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Cost effectiveness analysis of three colorectal cancer screening modalities in Kuwait

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Colorectal cancer (CRC) poses a significant health challenge in Kuwait, ranking as the second most common cancer with the incidence rate 13.2 cases per 100,000 people in year 2019. This study aims to determine the cost-effectiveness of three colorectal cancer (CRC) screening methods in Kuwait from the perspective of Kuwait's healthcare providers. Using a Decision Tree Analysis Model, the study compared three screening modalities: Fecal Occult Blood Test (FOBT) followed by colonoscopy or sigmoidoscopy, colonoscopy alone, sigmoidoscopy alone and alongside no screening. Over a 10-year period post-diagnosis, the model tracked costs and outcomes based on CRC patients' life expectancy, expressing results using Incremental Cost Effectiveness Ratios (ICERs). Colorectal cancer screening using FOBT followed by colonoscopy or sigmoidoscopy resulted in 7.7 quality-adjusted life years (QALYs) at a cost of USD 3,573. In contrast, no screening achieved 7.2 QALYs but was more expensive, costing USD 4,084. Screening with only sigmoidoscopy or only colonoscopy provided 6.8 QALYs each, at costs of USD 4,905 and USD 5,002, respectively. Sensitivity analyses explored uncertainties in cost and outcome estimates. FOBT followed by colonoscopy or sigmoidoscopy can be considered as an efficient and effective approach towards early detection of CRC. This approach can be used by healthcare policymakers in Kuwait, in the development of population-based CRC screening programs to optimize resource allocation and improve public health outcomes.

Keywords Cost-effectiveness, Colorectal cancer, Fecal occult blood testing, Colonoscopy, Sigmoidoscopy

Globally, colorectal cancer (CRC) ranks as the second leading cause of cancer-related mortality, claiming 1.1 million lives annually and representing 9.7% of all cancer-related Disability-Adjusted Life Years (DALYs)[1]. This underscores the significance of CRC as a pressing public health concern globally[2,3]. In Kuwait, CRC is the second most common cancer after breast cancer[4]. Data from the Kuwait Cancer Registry shows that between January 2010 and December 2019, there were 2,710 cases of CRC, accounting for approximately 10.2% of all cancer cases in the country. During this period, while the global age-standardized incidence rate of CRC is estimated at 19.7 per 100,000 people, Kuwait experiences a slightly lower rate of 13.2 per 100,000 according to data from the Kuwait Cancer Registry (2010–2019)[4].

Early detection of colorectal cancer allows for treatment before it becomes incurable, potentially lowering cancer mortality. Preventive cancer screening aims to identify and remove precursor lesions, like colorectal adenomas, to prevent cancer development. Consequently, preventive screening can reduce both the incidence of cancer and the associated mortality[5].

In the United States of America (USA), US Preventive Services Task Forces recommends screening for colorectal cancer in all adults aged 50 to 75 years to select from a number of suggested screening strategies such as FOBT, colonoscopy, sigmoidoscopy[6], meanwhile European Union (European Guide for Quality National Cancer Control Programmes) recommends CRC screening with a Guaiac Fecal Occult Blood Test (gFOBT) or immunochemical Fecal Occult Blood Test (iFOBT) for the age group 50–74 years, for all adult's women

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and men[7]. Despite the lower incidence of CRC in Kuwait compared to global rates, the lack of an established nationwide screening program poses a critical public health challenge. In 2015 a National Program for Early Diagnosis of Colorectal Cancer was launched by the Ministry of Health. Although we do not have any information regarding the reach of the program, a recent study indicates that only 19% of the Kuwait nationals eligible of CRC screening have done any checkups for colorectal cancer (Alharran et al., 2024), In addition, the cost-effectiveness of screening methods has not been evaluated for the Kuwaiti population[8].

Economic evaluation is a systematic and formal way of assessing the costs and benefits of screening interventions. There are a number of methods for screening for CRC; colonoscopy, one of the most widely used interventions, has been associated with relatively high accuracy performance[9]. In contrast, the FOBT is easier to use and less expensive than colonoscopy[10,11]. Until recently, gFOBT was the only test for which there was strong evidence of efficacy from randomized controlled trials (RCTs). In the UK, repeated screening with gFOBT has shown a 16% reduction in CRC mortality, making it a favored screening method in national programs[12]. FOBT screening has been shown to be beneficial in lowering the annual incidence eand death of CRC[13]. Screening for CRC can be done using methods like fecal occult blood testing (FOBT), colonoscopy, and flexible sigmoidoscopy. Each method varies in terms of cost, invasiveness, and efficacy, with colonoscopy being considered the most accurate, and FOBT being easier to implement and less expensive[14], while US population-based case control studies have demonstrated a respectable decrease in yearly mortality with colonoscopy screening[15,16]. A randomized controlled trial (RCT) should ideally offer concrete empirical proof of the relative efficacy of different CRC screening techniques. Prior RCTs were intended to randomly assign participants into a regular FOBT screening group in order to capture such long-term CRC risk; however, no screening group persisted for at least ten years[17–21].

