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Cost-effectiveness of venous thromboembolism prophylaxis protocol implementation compared to routine clinical practice in a tertiary hospital in Thailand

Piyanut Pootracool, MD[a], Suthas Horsirimanont, MD[a], Chaowanun Pornwaragorn, MD[a], Gorawee Tepsamrithporn, MD[a], Chiraphi S. N. Chonburi, MNS[b], Chotip Gajaseni, MSc[b], Chutirat Sonpee, MNS[b], Mauricio Nieto, MSc[c], Dana Bayani, PhD[c], Nutsiri Kittitirapong, MD[a,§]

Introduction: Venous thromboembolism (VTE) is a significant global health concern associated with substantial morbidity and mortality. Despite established guidelines for VTE prevention, there exists a gap between clinical recommendations and their implementation in practice. This study focuses on the implementation of a VTE prophylaxis protocol at a public hospital in Thailand, aiming to evaluate its cost-effectiveness.

Methods: A decision tree model was used to conduct a cost-effectiveness analysis, comparing the costs and health-related outcomes pre- and post-implementation of a risk-based VTE prophylaxis protocol, including pharmacological and mechanical prophylaxis, and early ambulation. The analysis was conducted from the perspective of a single public hospital and followed a 1-year time horizon.

Results: The base case analysis showed that the implementation of the VTE prophylaxis protocol resulted in an incremental cost of THB 726.46 per patient over a 1-year horizon, with an additional 0.30 QALYs. The resulting incremental cost-effectiveness ratio (ICER) was THB 2453.21 per QALY, well below the local willingness-to-pay threshold. Sensitivity analyses confirmed the robustness of the findings, and even in extreme value scenarios, the protocol remained cost-effective.

Conclusions: This study demonstrates the cost-effectiveness of implementing a comprehensive VTE prophylaxis protocol in a Thai hospital setting. While the study focused on a single center, the results suggest that similar protocol implementation may be effective in other tertiary hospitals with comparable resource utilization and unit costs. This research provides valuable evidence to inform healthcare resource allocation and decision-making in Thailand and potentially in other regions facing similar challenges in VTE prevention.

Keywords: cost-effectiveness, health economics, prophylaxis, Thailand, venous thromboembolism

Introduction

Venous thromboembolism (VTE), which includes deep vein thrombosis (DVT) and pulmonary embolism (PE), is the third most common cause of vascular mortality worldwide[1]. The annual incidence of VTE is estimated to range from 104 to 183 per 100,000 individuals[2]. Significant morbidity and mortality are associated with the development of VTE, including prolonged hospital admission, risk of bleeding with therapeutic anticoagulation, recurrent disease and reduced survival[3]. Other complications of VTE include post-thrombotic syndrome and chronic thromboembolic pulmonary hypertension, primarily due to impaired resolution of thrombus[4,5]. General surgical patients are at higher risk of VTE, with an estimated occurrence of up to 25% and prevalence ranging from 0.15% to 1.18% in these patients[3,6]. A retrospective

HIGHLIGHTS

- VTE is a global health concern with substantial morbidity and mortality.
- Ramathibodi Hospital in Thailand implemented a VTE prophylaxis protocol.
- Protocol implementation is cost-effective compared to before implementation.
- Sensitivity analyses confirm cost-effectiveness even in extreme scenarios.
- A similar protocol may be effective in other tertiary hospitals in Thailand.

[a]Division of Vascular and Transplantation Surgery, Department of Surgery, Faculty of Medicine, [b]Nursing Service Department, Faculty of Medicine, Ramathibodi Hospital, Mahidol University, Bangkok, Thailand and [c]Vista Health, Singapore, Singapore.

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[§]Corresponding author. Address: Division of Vascular Surgery, Department of Surgery, Faculty of Medicine, Ramathibodi Hospital, Mahidol University, 270 Rama VI Road, Ratchathewi, Bangkok, 10400 Thailand. Tel: +66 855539293; E-mail address: nutsiri.kit@mahidol.ac.th (N. Kittitirapong).

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study of patients from two hospital in Thailand revealed a case fatality rate of 8% for DVT and 22% for PE[7]. Fatal PE is the form of VTE with the highest mortality and has been recorded as the cause of death for 2% of hospitalized patients[8].

