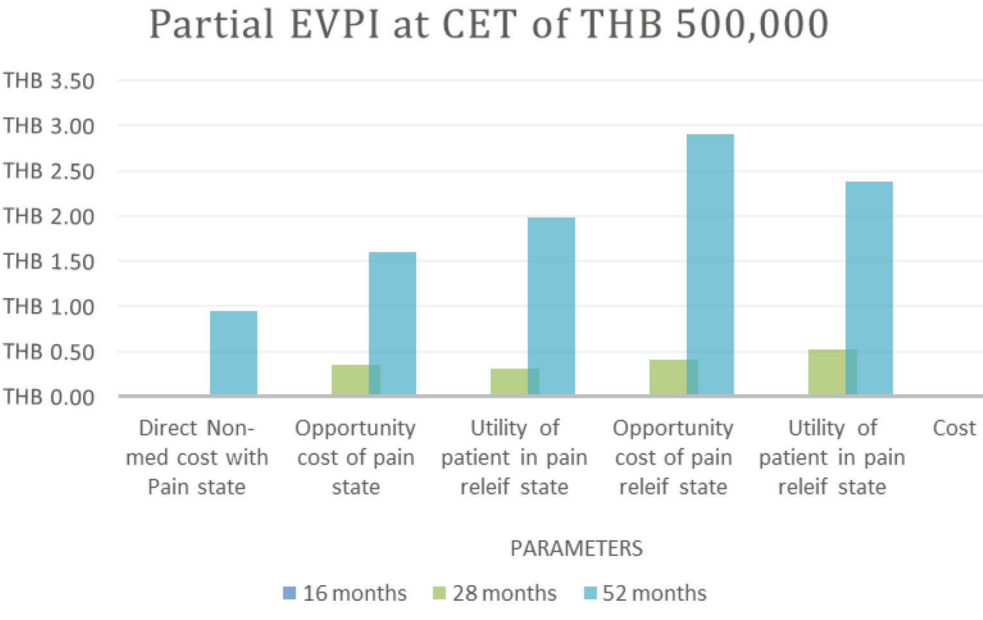




Supplement 5. *Full EVPI results*.



Supplement 5 cont. *Full EVPI results*.



Supplement 6. *Partial EVPI results*.