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Brief Report

Cost-Effectiveness of Increasing Access to Colorectal Cancer Diagnosis: Analysis From Thailand

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ABSTRACT

Objectives: The purpose of this study is to evaluate the cost-effectiveness of increasing access to colorectal cancer (CRC) diagnosis, considering resource limitations in Thailand.

Methods: We analyzed the cost-effectiveness of increasing access to fecal immunochemical test screening (strategy I), symptom evaluation (strategy II), and their combination through healthcare and societal perspectives using Colo-Sim, a simulation model of CRC care. We extended our analysis by adding a risk-stratification score (RS) to the strategies. We analyzed all strategies under the currently limited annual colonoscopy capacity and sufficient capacity. We estimated quality-adjusted life-years (QALYs) and costs over 2023 to 2047 and performed sensitivity analyses.

Results: Annual costs for CRC care will increase over 25 years in Thailand, resulting in a cumulative cost of 323B Thai baht (THB). Each strategy results in higher QALYs gained and additional costs. With the current colonoscopy capacity and willingness-to-pay threshold of 160 000 THB, strategy I with and without RS is not cost-effective. Strategy II + RS is the most cost-effective, resulting in 0.68 million QALYs gained with additional costs of 66B THB. Under sufficient colonoscopy capacity, all strategies are deemed cost-effective, with the combined approach (strategy I + II + RS) being the most favorable, achieving the highest QALYs (1.55 million) at an additional cost of 131 billion THB. This strategy also maintains the highest probability of being cost-effective at any willingness-to-pay threshold above 96 000 THB.

Conclusions: In Thailand, fecal immunochemical test screening, symptom evaluation, and RS use can achieve the highest QALYs; however, boosting colonoscopy capacity is essential for cost-effectiveness.

Keywords: cancer prevention, colonoscopy, colorectal cancer, screening, simulation modeling, system dynamics.

VALUE HEALTH REG ISSUES. 2024; 43:101010

Introduction

Colorectal cancer (CRC) is one of the most common cancers and a major cause of cancer deaths worldwide.[1] It is projected to have the second highest global cost in 2020-2050 among all cancers, with a burden of \$2.8 trillion.[2] Early detection efforts such as screening and symptom evaluation can effectively prevent CRC.[3] However, constraints in low- and middle-income countries (LMICs), such as limited access to early CRC detection and low colonoscopy capacity, a required tool to detect CRC, result in the growth of CRC incidence and mortality rates.[4]

The strategies for early CRC detection vary across countries based on factors such as population risks and resources.[5] For example, colonoscopy is recommended as a primary screening tool for average-risk individuals in developed countries such as the United States.[6] However, LMICs have often recommended the use of colonoscopy as a secondary test after a positive fecal immunochemical test (FIT), a low-cost screening modality, due to their limited colonoscopy capacity.[7] Since 2017, Thailand has recommended annual FIT as the primary screening method for asymptomatic individuals aged 50 to 75 years and direct colonoscopy for symptom evaluation.[8] Symptom evaluation involves assessing signs and symptoms such as bloody stool, unexplained weight loss, unexplained iron deficiency anemia, and changes in stool caliber to identify potential CRC.[9,10] However, 2 challenges persist.

First, a FIT-based screening still relies on colonoscopy resources; however, our recent research showed that the current colonoscopy capacity in Thailand is limited,[11] yet previous cost-effectiveness studies on increasing access to screening in Thailand did not take capacity constraints into account.[8,12] Building colonoscopy capacity is resource and time intensive, but there remains a scarcity of research on the specific economic requirements for building colonoscopy capacity and its cost-effectiveness.

Second, FIT exhibits low sensitivity in detecting precancerous conditions despite its benefit in decreasing CRC-related deaths.[11] To increase the sensitivity of FIT, risk-stratification scores, such as the 8-point risk score, have been used in the Asia-Pacific population,[13] which was also found to be cost-effective in Japan.[14] In contrast, using this risk score decreases specificity, resulting in more false-positive cases and greater colonoscopy demand.[13] Although research in Thailand recommends combining FIT with risk-stratification scores,[15] the cost-effectiveness of the risk score in countries with limited colonoscopy capacity is underexplored.

To address these gaps, we perform an economic evaluation of increasing access to CRC detection in the context of limited colonoscopy capacity. We analyzed different CRC detection approaches, including FIT screening (with and without the 8-point risk score) and symptom evaluation. We conducted this analysis under 2 scenarios where colonoscopy capacity remains at its current level and is increased to sufficient levels to meet the demands of each strategy. We also aimed to quantify the economic burdens of building colonoscopy capacity in Thailand.