VTE events are preventable through measures such as routine risk assessment and the provision of appropriate thromboprophylaxis. Several supportive strategies have been used to facilitate the implementation of such measures, including providing mandatory VTE training for clinical staff and monitoring the effectiveness of VTE preventive measures in routine clinical practice[9]. Recognizing the imperative to determine patients' risk level for VTE, in 1991, Caprini et al. developed a perioperative VTE risk assessment score to categorize patients into low risk (score of ≤4), moderate risk (score of 5–8), or high risk (score of ≥9) groups[10,11]. The 2012 American College of Chest Physicians (ACCP) guideline endorsed a combined approach of pharmacological and mechanical prophylaxis for non-orthopedic surgery[12], a recommendation reinforced by the 2019 American Society of Clinical Oncology (ASCO) guideline for malignancy-associated major surgical interventions[13]. The combined approach featured low-molecular-weight heparin and unfractionated heparin for pharmacological prophylaxis alongside graduated compressive stockings (GCS) and intermittent pneumatic compression (IPC) for mechanical prophylaxis. The use of thromboprophylaxis has led to significant reductions in VTE and PE incidences by 84% and 55%, respectively[14].

Despite the availability of comprehensive guidelines, there exists a notable disparity between what is recommended in clinical guidelines and what is implemented in clinical practice in Thailand. The multinational ENDORSE study unveiled that 58.5% of at-risk surgical patients globally received ACCP-recommended prophylaxis. However, the compliance rate in Thailand was low, standing at just 0.2% in the same study[15]. In response, an academic tertiary public hospital in Thailand implemented a multidisciplinary team-based VTE prophylaxis protocol aligned with ACCP recommendations to enhance adherence and standardization to counter the influence of surgeon preference. The outcomes of the implementation of this protocol have been reported in a retrospective cohort study of surgical patients conducted by Kittitirapong et al[16].

Previous economic evaluations in multiple settings suggested that implementing VTE prophylaxis protocols can lead to fewer cases of VTE and lower costs to healthcare systems, particularly among high-risk patients. However, there is a lack of cost-effectiveness evidence of the implementation of a VTE prophylaxis protocol in Thailand, where the healthcare system and costs differ from the countries where similar evaluations have been conducted to date. Therefore, this study aims to compare the costs and health-related outcomes before and after implementing the VTE prophylaxis protocol in a public hospital. The results from this study may help promote the use of the protocol and improve its uptake within and beyond a single public hospital to potentially support national healthcare policy shaping.

Materials and methods

Study design

The study utilized a decision tree to conduct a cost-effectiveness analysis, comparing costs and health-related outcomes in terms of quality-adjusted life years (QALYs). The selection of the modeling approach was informed by a review of existing economic evaluation of VTE prophylaxis strategies in different countries[17-19]. The intervention under evaluation was the implementation of a multidisciplinary VTE protocol involving Caprini risk assessment, pharmacological prophylaxis, mechanical prophylaxis and early ambulation at a public hospital. The intervention was compared against the outcomes prior to full VTE prophylaxis protocol implementation in 2019, during which compliance with prophylaxis was low at 0.2%. The study was conducted from the perspective of a single public hospital in Thailand and followed a 1-year time horizon aligned with the follow-up duration of the cohort study in Kittitirapong et al. Therefore, no discount rate was applied to either costs or outcomes. Whenever feasible, the study adhered to the Consolidated Health Economic Evaluation Reporting Standards (CHEERS) Statement[20].

To illustrate, Figure 1 shows the segment of the decision tree for the "After VTE protocol implementation" period. The same branches were produced for the "Before VTE protocol implementation" period.

Study population and intervention

The study cohort mirrored the patient population in Kittitirapong et al. The cohort consisted of patients admitted to the hospital's surgical department, excluding individuals who had previously undergone VTE prophylaxis. The cohort encompassed 4579 patients who underwent screening, with 28.54% of them receiving VTE prophylaxis in the form of enoxaparin, IPC therapy and early ambulation. There were 17 patients who experienced a VTE event in the cohort, of which only one patient died from VTE. The VTE prophylaxis algorithm at a public hospital is presented in Figure 2.

According to the VTE prophylaxis algorithm implemented in a Thai public hospital, the Caprini score was utilized for VTE risk assessment, categorizing patients as very low, low, moderate, or high risk for VTE. Subsequently, an assessment of contraindications for both pharmacological and mechanical prophylaxis was conducted. The surgical team then chose each patient's VTE prophylaxis regimen based on their VTE risk and contraindications for prophylaxis. Pharmacological prophylaxis involves administering 40 mg of enoxaparin via subcutaneous injection every 24 h for patients with normal kidney function (creatinine clearance rate ≥ 30 mL/min). As per the prescription recommendation, the administration of enoxaparin ceased 12 h prior to surgery. Patients with impaired kidney function (creatinine clearance rate < 30 mL/min) received subcutaneous injections of 5000 units of unfractionated heparin every 8 h, stopping 8 h before surgery. The pharmacologist verified the anticoagulant type and dosage. The surgical safety checklist, including VTE risk and prophylaxis method, was completed before, during and after surgical procedures involving a surgeon, scrub nurse and anesthesiologist. For patients receiving mechanical prophylaxis, preference was given to IPC devices over GCS. IPC devices were used intraoperatively. After surgery, a protocol for early ambulation and calf exercises was initiated. Patients continued IPC therapy until they could ambulate proficiently. Surgeons and nurses monitored patients daily for VTE signs, symptoms and prophylaxis-related complications. The rehabilitation team attended to patients who were unable to ambulate effectively.