Cost-effectiveness analysis (CEA) offers decision-making and rationale for effective resource allocation under a set budget restriction, aiming to strike a balance between costs and effectiveness incurred by CRC screening. The most cost-effective procedures in terms of live years (LYs) gained for an average-risk population are annual FOBT plus 5-yearly sigmoidoscopy under full compliance rate[22] and colonoscopy every 10 years[23], according to cost-effectiveness modeling conducted on the U.S. population. According to a study conducted on a population in Hong Kong, the incremental costs of colonoscopy and FOBT compared to no screening were US $7,211 and US $6,222 per life year gained, respectively[24]. According to UK research studies, the most economical screening approach was to use only biennial FOBT since it was projected to have an incremental cost of less than £3,000 per QALY when compared to no screening[25,26].

Given the absence of a national CRC screening program in Kuwait and the need for cost-efficient healthcare strategies, this study aims to evaluate the cost-effectiveness of three screening modalities: colonoscopy alone, sigmoidoscopy alone, and FOBT followed by colonoscopy or sigmoidoscopy.

By assessing the cost-effectiveness of different CRC screening methods in the Kuwaiti population, this study will help inform healthcare policy, potentially guiding the establishment of a more effective national screening program that balances cost and public health outcomes.

Methodology

Study population

The target population was a hypothetical cohort of adults aged 50–80 years at risk for CRC, based on the national population data such as disease prevalence, age distribution, and risk factors to simulate or model health outcomes. Three screening options were taken into consideration: annually FOBT followed by sigmoidoscopy or colonoscopy, sigmoidoscopy every five or ten years, and colonoscopy every ten years (Table 1). Positive FOBT results are followed up with sigmoidoscopy or colonoscopy, adhering to established clinical guidelines.

Development of an economic model

A decision tree analytic model was developed to conduct a cost-effectiveness analysis of various CRC screening modalities compared to no screening option. The model compared costs and outcomes of three major screening modalities for CRC which are (i) colonoscopy, (ii) sigmoidoscopy and (iii) Fecal Occult Blood Test (FOBT) followed by colonoscopy or sigmoidoscopy compared to no screening option. The model is presented in the Fig. 1.

This model adopted the third-party payer's perspective because, it reflects the role of the Kuwait Ministry of Health as the primary healthcare payer. In this case, the Kuwait Ministry of Health was used as the main data source to examine costs and outcomes associated with colorectal cancer screenings. This model tracks costs and outcomes for 10 years post-diagnosis based on the documented life expectancy of patients with colorectal cancer.

CRC screening strategy					
Strategies	Interval (Years)	Time horizon	Age at screening (years)	Outcome measures	Incremental cost-effectiveness ratio (ICER)
No Screening	-	Lifetime	50–80	QALYs	Cost/QALYs
FOBT	1	Lifetime	50–80	QALYs	Cost/QALYs
Sigmoidoscopy	5	Lifetime	50–80	QALYs	Cost/QALYs
Sigmoidoscopy	10	Lifetime	50–80	QALYs	Cost/QALYs
Colonoscopy	10	Lifetime	50–80	QALYs	Cost/QALYs

Table 1. CRC screening strategies used in this study.

