Cost-effectiveness of colorectal cancer screening in Slovakia

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Background **Colorectal cancer (CRC) is an ideal disease for screening due to known and detectable precursor lesions and slow progression from benign adenoma to invasive cancer. The introduction of organized population-based screening programs reduces the burden of colorectal cancer and increases the quality of the screening process with a more favorable harm to benefit ratio compared to opportunistic screening.**

Methods **The study used the microsimulation screening analysis-colon simulation model for the estimation of the effect of various factors on cancer incidence and mortality. The model simulated the Slovakian population from 2018 to 2050. Study includes the analysis of two screening strategies the fecal immunochemical test (FIT) every 2 years and annual FIT. Cost-effectiveness parameters were evaluated comparing each simulated screening scenario with no screening.**

Results **Compared to no screening, the biennial FIT would detect 29 600 CRC cases and annual FIT 37 800 CRC cases. Mortality due to CRC showed benefits for both strategies with 17,38% reduction in biennial FIT and 24,67% reduction in annual FIT approach. Both screening programs were more costly as well as more effective compared to no screening. The ICER for biennial FIT strategy was 1776 EUR per 1 QALY and for the annual FIT 3991 EUR per 1 QALY.**

Conclusions **In summary, this is the first cost-effectiveness analysis focusing on multiple national CRC screening strategies in Slovakia. Both strategies demonstrated cost-effectiveness compared to no screening. However, for optimal population-based programmatic screening strategy, the policymakers should also consider human resources availability, acceptability of screening test among the population or additional resources including the screening funding.** ***European Journal of Cancer Prevention*** **31: 415–421 Copyright © 2021 The Author(s). Published by Wolters Kluwer Health, Inc.**

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Keywords: cancer screening, colorectal cancer, cost-effectiveness, MISCAN-colon model

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Introduction

Colorectal cancer (CRC) is the second most common cancer in Europe. In 2018, there were an estimated 380 000 new cases and 175 000 CRC-related deaths (IARC, 2020). The incidence of colorectal cancer increases with age and significantly after 45–50 years (NIH, 2013). There are two main factors, which make CRC an ideal disease for screening. First, there are known and detectable precursor lesions (adenomatous polyps), resection of which decreases the risk of CRC, with a consequent reduction in mortality. Second, the progression from benign adenoma to invasive cancer is slow and provides a lot of time for intervention (Brenner *et al*., 2014).

The introduction of organized population-based screening programs reduces the burden of CRC as compared to opportunistic screening. It also increases the quality of the screening process with more favorable harm to benefit ratio (McClements *et al*., 2012; Zorzi *et al*., 2015; Levin *et al*., 2018). Most CRC screening programs in Europe involve screening the average risk population between ages 50–75 years (IARC, 2019). Screening options in European programs include fecal occult blood testing (FOBT) and subsequent colonoscopy for positive cases, or primary lower gastrointestinal (GI) endoscopy (either colonoscopy or sigmoidoscopy) (IARC, 2019). Compared with endoscopy, FOBT is less sensitive for detecting advanced colorectal neoplasms when only one-time testing is applied. However, the participation and safety profile improve with annual or biennial FOBT compared to endoscopy (Zorzi *et al*., 2015). The immunochemical FOBT (FIT) is currently considered an evidence-based screening test for CRC that fulfills the requirements of the Council Recommendation of 2 December 2003 (von Karsa *et al*., 2010). The optimal interval for FIT in CRC screening is unclear; however, it should not exceed three

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years (von Karsa *et al.*, 2010). FIT is usually done annually in the USA and typically less frequently in other countries (Doubeni *et al.*, 2018). Recommended coverage of the target population by colorectal cancer screening programs is at least 65% (Segnan *et al.*, 2011). However, the actual examination coverage of EU member states population aged 50–74 years remains at 14%. This represents average examination coverage in countries implementing national, regional or local screening programs and countries that are not. The coverage of the target population in countries with existing population-based programs is higher (IARC, 2017).