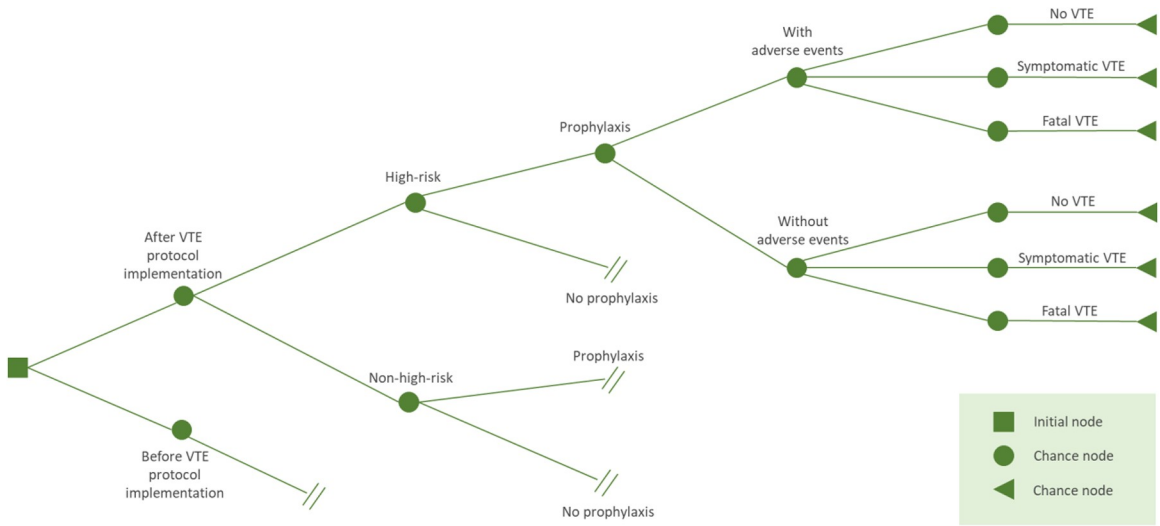

Figure 1. Decision-tree structure ("after VTE protocol implementation"). Abbreviation: VTE: Venous thromboembolism.

Regarding adverse events, minor bleeding was defined as the development of a wound hematoma, drain site bleeding or hematuria. Major bleeding refers to instances necessitating intervention and transfusion of more than two units of packed red blood cells[21]. IPC therapy and GCS-related adverse events and complications included sensory impairment, stocking material allergies, skin irritation and pressure injuries.

Outcomes

The decision tree model, illustrated in Figure 1, was developed to compare the costs and health-related outcomes of VTE prophylaxis before and after the implementation of the VTE prophylaxis protocol. The model categorizes surgical patients into two distinct VTE risk profiles: high-risk and non-high-risk for VTE. The latter risk profile groups patients at low and moderate risk of VTE. Each VTE risk profile was associated with a distinct compliance rate with VTE prophylaxis, which also varied between the periods before and after VTE prophylaxis protocol implementation.

The distribution of patients across prophylaxis regimens—namely, early ambulation, mechanical prophylaxis and pharmacological prophylaxis—is captured in the model's parameters. However, the model does not incorporate prophylaxis regimens as discrete branches with proportions adding up to 1 since patients undergoing VTE prophylaxis can simultaneously be assigned to