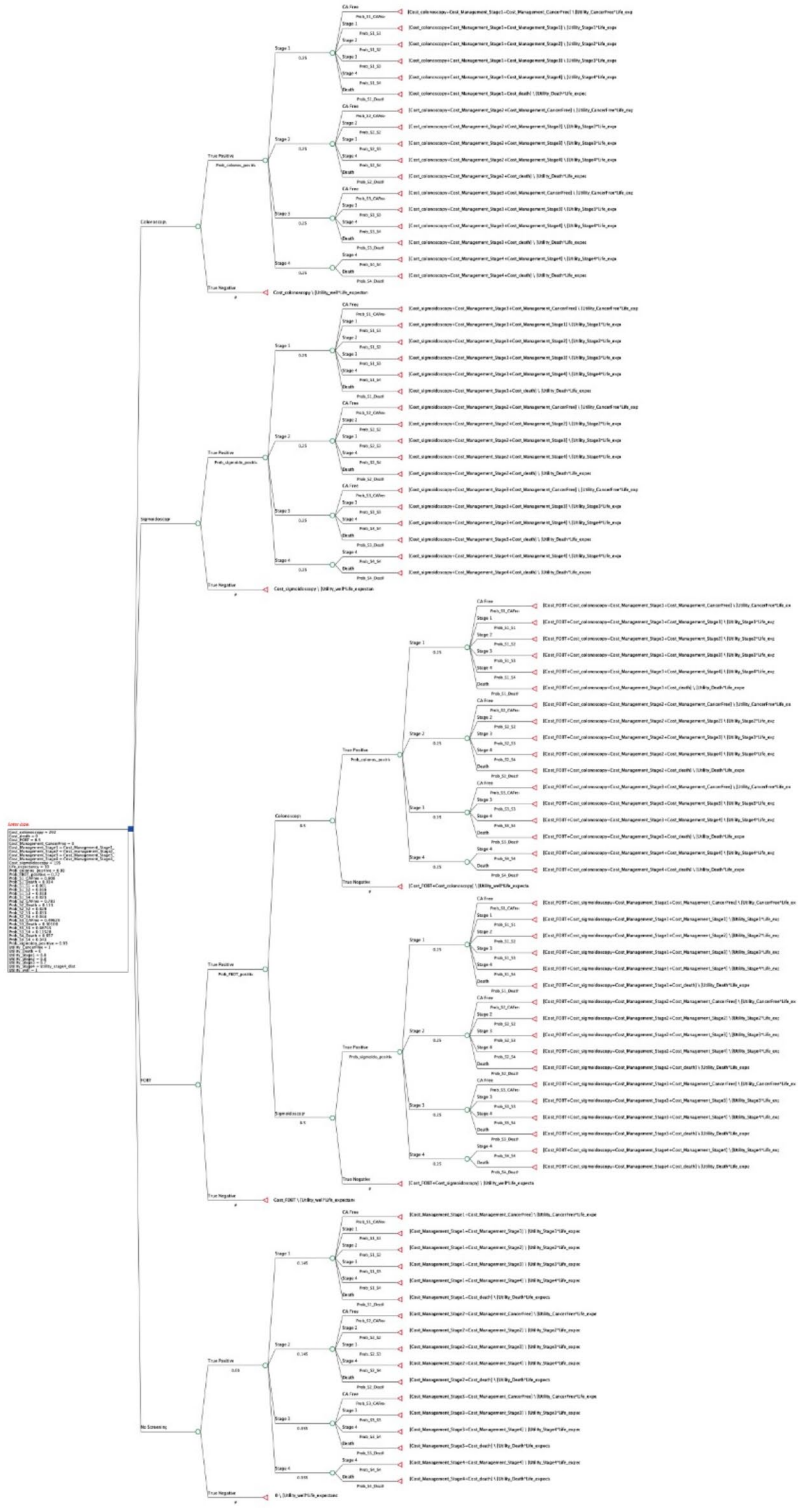

Fig. 1. Decision tree for colorectal cancer screening options.

All cost estimates were adjusted for inflation to the year 2023. For the cost-effectiveness analysis, a willingness to pay (WTP) threshold of 1 GDP per capita was used.

The final output of the model was expressed in terms of Incremental Cost Effectiveness Ratio (ICER) comparing those alternatives. ICER was calculated between two alternatives to determine the magnitude of the cost-effectiveness of the various CRC screening modalities. For the ICER, Cost-effectiveness was assessed using the WHO-recommended threshold of 1–3 times Kuwait's GDP per capita[27,28]. The uncertainties were assessed for any parameters estimated through deterministic and probabilistic sensitivity analyses. The findings

Costs information	Cost (USD)	Source
Cost of screening with colonoscopy	293.00	[29]
Cost of screening with sigmoidoscopy	195.00	[29]
Cost of screening with Fecal Occult Blood Test (FOBT)	6.50	[29]
The cost of managing a patient is stage 1 cancer	839.50	[30]
The cost of managing a patient is stage 2 cancer	1,682.00	[30]
The cost of managing a patient is stage 3 cancer	5,955.00	[30]
The cost of managing a patient is stage 4 cancer	7,159.00	[30]
Cost of death/cancer-free	0.00	NA

Table 2. List of cost information.

Utility	Utility value	Source
Well patient (cancer-free)	1	[31]
Patient with stage 1 cancer	0.8	[31]
Patient with stage 2 cancer	0.8	[31]
Patient with stage 3 cancer	0.7	[31]
Patient with stage 4 cancer	0.6	[31]
Death	0	[31]

Table 3. List of utility value of CRC patient by stages from published studies.

were presented in an ICER table and diagrams accordingly. Model parameters including probabilities, costs, and outcomes were derived from primary data collection, expert's opinions and published sources. Sensitivity analyses were used to account for uncertainty in these estimates.

Cost information

All cost information used in this model from the healthcare provider perspective, included screening cost and management cost of CRC patient. Indirect costs that are incurred by the patients such as transportation, meal, caregiver and loss of productivity were not included due to the focus on the healthcare provider's perspective. The cost of FOBT, Colonoscopy and Sigmoidoscopy were extracted from existing Kuwait MOH charges[29]. The management cost of CRC patient by stage level was computed by multiplying the length of stay (LOS) of each CRC patient with the existing average unit cost per day of stay in the Kuwait government hospital[30]. The existing unit cost was computed in the year 2017. The adjusted inflation with multiple years was made for the year 2023. Local costs evaluated in Kuwaiti Dinar in year 2023 were converted to US dollar (USD) which exchange rate of 1 Kuwaiti Dinar = 3.254 USD. Refer to the Table 2 for the list of cost information.

Effectiveness of health outcome

To measure the health outcomes of the various screening alternatives, the values of QALYs were used. The QALY was imputed to the model by incorporating utility values from published studies multiplied by the duration of the time spent in the disease state, which in this study was 10 years. The 10-year cut-off point was used based on the reported life expectancy of CRC patients[31]. The utility values are described in Table 3.