Material and Methods

Overview of Colo-Sim

We used Colo-Sim to conduct this economic evaluation. Colo-Sim is a population-based compartmental dynamic model representing CRC screening and care with constraints in low access to diagnosis and limited colonoscopy capacity.[11] The model was calibrated to Thai historical data from 2004 to 2021 and assessed through expert interviews. In Colo-Sim, we focused on patients aged 50 years or older in Thailand. The model simulated the progression of CRC development based on the adenoma-carcinoma sequence (see Appendix Fig. 1 in Supplemental Materials found at https://doi.org/10.1016/j.vhri.2024.101010).[11]

Colo-Sim includes 2 ways to diagnose CRC: screening and symptom evaluation. The model incorporates FIT as the primary screening modality. The national screening program for CRC launched by the National Cancer Institute of Thailand follows 2016 recommendations by the US Preventive Services Task Force, where all asymptomatic individuals aged 50 to 75 years are recommended to get a FIT screening annually.[8] The recommendations are for the asymptomatic individuals with a FIT-positive result to get a colonoscopy, whereas for the symptomatic individuals to receive an urgent evaluation directly with a colonoscopy.[8,16] In addition, we analyzed the impact of combining the 8-point risk score with FIT. This risk score is calculated by physicians based on age, sex, CRC family history, body mass index, and smoking history (see Appendix Table 1 in Supplemental Materials found at https://doi.org/10.1016/j.vhri.2024.101010). Individuals with 5 scores or more are considered high risk. Those with a high-risk score are recommended to skip FIT and directly receive a colonoscopy, whereas individuals with a score lower than 5 are directed toward FIT screening.[13]

Strategies

In the status quo (baseline), we assumed no improvement in access to diagnosis (ie, screening and symptom evaluation) or colonoscopy capacity. To estimate the values of access to screening and symptom evaluation, we conducted model calibration based on historical data in Thailand (see Wongseree et al[11] for more information). Then, we used their values in 2022 to project quality-adjusted life-year (QALY) and cost for 2023 to 2047. The strategies included increasing access to screening (strategy I), symptom evaluation (strategy II), and their combination (strategy I + II). The analysis was extended by adding the 8-point risk score (RS) to these 3 strategies.

We also evaluated these 6 strategies under 2 scenarios: current annual colonoscopy capacity and sufficient capacity, that is, where colonoscopy capacity is increased to a sufficient level. We estimated sufficient capacities based on the maximum colonoscopy demand for each strategy over 2023 to 2047. See more details in Appendix Table 2 in Supplemental Materials found at https://doi.org/10.1016/j.vhri.2024.101010.

Data Input and Assumptions

We used costs from both healthcare and societal perspectives reported in Thai baht (THB) (as of December 2023, 1 US dollar = 35 THB). We gathered cost and utility data from published literature in Thailand. Cost data were reported in 2022 using the consumer price index from Thailand.[17] Future costs and QALYs were discounted at the rate of 3% per year.[18] More details on parameters are presented in Appendix Table 3 in Supplemental Materials found at https://doi.org/10.1016/j.vhri.2024.101010, and model parameters are described in Wongseree et al[11] study.

The current annual colonoscopy capacity in Thailand is roughly estimated to be 200 000 people per year[15]—this estimate is subject to our sensitivity analyses. We estimated and reported the colonoscopy demand for each strategy under sufficient capacity in Table 1.

Information on resources required to build colonoscopy and estimates on the cost of increasing colonoscopy capacity is limited; hence, we collected and combined information from literature, a Thai database,[19] and expert interviews (see Appendices Tables 3 and 4 in Supplemental Materials found at https://doi.org/10.1016/j.vhri.2024.101010). The interviews were conducted with 4 experts in gastroenterology, colorectal surgery, and CRC modeling in Thailand. We collected information for building capacity, including medical devices, colonoscopy units, and healthcare workforces. Based on colonoscopy demand and available resources, experts believe that the current devices and colonoscopy units in Thailand are sufficient to meet the demand for colonoscopy under all 6 strategies (see Appendix Table 2 in Supplemental Materials found at https://doi.org/10.1016/j.vhri.2024.101010). However, there is a shortage of healthcare workforces, including physicians and nurses, to perform the procedure. Thus, we assumed that expanding colonoscopy capacity for the strategies only requires training more physicians and nurses.