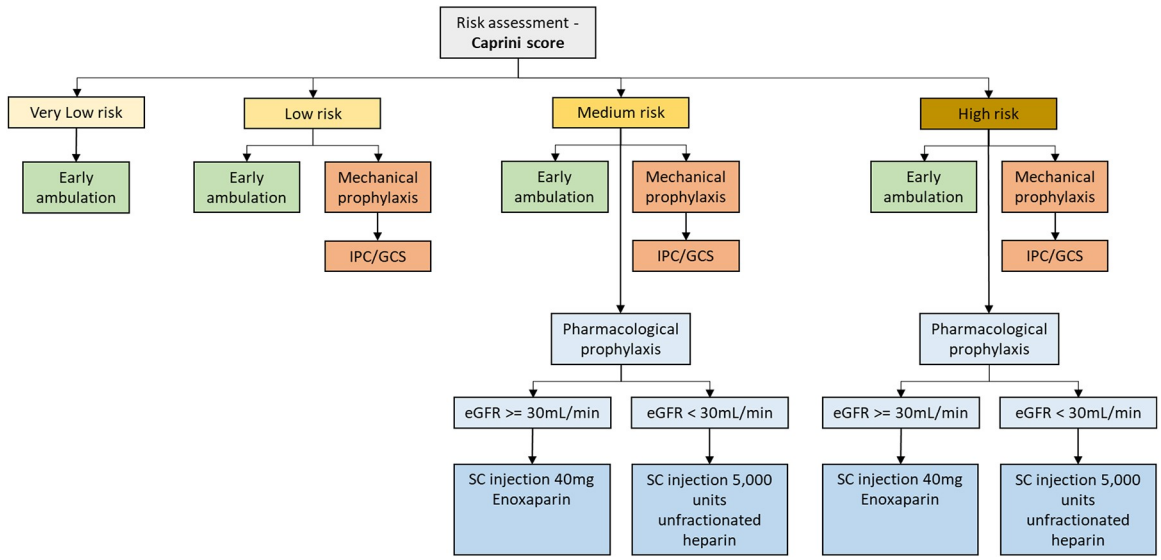

Figure 2. Algorithm from the VTE prophylaxis protocol in a public hospital in Thailand. Abbreviations: IPC, intermittent pneumatic compression; GCS, graduated compressive stockings; eGFR, estimated glomerular filtration rate; SC: subcutaneous.

one or more regimens. Patients undergoing mechanical prophylaxis are at risk of experiencing adverse events, including allergies or irritation from IPC therapy, pressure injuries ranging from grades 1 to 4 and numbness. Similarly, those on pharmacological prophylaxis may experience minor or major bleeding.

The intermediate outcomes described above were assigned risk distributions or probabilities of occurrence sourced from Kittitirapong et al. for high-risk patients and derived for non-high-risk patients as *1—high-risk patient risk/probability*. The only prophylaxis-related estimates not directly sourced or derived from Kittitirapong et al. pertained to the percentage of patients administered unfractionated heparin and low molecular weight heparin as part of the pharmacological prophylaxis. These estimates were obtained through direct consultation with local clinical experts who possessed a comprehensive understanding of the VTE prophylaxis protocol. A summary of the risk distributions and probabilities associated with prophylaxis-related outcomes can be found in Table 1.

The clinical outcomes of interest were the incidence of symptomatic VTE, either DVT or PE, and fatal VTE. These clinical outcomes were captured in the model and accounted for in terms of QALYs. For the estimation of QALYs, disutilies associated with VTE events and the various prophylaxis regimens were sourced from the literature. These quality-of-life estimates are shown in Table 2.

Costs

All cost estimates utilized in this study were obtained from a public hospital in Thailand. Four primary cost categories were identified: cost associated with VTE risk assessment (including Caprini score evaluation), cost linked to the use of various prophylactic regimens, cost related to the management of resulting adverse events from prophylaxis and the cost of VTE events. These cost inputs were derived from the hospital's established service codes that pertain to these procedures, as most

Table 1

Risk distribution and prophylaxis-related outcome estimates.

Parameter	Base case	Lower	Upper	Reference
Distribution per risk category				
Proportion of patients identified as non-high risk	65.52%	–	–	Derived from[13]
Proportion of patients identified as high risk (%)	34.48%	–	–	[13]
Compliance with VTE Prophylaxis; i.e., proportion of patients who underwent any prophylaxis regimen				
During VTE protocol implementation—high risk (%)	61.05%	45.79%	72.50%	[13]
Before VTE protocol implementation—high risk (%)	0.20%	0.15%	0.24%	[13]
During VTE protocol implementation—non-high risk (%)	11.43%	8.57%	13.57%	[13]
Before VTE protocol implementation—non-high risk (%)	0.20%	0.15%	0.24%	[13]
Risk of adverse events (any prophylaxis regimen)—all risk categories				
Proportion with any adverse events	9.78%	–	–	[13]
Proportion without adverse events	90.22%	–	–	Derived from[13]
Distribution between prophylaxis regimens, out of the total who underwent any form of prophylaxis				
Proportion of patients undergoing early ambulation (%)—high risk	76.24%	57.18%	90.54%	[13]
Proportion of patients undergoing mechanical prophylaxis (%)—high risk	50.93%	38.20%	60.48%	[13]
Proportion of patients undergoing pharmacological prophylaxis (%)—high risk	25.83%	19.37%	30.67%	[13]
Proportion of patients undergoing early ambulation(%)—non-high risk	34.99%	26.24%	41.55%	Derived from[13]
Proportion of patients undergoing mechanical prophylaxis (%)—non-high risk	88.63%	66.47%	100.00%	Derived from[13]
Proportion of patients undergoing pharmacological prophylaxis (%)—non-high risk	20.41%	15.31%	24.24%	Derived from[13]
Pharmacological prophylaxis—all risk categories, out of the total who underwent pharmacological prophylaxis				
Proportion of patients taking unfractionated heparin (%)	0.00%	–	–	Expert opinion
Proportion of patients taking low molecular weight heparin (%)	100.00%	–	–	Expert opinion
Risk of VTE events, out of all patients per risk group				
Probability of experiencing symptomatic VTE (%)—high risk, with VTE prophylaxis	1.08%	0.81%	1.28%	[13]
Probability of experiencing fatal VTE (%)—high risk, with VTE prophylaxis	0.06%	0.05%	0.07%	[13]
Probability of experiencing no VTE event (%)—high risk, with VTE prophylaxis	98.86%	–	–	Derived from[13]
Probability of experiencing symptomatic VTE (%)—non-high risk, with VTE prophylaxis	0.00%	–	–	[13]
Probability of experiencing fatal VTE (%)—non-high risk, with VTE prophylaxis	0.00%	–	–	[13]
Probability of experiencing no VTE event (%)—non-high risk, with VTE prophylaxis	100.00%	–	–	Derived from[13]
Probability of experiencing symptomatic VTE (%)—no VTE prophylaxis	1.77%	1.33%	2.10%	[13]
Probability of experiencing fatal VTE (%)—no VTE prophylaxis	0.15%	0.11%	0.18%	[13]
Probability of experiencing no VTE event (%)—no VTE prophylaxis	98.08%	–	–	Derived from[13]
Risk of adverse events from mechanical prophylaxis—all risk categories				
Complications from IPC therapy (allergy, irritation)	7.67%	–	–	[13]
Pressure injury grade 1–2	5.28%	–	–	[13]
Pressure injury grade 3–4	0.00%	–	–	[13]
Numbness	0.25%	–	–	[13]
Risk of adverse events from pharmacological prophylaxis—all risk categories				
Minor bleeding	1.25%	–	–	[13]
Major bleeding	0.00%	–	–	[13]