Probability data

All the probabilities that were incorporated in the cost-effectiveness model were obtained from published literature and expert's inputs. The values used are described in Table 4:

Assumptions

In the model, several assumptions were made given the unavailability of the data. Firstly, it was assumed that, following the screening and disease staging, the probability of patients diagnosed at various stages of colorectal cancer (stage 1 to 4) is the same, and therefore probability of 0.25 was applied for each stage. Secondly, following FOBT, the probability of disease confirmation through colonoscopy and sigmoidoscopy is also the same and a probability of 0.5 was applied for each alternative. In the no-screening option, the number of patients with colorectal cancer was based on the information of the under-reported cases which was 63%. Therefore, the probability of 0.63 was applied which supported by references to relevant literature[32]. Following that the distribution of patients in each stage of CRC was based on data from published studies[37–39]. Regarding the probability of patients at various stages of cancer, mathematical calculations were imputed in which the probabilities were first determined through the survival rate to determine the probability of death. Subsequently, the remaining probabilities were further distributed according to the weightage for each stage of cancer. The weights used were based on published literature[37,38].

Probability	Value	Source
Positive detection rate with colonoscopy	0.93	[32]
Positive detection rate with sigmoidoscopy	0.93	[32]
Positive detection rate with Fecal Occult Blood Test (FOBT)	0.72	[32]
Remain at stage 1	0.001	[33–35]
Stage 1 to Stage 2	0.016	[33–35]
Stage 1 to stage 3	0.018	[33–35]
Stage 1 to stage 4	0.023	[33–35]
Stage 1 to cancer-free	0.908	[33–35]
Stage 1 to Death	0.034	[33,36]
Remain at stage 2	0.029	[33–35]
Stage 2 to stage 3	0.033	[33–35]
Stage 2 to stage 4	0.044	[33–35]
Stage 2 to cancer-free	0.781	[33–35]
Stage 2 to Death	0.113	[33–35]
Remain at stage 3	0.08743	[33–35]
Stage 3 to Stage 4	0.11528	[33–35]
Stage 3 to cancer-free	0.49629	[33–35]
Stage 3 to Death	0.30100	[33,36]
Remain at stage 4	0.343	[33–35]
Stage 4 to Death	0.657	[33,36]

Table 4. List of CRC probability detection rate by various CRC screening modalities and probability of CRC by stages, cancer free and death from published studies.

Alternatives	Cost (USD)	Incremental cost (*comparison with the undominated alternative)	Effectiveness of health outcomes (QALYs per person)	Incremental effectiveness	ICER
FOBT followed by colonoscopy or sigmoidoscopy	3573		7.7		
No screening	4084	511	7.2	-0.5	-1010.00
Sigmoidoscopy	4905	1332	6.8	-0.9	-1498.06
Colonoscopy	5002	1429	6.8	-0.9	-1607.16

Table 5. Cost, incremental cost, QALYs per person (Effectiveness of health outcome) for each screening strategy, incremental effectiveness, and ICER compared with FOBT followed by colonoscopy or sigmoidoscopy.

Results

In cost-effectiveness analysis, a strategy is considered to "dominance" if it is both less costly and more effective than its alternatives. Conversely, a strategy is considered "dominated" if it is more costly and less effective. These criteria provide clarity when comparing and prioritizing health interventions, helping to assess their economic value and clinical outcomes. In this study, the Incremental Cost-Effectiveness Ratio (ICER) is used to represent the additional cost per additional unit of effectiveness (measured in Quality-Adjusted Life Years, or QALYs) when comparing one strategy to another. Our findings indicate several important insights regarding the relative cost-effectiveness of different screening approaches.

The ICER values observed in this study provide a clear picture of the comparative effectiveness of each screening strategy. For instance, the ICER for No Screening versus FOBT with Follow-Up is -$1,010, indicating that FOBT with colonoscopy or sigmoidoscopy is both less costly and more effective, thereby dominating the no screening strategy. Similarly, the ICER for Sigmoidoscopy Alone versus FOBT with Follow-Up is -$1,498.06, confirming the dominance of FOBT with follow-up over sigmoidoscopy alone. Finally, the ICER for Colonoscopy Alone vers202-us FOBT with Follow-Up is -$1,607.16, which also highlights the economic and clinical superiority of the FOBT strategy (Table 5).

These negative ICER values demonstrate that the FOBT with colonoscopy or sigmoidoscopy strategy dominates the other screening options by being more effective while also reducing costs. A detailed comparison of the four screening strategies further highlights their differences in terms of both cost and effectiveness. For example, FOBT with colonoscopy or sigmoidoscopy costs $3,573 and yields 7.7 QALYs. In contrast, no screening costs $4,084 but provides only 7.2 QALYs, while sigmoidoscopy alone costs $4,905 and results in 6.8 QALYs. Colonoscopy alone, at $5,002, also produces 6.8 QALYs. FOBT with follow-up achieved the highest effectiveness (7.7 QALYs) at the lowest cost ($3,573), making it the most cost-effective strategy. (Table 5)

Incorporating these findings emphasizes the significant clinical and economic value of using FOBT followed by colonoscopy or sigmoidoscopy for colorectal cancer (CRC) screening. This strategy optimizes both patient outcomes and resource use, offering a more effective alternative to other screening methods while minimizing costs. The results underscore the importance of prioritizing cost-effective strategies that provide the best value for both health outcomes and economic efficiency.