There are several ways to expand the number of physicians, such as training more gastroenterologists and surgeons—the only subspecialties qualified to perform the procedure in Thailand.[20] Therefore, we considered training internal medicine doctors and general practitioners through a short course on performing colonoscopy, which is relatively low cost and has a short training duration.[21,22] Based on inputs from experts, we estimated that each doctor trained with the short course could perform colonoscopies for 4 patients per week, and training each doctor requires 1 more nurse assistant. In other words, training 1 doctor and 1 nurse can increase colonoscopy capacity by 208 people per year.

Strategy Analyses

We estimated costs and QALYs for the status quo and each strategy over 25 years (2023-2047). We compared the QALYs and costs of each strategy with the status quo. We also estimated the incremental cost-effectiveness ratio (ICER) per QALY gained compared with the status quo for each strategy. We used 1.5 times per capita gross domestic product (GDP) (160 000 THB/QALY) as the common willingness-to-pay (WTP) threshold in Thailand.[23]

Sensitivity Analysis

We conducted a probabilistic sensitivity analysis on all model parameters, using 1000 simulation runs with Latin hypercube sampling.[24] We considered parameter distributions based on the

Table 1. Key results of the cost-effectiveness and sensitivity analyses, cumulative from 2023 to 2047.

Colonoscopy capacity	Strategy	Annual colonoscopy capacity,*people/year	Cumulative QALYs gained compared with status quo	Cumulative additional costs compared with status quo (THB)	ICER(THB per QALY gained)	Probability of being cost-effective, WTP = 160 000 THB/QALY
	Status quo	200 000†	-	-	Reference	Reference
	Strategy I	200 000	196 806	66 143 459 935	336 084‡	0.17
	Strategy II	200 000	674 893	66 312 249 119	98 256	0.99
Current capacity	Strategy I + II	200 000	798 788	126 567 743 924	158 450	0.57
	Strategy I + RS	200 000	130 006	49 389 698 165	379 903‡	0.24
	Strategy II + RS	200 000	677 350	66 377 401 316	97 996	0.99
	Strategy I + II + RS	200 000	752 931	111 217 508 310	147 713	0.67
	Strategy I	667 000	768 566	87 878 641 611	114 341	0.49
	Strategy II	258 000	675 249	66 438 302 007	98 391	0.99
Sufficient capacity†	Strategy I + II	728 000	1 371 703	133 837 228 245	97 570	0.75
	Strategy I + RS	1 230 000	972 867	86 979 193 010	89 405	0.73
	Strategy II + RS	264 000	677 891	66 608 013 341	98 258	0.99
	Strategy I + II + RS	1 250 000	1 545 732	130 985 904 910	84 740	0.86

ICER indicates incremental cost-effectiveness ratio; QALY, quality-adjusted life-year; THB, Thai baht; WTP, willingness-to-pay.
*We considered sufficient colonoscopy capacity to be equal to the maximum colonoscopy demand during 2023-2047; however, the demands are capped at 200 000 under the current capacity scenario.
†At the status quo, colonoscopy demand is estimated to be 156 000, below the capacity of 200 000.
‡ICER > WTP threshold of 160 000 THB/QALY.

literature (Appendix Table 3 in Supplemental Materials found at https://doi.org/10.1016/j.vhri.2024.101010). In the absence of distribution information, we used a uniform distribution with a range of ± 20%.

In addition, we analyzed uncertainties on QALYs gained from each strategy and costs compared with the status quo, as well as various WTP thresholds from 0 to 3 times per capita GDP in Thailand. We calculated the probability of each strategy being the most cost-effective choice at each WTP.

Results

Cost-Effectiveness Analysis of Strategies

The main results of the cost-effectiveness analysis are presented in Table 1; more details are presented in Appendix Table 5 in Supplemental Materials found at https://doi.org/10.1016/j.vhri.2024.101010. In the status quo, we project that annual costs for CRC care will increase due to the rising CRC incidence rates (see Appendix Fig. 2 in Supplemental Materials found at https://doi.org/10.1016/j.vhri.2024.101010), resulting in a cumulative cost of 323B THB over 25 years. Compared with the status quo, each strategy requires additional costs but offers greater QALYs gained. In addition, moving from current to sufficient colonoscopy capacity increases both QALYs gained and costs. Below we discuss the results under the current and sufficient levels of capacity.

Under current colonoscopy capacity, strategy I + II has the highest QALYs gained and costs, whereas strategy I + RS has the lowest QALYs gained and costs. Adding RS to strategies I and I + II reduces their QALYs gained and costs; however, that for strategy II slightly increases its QALYs gained and costs.