Abbreviations: VTE, venous thromboembolism; IPC, intermittent pneumatic compression.

Table 2

Quality of life estimates.

Parameter	Base case	Lower	Upper	Reference
VTE event and complications				
Disutility from fatal VTE	1.000			Assumed
Disutility from symptomatic VTE	0.053	0.040	0.063	Derived from[14]
Utility from no VTE	0.694	0.521	0.824	Derived from[14]
Disutility from bleeding	0.222	0.167	0.264	Derived from[19]
Treatment disutilities				
Disutility from IPC/mechanical prophylaxis	0.081	0.061	0.097	Derived from[19]
Disutility from pharmacological prophylaxis	0.012	0.009	0.014	Derived from[19]

Abbreviations: VTE, venous thromboembolism; IPC, intermittent pneumatic compression.

patients opt for standard services rather than premium offerings. The cost estimates are summarized in Table 3.

Individual patient-level data for VTE management were drawn from the VTE risk registry, which contained detailed information on the resource use of patients who experienced VTE events within the retrospective cohort. The cohort consisted of 17 individuals who developed either PE or DVT, wherein one patient died from a VTE-related cause. Their costs and resource utilization were based on the duration of follow-up of the cohort, from November 2019 to November 2020.

The cost of symptomatic VTE was approximated by calculating the mean cost incurred by each patient for diagnostic procedures such as duplex ultrasound screening, computed tomography (CT) pulmonary angiogram, echocardiogram and anticoagulation therapy. The costs related to fatal VTE cases were estimated based on the sum of the costs of diagnostics, anticoagulants and reperfusion (e.g., aspiration thrombectomy), adjusted based on the probability of requiring these interventions. It was assumed that 100% of patients would require diagnostics and anticoagulants. Hence, the full cost of symptomatic VTE is considered. As for aspiration thrombectomy, a combined estimate of 5.4% was adopted, reflecting the registry's distribution of DVT (47.1%) and PE (52.9%) cases, multiplied by the proportion of patients necessitating reperfusion strategies based on guidelines by the American Society of Hematology[22]. According to the guideline, about 4.5% of DVT patients and 6.2% of acute PE patients require reperfusion to restore vascular patency in order to improve clinical outcomes. Additionally, it was assumed that 1% of patients will require extracorporeal membrane oxygenation to manage a fatal VTE event.

All costs are denoted in Thai Baht (THB), with an exchange rate of 1 THB to 0.03 USD[23]. No inflation adjustments were applied since most costs were representative of present values.

Sensitivity analysis

To ensure the robustness and validity of the model, an expert validation meeting was conducted involving clinical (surgical) and health economics experts. The experts meticulously evaluated the assumptions, model structure and results. The model was developed in Microsoft Excel to ensure maximum transparency in the inputs and calculations. Furthermore, two analysts

Table 3

Cost estimates (in Thai Baht).