The results highlight that the parameters most significantly influencing cost-effectiveness of the different strategies. The cost of managing patients in advanced cancer stages (Stages 3 and 4) was found to have the greatest impact on the ICER values, as evidenced by its prominent position in the tornado diagram. Additionally, variations in screening costs—such as those associated with FOBT, sigmoidoscopy, and colonoscopy—also played a significant role in shaping the ICER outcomes. For instance, the cost of managing Stage 4 CRC patients exhibited a wide range of ICER variations, underscoring its critical influence on the overall cost-effectiveness of screening strategies. Increasing the cost of managing advanced cancer stages led to more negative ICER values, reinforcing the dominance of FOBT followed by colonoscopy or sigmoidoscopy as the most cost-effective approach.

Sensitivity analysis

To test the effect of single variables on the overall economic conclusion from this model, multiple one-way sensitivity analyses were conducted. The tornado diagram (Fig. 2) was used to visually demonstrate the resulting ICERs when one variable is changed to become either the maximum or minimum value of the range provided. It is used to identify the relative importance of a variable since it can demonstrate if the economic conclusion changes based on changing the variable. In an ICER tornado diagram, the importance of each variable on the economic conclusion is presented from top to bottom. The tails of each bar indicate the maximum and minimum ICER for each variable. The dashed line represents the ICER from the reference case to provide a reference for the changes in ICERs.

In this study, 14 parameters were used in the multiple-1-way sensitivity analyses. All the included parameters with the lower value and upper value used are presented in the table below. The values were taken from the published studies and also expert input as shown in Table 6.

To conduct the sensitivity analysis, two alternatives were chosen which are the FOBT followed by colonoscopy or sigmoidoscopy. The results of the multiple-1-way sensitivity analyses demonstrated that this CEA model was most sensitive to the cost of managing patients in stages 4, 3 and 2 of the cancer as illustrated Fig. 2.

Based on the results of the multiple-1-way sensitivity analyses, the parameters tested for sensitivity analysis changed the magnitude of ICER. The tornado diagram shows that all the parameters tested resulted in further negative ICERs when a higher value was set. Subsequently, a Probabilistic Sensitivity Analysis (PSA) was done for multivariate analysis using TreeAge Pro software. In the PSA, instead of changing one parameter value at a time, all variables were changed at once according to their plausible values by random sampling from their distributions. The model was simulated 10,000 times in the PSA from the probability distribution of each parameter. All cost data were assigned to a gamma distribution. Utility data followed a beta distribution. The