In Slovakia, all people who are 50 years or older are entitled and reimbursed by their insurance company to undergo CRC screening by FIT every 2 years (Hrcka and Hlavaty, 2020). However, only a small proportion of the population is actively invited by their general practitioners. Moreover, the process is neither monitored nor evaluated. The participation is low, although, since 2014, the number of FIT tests performed has been increasing (Hrcka and Hlavaty, 2020). At the end of 2019, the population-based CRC screening program was initiated by the Ministry of Health (MoH) to improve screening strategies from opportunistic to organized screening. According to the National guideline for CRC screening, the target population is people aged 50–75 years old, who have an average risk of colorectal cancer (Hrcka and Hlavaty, 2020). The screening test is a biennial FIT with invitation letters and a FIT kit provided by health insurance companies.

The health and cost consequences of CRC screening strategy under Slovak conditions are currently unknown. The study aims to analyze the comparative effectiveness and cost-effectiveness of two most often used strategies in Europe and the USA, annual and biennial FIT, in reducing CRC incidence and mortality in the Slovak population of 50–75 years of age using the microsimulation screening analysis model.

Materials and methods

MISCAN-colon model

For the purpose of our study, we used the webtool based on the MISCAN-colon model (Gini, Buskermolen, *et al.*, 2021; Gini, van Ravesteyn, *et al.*, 2021). The MISCAN-colon model is a simulation model for the estimation of the effect of various factors on cancer incidence and mortality (Gini, Buskermolen, *et al.*, 2021). The purpose of MISCAN-colon can be described in three specific aims: to simulate colorectal cancer incidence and mortality according to observed figures, to estimate the absolute and relative contribution of current CRC screening on observed cancer incidence and mortality trends, and to predict how changes in CRC screening (screening tests, target age, screening interval, screening participation, invitation coverage) and treatment practices will impact future incidence and mortality.

MISCAN-colon is a stochastic, semi-Markov microsimulation model. In a microsimulation model, individuals are simulated one at a time instead of as proportions of a cohort. The advantage of this is that new events can be dependent on past events of that individual, giving the model a 'memory'. The model is stochastic, which means that sequences of events are simulated by drawing from distributions of probabilities and durations instead of using fixed values. Therefore, the outcomes of the model are subject to random variation. The model uses the Monte Carlo method to simulate all events in the program. Possible events are birth and death of a person, adenoma incidence and transitions from one state of disease to another. MISCAN-colon consists of three parts: demography part, natural history part and the screening part (Gini, Buskermolen, *et al.*, 2021). MISCAN-Colon has already been used to inform public health policies in several countries across the globe, including the European Union (Cenin *et al.*, 2014; Van Hees *et al.*, 2015; Knudsen *et al.*, 2016; Peterse *et al.*, 2018; Csanádi *et al.*, 2021). The structure and underlying assumptions of the model are reported elsewhere (Gini, Buskermolen, *et al.*, 2021).

Study population

The model simulated the Slovakian population from 2018 to 2050. The age distribution was on the basis of the officially published age distribution in Slovakia in 2018 (VDC, 2018). Overview of the main model assumptions are in Table 1. The model was calibrated to replicate the age-specific CRC incidence observed in Slovakia in 2014–2018. Cancer epidemiology data, including incidence and age-specific mortality, were obtained from the National Health Information Center (NHIC, 2020). Slovak all-cause mortality data from 2018 were extracted from the Statistical Office of the Slovak Republic (SOSR, 2020). Additional model parameters, which were not published or accessible for Slovakia, were calibrated by using the pre-screen data from reference country, Slovenia, including the CRC relative survival specific to age and cancer stage (SLORA, 2020).

Screening and treatment effectiveness

For the Base case scenario, we included in the analysis two similar screening strategies that would be reasonable to implement nationally in Slovakia with an established medical infrastructure. The first scenario is (1) fecal immunochemical test (FIT) every 2 years (biannual FIT) and second (2) annual FIT test. We assumed that a personal invitation letter was sent to everybody in the target population including the FIT kit. We did not assume any reminder letters being sent. Since no data on screening performance were available for Slovakia, sensitivity of FIT was based on detection rates in Slovenia. The Slovenian CRC screening program invites individuals to perform two fecal samples of the OC-sensor (Eiken, Japan) FIT, which is analyzed at a cutoff 20 μg