Parameter	Base case	Lower	Upper	Reference
VTE risk assessment				
Caprini score evaluation	฿200.00	฿150.00	฿237.50	Thai public hospital Practice
Early ambulation				
Total cost of early ambulation—rehabilitation	฿250.00	฿187.50	฿296.88	Thai public hospital code
Mechanical prophylaxis				
Use of IPC device	฿1265.00	฿948.75	฿1502.19	Thai public hospital code
IPC service	฿3850.00	฿2887.50	฿4571.88	Thai public hospital code
Management of complications from IPC therapy (allergy, irritation)	฿86.00	฿64.50	฿102.13	Thai public hospital code
Management of pressure injury grade 1-2 from IPC	฿115.00	฿86.25	฿136.56	Thai public hospital code
Management of pressure injury grade 3-4 from IPC	฿5000.00	฿3750.00	฿5937.50	Thai public hospital code
Pharmacological prophylaxis				
Subcutaneous administration of enoxaparin (40 mg enoxaparin)	฿1909.25	฿1431.94	฿2267.23	Thai public hospital code
Management of minor bleeding	฿1000.00	฿750.00	฿1187.50	Thai public hospital code
Management of major bleeding	฿2000.00	฿1500.00	฿2375.00	Thai public hospital code
VTE management				
Total cost of symptomatic VTE	฿107,640.00	฿80,730.00	฿127,822.50	Thai public hospital risk registry
Total cost of fatal VTE	฿122,236.00	฿91,677.00	฿145,155.25	Thai public hospital risk registry
Monitoring for VTE and complications	฿2100.00	฿1575.00	฿2493.75	Thai public hospital code

Abbreviations: VTE, venous thromboembolism; IPC, intermittent pneumatic compression.

conducted independent checks to validate the accuracy of input data, calculations and outcomes.

One-way sensitivity analysis (OWSA) was performed to identify the key drivers of the results. All parameters were included in the sensitivity analyses and adjusted by ±20% or based on available confidence intervals. We also explored extreme values, such as an estimate of zero cost for fatal VTE, given the possibility that patients with severe VTE events may die immediately without any intervention.

A probabilistic sensitivity analysis (PSA) was also executed, encompassing all inputs that were subject to uncertainty. This involved random selection of point estimates drawn from input distributions in each simulation. The incremental cost-effectiveness ratio (ICER), representing the cost per QALY gained, was recorded for each simulation. A total of 1000 simulations were undertaken to ascertain parametric uncertainty and estimate the likelihood of the ICER falling below different willingness-to-pay thresholds. Guided by the recommendations of Thai health economics guidelines, a willingness-to-pay threshold of THB 160,000 was considered[24]. A cost-effectiveness acceptability curve (CEAC) was generated post-PSA, illustrating the likelihood of intervention cost-effectiveness across various willingness-to-pay thresholds.

It is important to note that this analysis focused primarily on sensitivity analyses conduct and model validation. Distributional effects were not explored, and engagement with patients or other stakeholders was not undertaken as part of this study's scope.

Results and discussion

Base case results

In our analysis, the implementation of a VTE prophylaxis protocol incurred an incremental cost of THB 726.46 per patient over a 1-year time horizon, as compared to the pre-protocol period. The primary factor driving this cost difference was related to the expense associated with the use of IPC service, which was the costliest item as part of the protocol implementation. Nevertheless, there was a reduction in the costs attributed to VTE events, encompassing both symptomatic and fatal VTE cases. Regarding health-related outcomes, the protocol implementation yielded an extra 0.30 QALYs. Given the costs and QALYs gained, the resulting ICER amounted to THB 2453.21 per QALY. This result shows that the intervention is significantly cost-effective, as it falls well below the decision-making threshold in Thailand, which is THB 160,000.

Sensitivity analyses

The results of the OWSA illustrate the most influential parameters on the ICER. Notably, changes in the cost of IPC service, the proportion of patients undergoing mechanical prophylaxis, the risk of symptomatic VTE events and the cost of managing symptomatic VTE events caused the most significant shift in the ICER. The implications of changes in these parameters are visually represented through a tornado diagram in Figure 3.

Figure 3. One-way sensitivity analyses. Abbreviations: VTE, venous thromboembolism; IPC, intermittent pneumatic compression.

An additional scenario analysis was carried out to assess the impact of having no treatment cost for fatal VTE events if patients were assumed to die instantaneously prior to any intervention. Despite a slight increase in the ICER value to THB 2576.72 or 5%, the result remains below the willingness-to-pay threshold in Thailand.

Results of the PSA are presented graphically in the cost-effectiveness plane in Figure 4. The majority of the simulations (61%) fell within the northeast quadrant of the plane, with an average of THB 423.43 per QALY gained. The remaining simulations clustered within the southeast quadrant, signaling the potential for the intervention to yield cost savings. Notably, the implementation of the VTE prophylaxis protocol demonstrated a strong likelihood of being cost-effective, even at relatively modest threshold levels. This trend persisted even when subjected to extreme value scenarios, as underscored in the CEAC showcased in Figure 5.