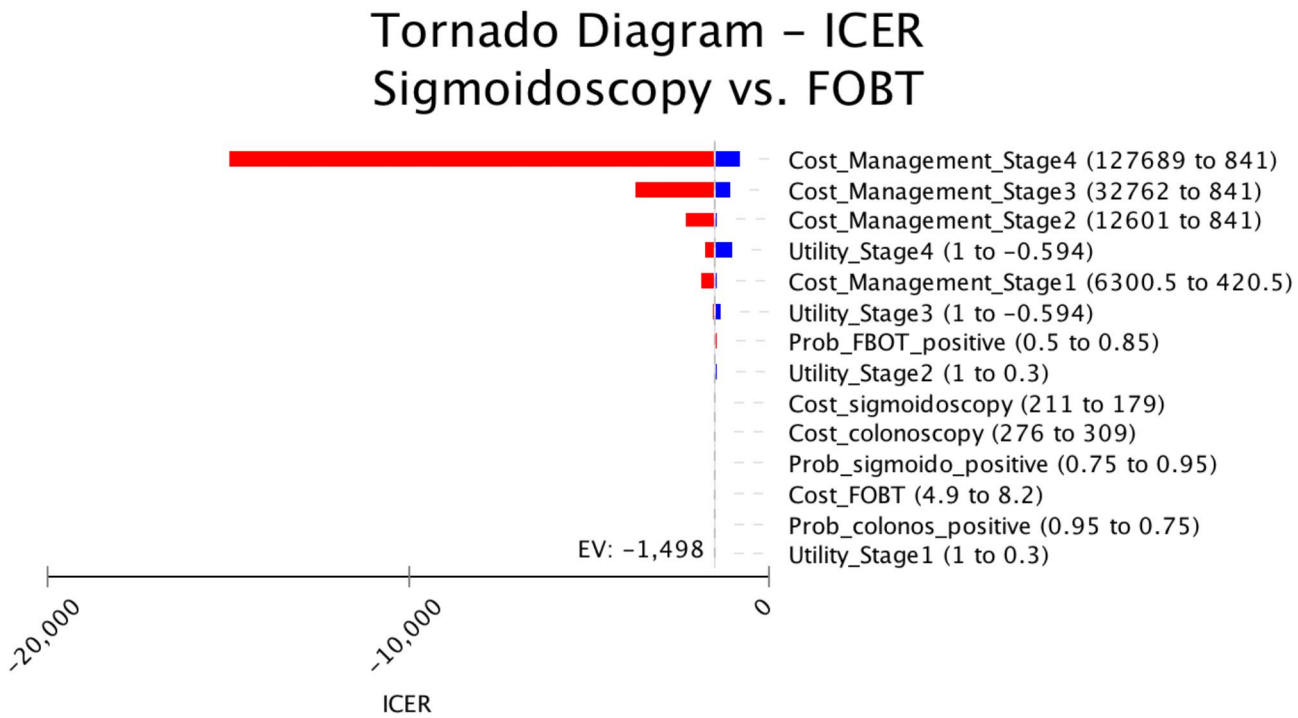

Fig. 2. Tornado diagram between ICER Sigmoidoscopy and FOBT.

	Parameters	Lower value	Upper value	Source
1	Positive detection rate with colonoscopy	0.75	0.95	[39,42–45]
2	Positive detection rate with sigmoidoscopy	0.75	0.95	[39,42–45]
3	Positive detection rate with Fecal Occult Blood Test (FOBT)	0.5	0.85	[39–41]
4	Cost of screening with colonoscopy	276	309	[29]
5	Cost of screening with sigmoidoscopy	179	211	[29]
6	Cost of screening with Fecal Occult Blood Test (FOBT)	4.9	8.2	[29]
7	Cost of managing a patient with Stage 1 cancer	420.50	6300.50	[30]
8	Cost of managing a patient with Stage 2 cancer	841.00	12601.00	[30]
9	Cost of managing a patient with Stage 3 cancer	841.00	32762.00	[30]
10	Cost of managing patients in stage 4 of cancer	841.00	127689.00	[30]
11	Utility for patients with stage 1 cancer	0.3	1	[31]
12	Utility for patients with stage 2 cancer	0.3	1	[31]
13	Utility for patients with stage 3 cancer	-0.594	1	[31]
14	Utility for patients with stage 4 cancer	-0.594	1	[31]

Table 6. The 14 parameters were used in the multiple-1-way sensitivity analyses.

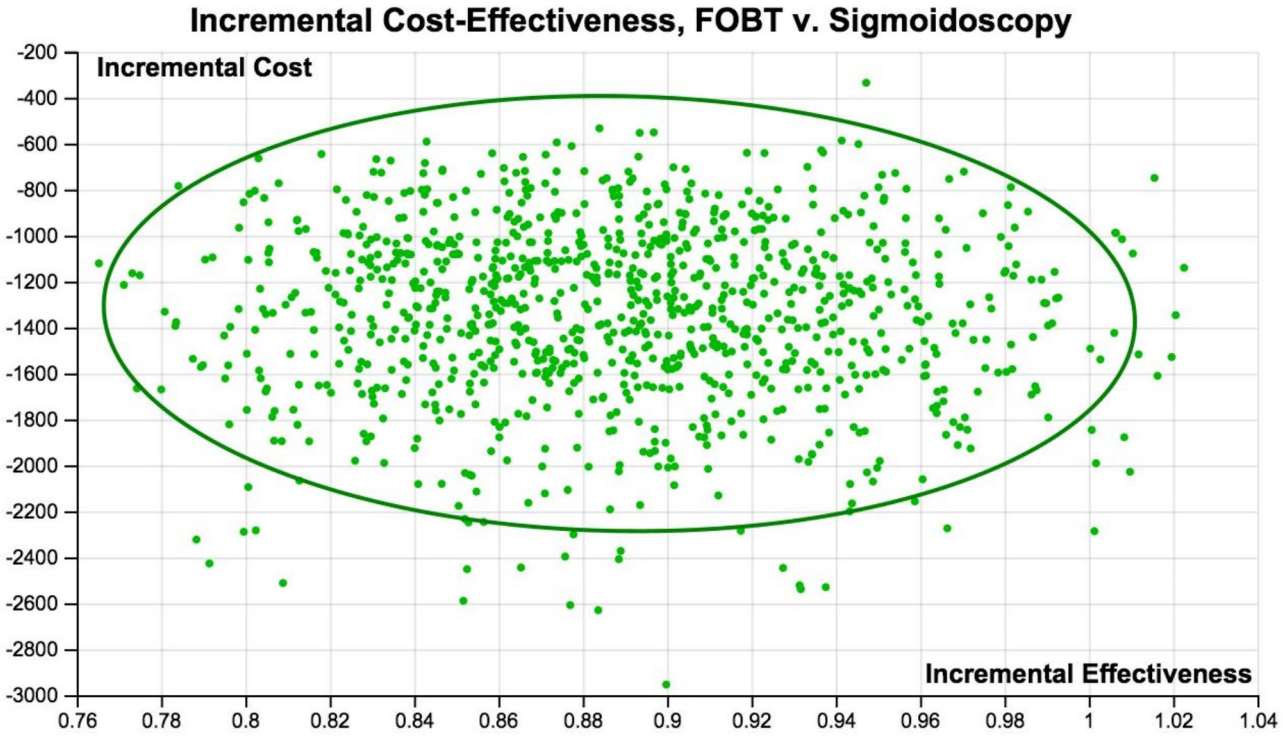

Fig. 3. Incremental Cost Effectiveness Between FOBT and Sigmoidoscopy.

cost-effectiveness scatterplot was used to test the stability of the model results. Based on the multiple-1-way sensitivity analyses, parameters that were sensitive to the changes of ICER were identified and applied for the PSA. The parameters included the cost of disease management for all the stages of colorectal cancer and utility value for stage 4 of the cancer.