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Table 1 Model parameters and assumptions with range used for the sensitivity analysis

	Base case	Range	References
Screening population (Slovak population data)	50–75 years old	n.a.	(VDC, 2018)
Screening strategy	FIT test with invitation	n.a.	Slovak guidelines (Hrcka and Hlavaty, 2020)
Roll-out period (years)	2	n.a.	Expert opinion
Invitation coverage (in %)	100	n.a.	Expert opinion
Participation (in %)	34	n.a.	(National oncology institute, 2020)
All-cause mortality	Slovak lifetables	n.a.	(SOSR, 2020)
Adenoma onset	Age-dependent	n.a.	(SLORA, 2020)
5-year relative survival, all	Stage I: 90%, Stage II: 85%, Stage III: 72%, Stage IV: 12%, Unknown: 29%	n.a.	MISCAN-Colon Model
CRC stage distribution in 5 most recent years (Slovakian data)	UICC I: 21.42%	21.24–21.57%	(NHIC, 2020)
	UICC II: 22.66%	22.63–22.68%	(NHIC, 2020)
	UICC III: 28.52%	28.40–28.62%	(NHIC, 2020)
	UICC IV: 26.06%	25.79–26.40%	(NHIC, 2020)
	Unknown: 1.34%	1.34–1.34%	(NHIC, 2020)
CRC localization distribution (MISCAN-colon model data verified by Slovak experts)	Cecum: 14.03%	11.53–17.14%	(Gini, Buskermolen, *et al.*, 2021)
	Ascending colon: 10.70%	8.90–12.94%	(Gini, Buskermolen, *et al.*, 2021)
	Transverse colon: 12.20%	11.23–13.41%	(Gini, Buskermolen, *et al.*, 2021)
	Descending colon: 3.06%	3.03–3.10%	(Gini, Buskermolen, *et al.*, 2021)
	Sigmoid: 27.01%	24.84–28.76%	(Gini, Buskermolen, *et al.*, 2021)
	Rectosigmoid junction: 2.60%	2.43–2.73%	(Gini, Buskermolen, *et al.*, 2021)
	Rectum: 30.40%	26.15–33.82%	
Colorectal cancer survival	Age-/stage-/localization-dependent	n.a.	(Lemmens *et al.*, 2010; Csanádi *et al.*, 2021)
FIT performance (MISCAN-colon model data verified by Slovak experts, sensitivity in %)	Adenomas ≤5 mm: 0%	n.a.	(Lansdorp-Vogelaar *et al.*, 2009)
	Adenomas 6–9 mm: 11.4%	n.a.	(Lansdorp-Vogelaar *et al.*, 2009)
	Adenomas ≥10 mm: 15.9%	n.a.	(Lansdorp-Vogelaar *et al.*, 2009)
	Malignant neoplasia: 62.5-88.6%	n.a.	(Lansdorp-Vogelaar *et al.*, 2009)
	Sensitivity: 96%	n.a.	(Imperiale *et al.*, 2014; Van Der Meulen *et al.*, 2016)
Cost (Slovakian data, EUR)			
Program investment costs (2020)	300 000	200 000–400 000	Experts' proposal
Screening invitation letter	1	0.7–1.3	(IHA, 2020)
FIT kit	1	0.7–1.3	(IHA, 2020)
Analysis of the FIT	7	4.9–9.1	(IHA, 2020)
Sigmoidoscopy wo polypectomy	60	42–78	(IHA, 2020)
Colonoscopy wo polypectomy	121	84.7–157.3	(IHA, 2020)
Colonoscopy w polypectomy	146	102.2–189.80	(IHA, 2020)
Communication of test result	9	6.3–11.7	(IHA, 2020)
Treatment of CRC stage I	1400	980–1820	(IHA, 2020)
Treatment of CRC stage II	3400	2380–4420	(IHA, 2020)
Treatment of CRC stage III	7600	5320–9880	(IHA, 2020)
Treatment of CRC stage IV	10 500	7350–13 650	(IHA, 2020)

CRC, colorectal cancer; FOBT, fecal occult blood test; FIT, fecal immunochemical test.