Discussion

The study's robustness is affirmed by the consistent outcomes across various analyses, including OWSA and PSA. Notably, the VTE protocol implementation remains cost-effective even at more conservative threshold levels, emphasizing its viability within the current economic context. Moreover, potential cost reductions can be achieved through targeted adjustments, such as decreasing the unit costs of specific interventions, like IPC services.

The results from this study were compared with another evaluation conducted in an Italian hospital setting, wherein authors employed a decision-tree model to assess the cost-effectiveness of a VTE guideline implementation[18]. The Italian study showed a significant increase in prophylaxis adoption and a noteworthy 14% reduction in average VTE-related patient costs post-guideline implementation. This underscores the cost-saving attributes of the guideline, particularly relevant to high-risk individuals with higher risk of VTE. Similarly, those in the Italian study highlight the sensitivity of outcomes to factors such as the proportion of high-risk patients receiving prophylaxis and their associated VTE risk. A pivotal distinction between our analysis and the Italian study lies in our use of real-world data sources to estimate the effectiveness of the intervention. We've leveraged outcomes from an expansive cohort study and patient-level data related to the costs of VTE events. This approach enhances the generalizability of our study's findings to the Thai context. In contrast, the Italian study acknowledged limitations due to relying on literature-derived data for estimating VTE and bleeding event risks among hospitalized patients.

To the best of our knowledge, this study is the first of its kind in Thailand to evaluate a comprehensive VTE prophylaxis protocol, encompassing screening, procedures and pharmacological interventions. However, the study is not without limitations. The study's single-center focus limits its generalizability to other Thai hospitals. Nevertheless, given the results of the sensitivity analyses, the VTE prophylaxis protocol has the potential to be cost-effective in other tertiary hospitals, assuming similar utilization rates of the prophylactic regimen and unit costs.

An additional constraint is that the model adopted a time horizon limited to 1 year, which was based on the cohort study's follow-up duration. While this might not encompass the entire spectrum of costs for patients undergoing prolonged anticoagulation therapy or additional surgeries, the study benefits from capturing costs for a substantial portion of the cohort undergoing treatment for nearly a year. This suggests

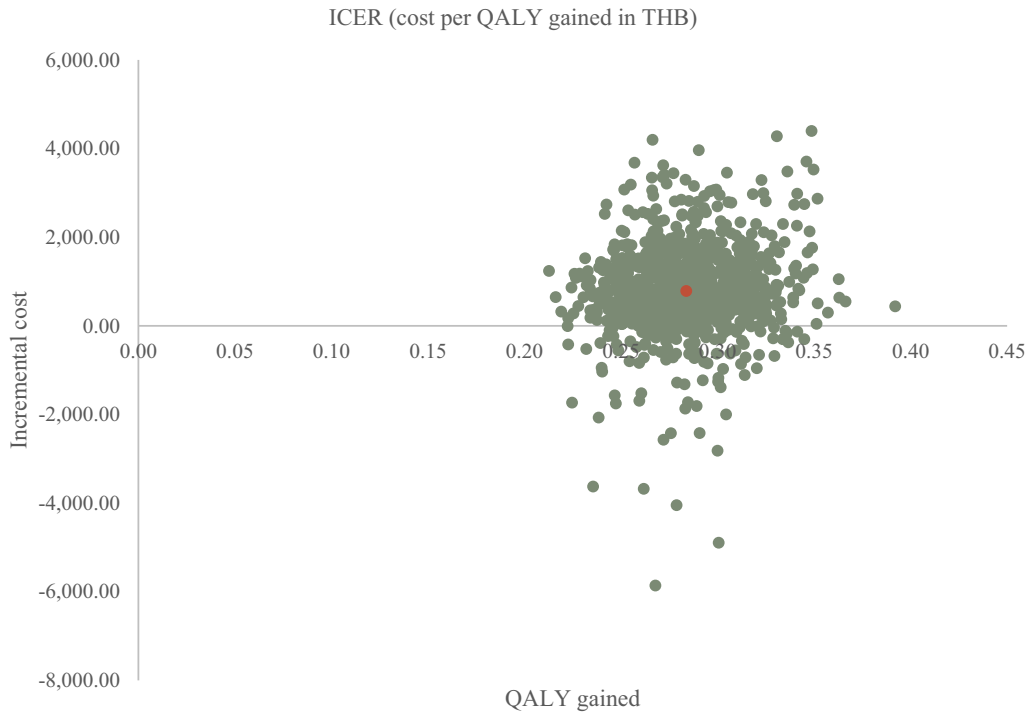

Figure 4. Probabilistic sensitivity analyses. Abbreviations: ICER, Incremental cost-effectiveness ratio; QALY, Quality-adjusted life year; THB, Thai Baht.