In this study, when the ICERs from the PSA are plotted onto the cost-effectiveness plane, comparing sigmoidoscopy and FOBT followed by colonoscopy or sigmoidoscopy, it demonstrates that the probabilistic sensitivity analysis (PSA) provided further validation of these findings. Over 95% of ICER outcomes for the FOBT-based screening strategy fell within the dominance quadrant of the cost-effectiveness plane. This robust result, confirmed across multiple scenarios, highlights the strength and reliability of FOBT with follow-up colonoscopy or sigmoidoscopy as the most cost-effective CRC screening strategy, further supporting its use in clinical practice.

Based on the 10,000 iterations, all negatives ICERs were obtained. This finding demonstrated that the sigmoidoscopy is a dominated alternative compared to FOBT followed by colonoscopy or sigmoidoscopy. The result of the PSA is illustrated in Fig. 3.

Discussion

This study assessed the cost-effectiveness of three colorectal cancer (CRC) screening modalities—FOBT followed by colonoscopy or sigmoidoscopy, colonoscopy alone, and sigmoidoscopy alone—in the Kuwaiti context. Using a decision tree model, the findings highlight the superiority of FOBT followed by colonoscopy or sigmoidoscopy as a cost-effective strategy, offering both economic and clinical benefits. This discussion synthesizes the results, compares them with prior studies, and explores implications for healthcare policy in Kuwait.

The study's findings demonstrate that FOBT followed by colonoscopy or sigmoidoscopy yields the highest QALYs (7.7) at the lowest cost (USD 3,573). In contrast, no screening, colonoscopy alone, and sigmoidoscopy alone incur higher costs while offering fewer QALYs. These results underscore that FOBT-based strategies effectively optimize resource allocation while improving health outcomes. This directly aligns with the study's objectives of identifying cost-effective CRC screening methods and informing healthcare policy development in Kuwait.

Implementing FOBT-based screening programs can lead to significant cost savings while effectively detecting and preventing CRC. Several meta-analyses from 1998 to 2016 consistently showed a modest but significant reduction in CRC mortality with gFOBT. The relative risks for CRC mortality ranged from 0.82 to 0.87. In fact, a pooled estimate from the Minnesota and Nottingham trials, indicated an 8% reduction in late-stage CRC incidence with gFOBT screening[46–48].

Regarding the cost-effectiveness finding, studies across several regions confirm that gFOBT screening for CRC is cost-effective. For example, Helm et al. (2000) indicated the cost-effectiveness of gFOBT based on trials conducted in Minnesota, Nottingham, and Funen[49], while Whynes et al. followed up on the Nottingham trial, and reaffirmed the cost-effectiveness of gFOBT screening[50]. Three systematic reviews by Pignone et al., Lansdorp-Vogelaar et al., and Patel & Kilgore consistently found that gFOBT or FIT screening to be cost-effective compared to no screening[51–53]. Additional studies by Ladabaum & Mannalithara, gs Kingsley et al., Barzi et al., and Lee & Park, also found cost savings for annual FIT and gFOBT[54–57]. Overall, 14 new international studies have been published since Lansdorp-Vogelaar et al.'s review in 2011, which predominantly showed that FOBT screening is cost-saving[58–70].

Furthermore, the individual screening modalities of sigmoidoscopy and colonoscopy, while demonstrating similar effectiveness scores of 6.8, incur significantly higher costs compared to the FOBT-based strategy. Sigmoidoscopy incurs an incremental cost of USD 1332 and an ICER of USD 1498.06, while colonoscopy incurs an incremental cost of USD 1429 and an ICER of - USD 1607. These findings highlight the economic trade-offs associated with more invasive screening procedures.

To date, only two methods have been assessed in RCTs to investigate reductions in CRC incidence or mortality: gFOBT and sigmoidoscopy. This section deals with comparisons between major endoscopic and stool-based CRC screening methods (i.e.,sigmoidoscopy or colonoscopy vs. gFOBT or FIT) in terms of mortality or incidence outcomes, ADRs, and cost–effectiveness. No RCT is available that directly compares two or more CRC screening tests. Evidence comes from indirect comparisons of observational studies and from indirect meta-analyses, so-called network meta-analyses using Bayesian statistics[71].