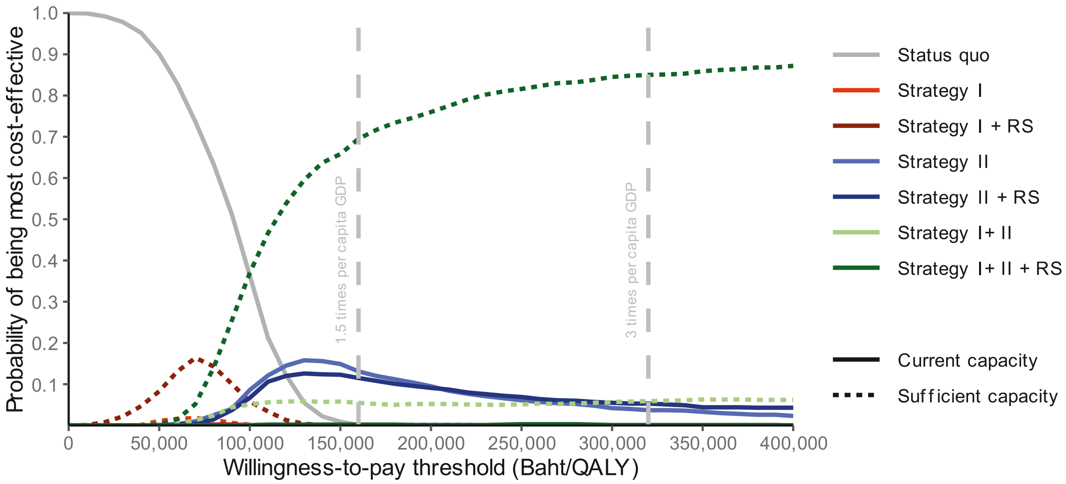
Under sufficient colonoscopy capacity, strategy I + II + RS has the highest QALYs gained, whereas strategy II has the lowest QALYs gained and costs. Adding RS to strategies I and I + II increases their QALYs gained and decreases their costs; however, that for strategy II increases its QALYs gained and costs.

Here, we compare the ICERs with the WTP threshold of 160 000 THB/QALY. Under current colonoscopy capacity, strategies I and I + RS are not cost-effective, and strategy II + RS is the most cost-effective. Adding RS to strategies II and I + II reduces their ICERs compared with the status quo, yet that for strategy I increases its ICER. However, under sufficient capacity, all strategies are cost-effective, and strategy I + II + RS is the most cost-effective. Adding RS to strategies I, II, and I + II reduces their ICERs compared with the status quo.

Probabilistic Sensitivity Analysis

The uncertainties in QALYs gained and costs for each strategy under the 160 000 THB/QALY WTP threshold compared with the status quo are presented in Table 1 and Appendix Figure 3 in Supplemental Materials found at https://doi.org/10.1016/j.vhri.2024.101010. Among all strategy combinations, strategies II and

Figure 1. Cost-effective acceptability curve for strategies across various levels of WTP thresholds (in Thai Baht) as well as current and sufficient colonoscopy capacities



II + RS have the highest probability of being cost-effective at 0.99 at current and sufficient capacities.

The probability of each strategy being the most cost-effective among all 12 strategy combinations at different WTP thresholds is presented in Figure 1. Up to the WTP threshold of about 96 000 THB/QALY, the status quo has the highest probability of being the most cost-effective. When WTP increases over 96 000 THB/QALY, strategy I + II + RS with sufficient capacity has the highest probability. The same strategy remains the most cost-effective, with the highest probability of 0.7 and 0.85, at the WTP of 1.5 and 3 times per capita GDP, respectively. More details are presented in Appendix Table 6 in Supplemental Materials found at https://doi.org/10.1016/j.vhri.2024.101010.

Discussion

This study addressed 3 research gaps: (1) analyzing cost-effectiveness of increasing access to CRC screening considering limitations in colonoscopy capacity, (2) estimating resource requirements and cost-effectiveness of building colonoscopy capacity, and (3) analyzing the cost-effectiveness of increasing sensitivity of FIT screening through RS with colonoscopy capacity considerations. We analyzed the status quo and 6 strategies, which includes various combinations of increased access to CRC diagnosis (ie, FIT screening, symptom evaluation) with and without the 8-point risk score, and then analyzed these strategies in a scenario where colonoscopy capacity is increased.