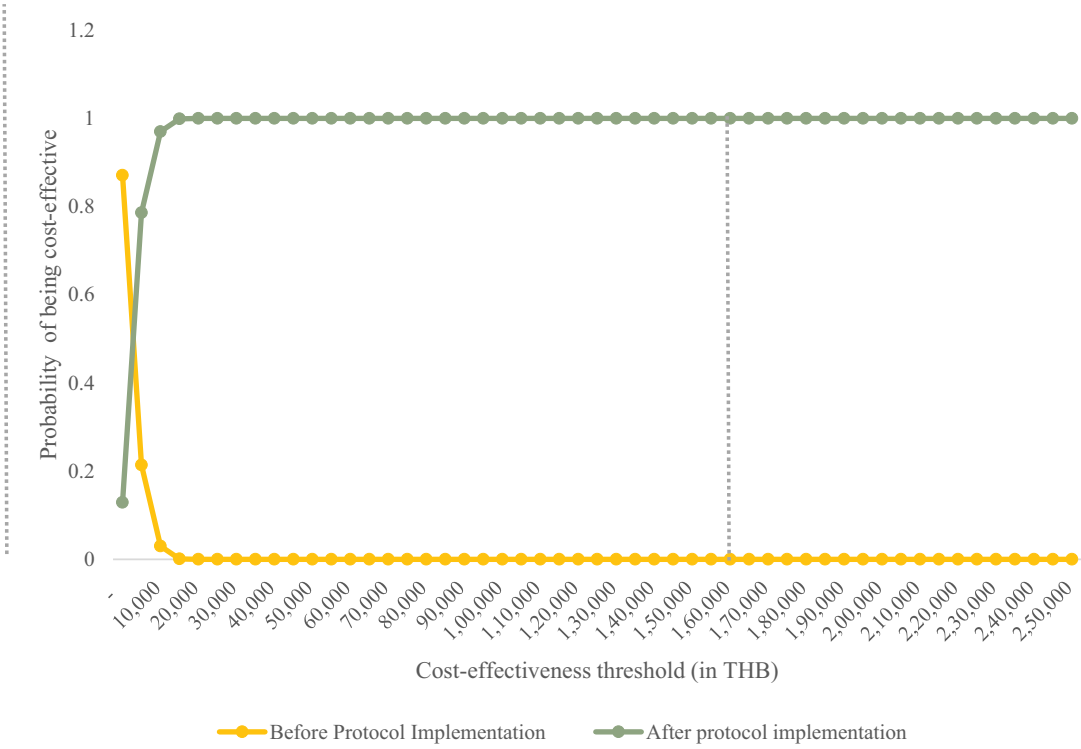

Figure 5. Cost-effectiveness acceptability curve. Abbreviations: THB: Thai Baht.

that the cost estimates remain robust and unlikely to underestimate the costs.

To enrich the evidence base, future research could explore data collection from other surgical hospitals in Thailand and other regions, enhancing the precision of cost and outcome parameters used. This study can be used as a first step to demonstrate the cost-effectiveness of a VTE prophylaxis protocol implementation to inform future healthcare resource allocation and decision-making in Thailand.

Conclusion

The evaluation showed that introducing a comprehensive VTE prophylaxis protocol in a Thai hospital setting presents a favorable cost-effectiveness result compared to scenarios without such protocols, even at minimal willingness-to-pay thresholds. These findings can inform the development and implementation of similar strategies for VTE prevention in other settings facing comparable challenges.

Ethical approval

The study protocol was approved by the Human Research Ethics Committee, Faculty of Medicine Ramathibodi Hospital, Mahidol University, MURA2023/737.

Consent

This was a retrospective study. Therefore, written consent was not required.

Sources of funding

Sanofi financially supported the study conduct but had no role in data collection, analysis, interpretation of the data, or in the writing of the manuscript.

Author contribution

This manuscript was developed collaboratively among all authors. NK and PP contributed to the conception and design of the study, and the acquisition, analysis and interpretation of the incorporated data. NK participated in the revision of the manuscript. SH, CP, GT, CS, CG and CS participated in reviewing the design and application of methods for data collection. DB and MN contributed to the study design, data analysis and data interpretation. All authors participated in the preparation and critical review of the manuscripts. In addition, all authors reviewed and approved the manuscript.

Conflicts of interest disclosure

None declared.

Research registration unique identifying number (UIN)

The study was reviewed, approved and registered by the Thai Clinical Trials Registry, with TCTR identification number TCTR20231101006 (https://www.thaiclinicaltrials.org/show/TCTR20231101006).

Guarantor

Dr. Nutsiri Kittitirapong.

Provenance and peer review

Not applicable.

Data availability statement

Not required.

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