Combining FOBT with colonoscopy or sigmoidoscopy in this study was a cost-effective screening strategy. This finding is supported by the literature. For example, Littlejohn et al., found that sigmoidoscopy, either alone or combined with FOBT, was more effective in detecting advanced adenoma compared to FOBT alone[72]. Similar results were observed for the detection of CRC. In Holme et al., found that the detection rates of advanced adenoma and CRC were similar between sigmoidoscopy alone and a combination of FIT with sigmoidoscopy[73]. All studies that used combined screening methods (either FIT or gFOBT with flexible sigmoidoscopy or colonoscopy) demonstrated consistently increased detection rates for CRC[70,73–75].

Sensitivity analyses were used to account for uncertainty in these estimates. Based on the sensitivity analyses, the economic conclusions are robust, with significant savings maintained across different parameters. In conclusion, the model favoured FOBT followed by colonoscopy or sigmoidoscopy screening as a cost-effective CRC screening program.

This study adds to existing evidence by focusing on Kuwait, where CRC screening policies remain underdeveloped. Unlike previous studies conducted in high-income settings, this analysis incorporates local healthcare costs and population characteristics, offering insights specific to Kuwait. The findings emphasize that adopting FOBT with follow-up colonoscopy or sigmoidoscopy could enable Kuwait's healthcare system to achieve comparable outcomes to those observed in global CRC screening programs while maintaining cost efficiency.

Limitations and future directions

It is important to acknowledge certain limitations of this study. First, the costs of CRC screening were calculated from the healthcare provider perspective (Kuwait MOH). The cost of lost productivity, meal, cost of transportation and caregiver is not included. Second, the model did not incorporate the potentially high cost of establishing a national screening program in Kuwait, including the costs of addressing adherence, public health campaigns to change attitudes toward CRC screening or other methods at the provider level to increase adherence as a reference the other paper that we just published[76]. Third, the utility data were measured by cross-sectional study rather than randomized controlled trial with sufficient follow-up periods, which involves the consideration of time-dependent utility data in the short and long term.

To our knowledge this is the first cost-effectiveness analysis focusing on screening strategies for colorectal cancer in Kuwait and has the potential to contribute significantly to the knowledge base guiding rational decision making with respect to clinical practice and health care resource allocation. If acted upon, the findings of our study may substantially improve CRC care in Kuwait and can be used to concentrate efforts on developing a national screening program.

The decision tree analysis model relies on various assumptions (14 parameters) regarding the accuracy of screening tests, the effectiveness of treatment interventions, the probability of each CRC screening positive etc. Future research could address these limitations by incorporating real-world data and conducting sensitivity analyses to validate the robustness of the findings.

Policy implications

FOBT CRC screening presents a non-invasive, safe, and easily implementable alternative to colonoscopy screening. In contrast to the invasive nature of colonoscopy, FOBT involves minimal discomfort and presents considerably lower risks to patients. Not only does FOBT mitigate the risks inherent in invasive procedures like colonoscopy, including the potential for bleeding due to perforation, pain, and the arduous preparation process, but it also serves as a convenient and accessible means for early detection of colorectal cancer. Therefore, advocating for the widespread adoption and promotion of FOBT screening can significantly bolster public health initiatives aimed at reducing colorectal cancer incidence and mortality rates.

The results advocate for the implementation of a structured, FOBT-based screening initiative. Such a program could reduce CRC incidence and mortality while remaining within Kuwait's healthcare budget. Moreover, the relatively low cost of FOBT (USD 6.50) enhances its feasibility for large-scale deployment. Integrating FOBT-based screening into the healthcare system would align with global best practices and address the current public health gap.

To ensure successful implementation, policymakers should consider strategies to improve screening adherence, such as public awareness campaigns and capacity building for follow-up diagnostic services. Addressing logistical and financial barriers, including those related to colonoscopy follow-ups, will be critical for the program's sustainability.

Conclusions

FOBT followed by colonoscopy or sigmoidoscopy is the most cost-effective CRC screening strategy for Kuwait, offering significant health and economic benefits. Policymakers should prioritize this approach to establish a sustainable national CRC screening program. By doing so, Kuwait can reduce CRC burden, improve public health outcomes, and ensure optimal use of healthcare resources.

Data availability

The data that support the findings of this study are available from the Kuwait Cancer Control Centre (KCCC) and Kuwait Ministry of Health, but restrictions apply to the availability of these data, and so are not publicly available. Data are however available from Dr. Amrizal Nur upon reasonable request and with permission of the Kuwait Ministry of Health.

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Author contributions

SMA, ELT, AMN, MA, RA, AE were involved in the design of the study. AMN and SMA were involved in data analysis, interpretation, and critical revision of the manuscript. MA, RA, AE, ELT, WQA, SMA were involved in data validation. AMN wrote the manuscript. AMN was involved in project administration. All authors reviewed and approved the final draft of the manuscript.

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Declarations

Competing interests

The authors declare no competing interests.

Ethics approval and consent to participate

The study adhered to the principles of the Declaration of Helsinki and was approved (approval# 2017/694) by the Kuwait Ministry of Health Standing Committee for the Coordination of Health and Medical Research (Ethics Committee). All participants filled out a written informed consent for participation in the study.

Additional information

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