First, each strategy increases early detection and treatment, resulting in a better overall prognosis and greater QALYs than the status quo. However, each requires additional costs due to higher coverage of CRC diagnosis, treatment, and surveillance. LMICs face the constraint of limited colonoscopy capacity. However, economic evaluations in LMICs, including Thailand, analyzed strategies for increasing screening access without considering this limitation.[8,12] A previous study in Thailand suggested that increasing access to FIT screening is cost-effective.[8] However, we show that, under the current colonoscopy capacity (200 000 people/year), increasing access to FIT screening alone is not cost-effective (at 160 000 THB/QALY WTP threshold), whereas increasing access to symptom evaluation and its combination with FIT screening are cost-effective.

Second, our previous study showed that colonoscopy capacity building prevents CRC deaths and cases.[11] However, the cost of building more capacity and its cost-effectiveness is unknown. Drawing on insights from expert interviews, here we have estimated the costs associated with building colonoscopy capacity, specifically through the expansion of the healthcare workforce trained to perform colonoscopies. We found that, with sufficient capacity, all strategies are cost-effective at the WTP threshold of 160 000 THB/QALY. Building sufficient colonoscopy capacity is only marginally less cost-effective for symptom evaluation with and without RS, but it is more cost-effective for the rest of the strategies. When colonoscopy capacity is increased to a sufficient level, the combination of increasing access to symptom evaluation and screening with risk score becomes the most cost-effective at the WTP of 160 000 THB/QALY, with an 86% probability of being cost-effective. Furthermore, for WTP higher than 96 000 THB/QALY (0.9 times per capita GDP), this strategy has the highest probability of being the most cost-effective strategy.

Third, using risk stratification such as the 8-point risk score has both benefits and drawbacks to CRC care when colonoscopy capacity is limited. It increases the sensitivity to detect polyps and CRC, resulting in more early treatment, more CRC prevention, and overall better CRC prognosis. However, the risk score also decreases the specificity, resulting in more false-positives in primary screening.[13] Thus, combining the 8-point risk score might allocate the limited colonoscopy capacity into false-positive individuals, resulting in delayed treatment in true positive and less QALY gained. For example, at the WTP of 160 000 THB/QALY, combining the risk score with increasing access to FIT screening results in a higher ICER. However, at the same WTP, when colonoscopy is sufficient, each strategy combined with the risk score is more cost-effective than without the risk score. Moreover, with sufficient capacity level, combining risk score with increasing access to FIT screening and symptom evaluation has the highest probability of being the most cost-effective across a wide range of acceptable WTP thresholds.

Our study has several limitations. First, all limitations of the Colo-Sim[11] are limitations to this study. Second, several inputs were missing to calculate the cost of colonoscopy capacity building. We estimated them using assumptions made by the experts interviewed. Third, our analysis is at the national level. We did not consider area differences in colonoscopy capacity, workforce, and access to CRC diagnosis. Fourth, we assumed that access to CRC diagnosis remains constant after strategy implementations. However, the level of access may decline over time. Finally, we did not include opportunity costs from delayed treatment in other benign diseases, such as hernia, osteoarthritis of the knee, and chronic gastritis. All strategies we analyzed increase CRC burdens because of higher coverage in CRC diagnosis, treatment, and surveillance. Healthcare workers will spend more time on CRC care, resulting in less time to take care of these diseases. Moreover, operating rooms will be used for CRC screening, treatment, and surveillance, which might delay the treatment of these diseases.

Despite these limitations, this study showed that increasing access to CRC diagnostic approaches in Thailand can be cost-effective, and a concurrent enhancement in colonoscopy capacity is needed to realize the full benefits of these diagnostic approaches.

Author Disclosures

Author disclosure forms can be accessed below in the Supplemental Material section.

Supplemental Material

Supplementary data associated with this article can be found in the online version at https://doi.org/10.1016/j.vhri.2024.101010.

Article and Author Information

Accepted for Publication: April 30, 2024

Published Online: xxxx

doi: https://doi.org/10.1016/j.vhri.2024.101010

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Provision of study materials or patients: Wongseree
Obtaining funding: Wongseree
Supervision: Jalali

Funding/Support: This work was supported in part by the Prince Mahidol Award Youth Program, Prince Mahidol Award Foundation under the Royal Patronage, Thailand. This article reflects the views of the authors and should not be construed to represent the views or policies of the funding agency.

Role of the Funder/Sponsor: The funder had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; or decision to submit the manuscript for publication.

Acknowledgment: The authors thank Jonathan Huang and Hannah Lee, as well as participants at the 2023 International System Dynamics Conference and Society of Medical Decision Making 18th Biennial European Conference, for their feedback on earlier versions of this report.

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