Hb/g feces. Data on screening complications rates and utilities were based on literature (Warren *et al.*, 2009; Peterse *et al.*, 2021).

Cost-effectiveness analysis

We performed a cost-effectiveness analysis from a health-care payer perspective. Costs for CRC screening and CRC treatment were obtained from the Institute for Healthcare Analysis, Ministry of health. These costs represent unit cost of CRC patients' care at patient-level in Slovakia in 2020 (IHA, 2020). Cost-effectiveness parameters were evaluated comparing each simulated screening scenario with no screening. Incremental cost-effectiveness ratios (ICERs) were estimated as ratio of additional costs and additional QALY in comparison between biennial screening and no screening and between annual screening and biennial screening. Additional model parameters including the predefined disutilities in the MISCAN-colon model published previously are in Table 2; (Gini, Buskermolen, *et al.*, 2021). The most cost-effective strategy was identified by comparing the ICERs against the cost-effectiveness threshold for an

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Table 2 Model parameters and assumptions: predefined disutilities in MISCAN-colon model (Gini, Buskermolen, *et al*., 2021)

	No screening	Biennial FIT	Annual FIT	Duration	Metric
Performing stool test	0.1	0.1	0.1	2.0	Hours
Sigmoidoscopy	0.2	0.2	0.2	1.0	Days
Colonoscopy	0.5	0.5	0.5	2.0	Days
Complication from colonoscopy	0.5	0.5	0.5	2.0	Weeks
Initial care CRC stage I	0.3	0.3	0.3	6	Months
Initial care CRC stage II	0.5	0.5	0.5	6	Months
Initial care CRC stage III	0.5	0.5	0.5	6	Months
Initial care CRC stage IV	0.8	0.8	0.8	6	Months
Continuous care CRC stage I–III	0.1	0.1	0.1	Remaining	Years
Continuous care CRC stage IV	0.8	0.8	0.8	Remaining	Years
Terminal care CRC stage I-IV	0.8	0.8	0.8	6	months

CRC, colorectal cancer; FIT, fecal immunochemical test.

Table 3 Screening outcomes (×10 000) from MISCAN-colon model simulations for biennial FIT and yearly FIT scenarios in individuals aged 40–100, 2018–2050

	No screening	Biennial FIT	Annual FIT
Population older than 40 years in 2018	278.22	278.22	278.22
Person-years, 2018–2050	10 198.5	10 198.5	10 198.5
Colorectal cancer deaths (age 50–74)	3.61	2.99	2.72
Colorectal cancer mortality reduction vs. no screening (%, 50–74)	0	17.38	24.67
FIT tests	0	1003.62	1864.63
Positive screening tests	0	61.72	105.46
Diagnostic follow-up colonoscopies performed	0	56.92	97.14
Adenomas detected	0	26.74	42.13
Colorectal cancers detected	0	2.96	3.78
Colonoscopy complications		0.38	0.59

FIT, fecal immunochemical test.

additional QALY (York Health Economics Consortium, 2016). The cost-effectiveness threshold per 1 QALY is strictly defined in Slovakia by law as the 41 multiplications of average salary in the industry 2 years before the time of the analysis. The threshold for 2020 was 35 455 EUR per 1 QALY (Slov_Lex, 2020). Cost-effectiveness results were computed specifically among individuals older than 50 years during the period 2018–2050. The law does not exactly define cost-effectiveness thresholds for public health programs; however, the cost-effectiveness threshold is defined for new technologies. The cost-effectiveness results are presented by 1 million individuals followed from 2018 over their lifetimes (Table 3). Both costs and effects are discounted by 3% per year.

Sensitivity analyses

We conducted deterministic sensitivity analyses to determine the impact of different variables on the cost-effectiveness results. The variables that we varied were adherence with screening, coverage and costs of screening strategies and treatment. The ranges were chosen according to local requirements for health economic evaluations, +30% and –30% available in Table 4 (Slov_Lex, 2020). The model uncertainty was investigated for majority of the parameters included in both scenarios. Parameters such as adherence and invitation were predefined in the MISCAN-colon model and all ranges were tested. Additional cost parameters were tested for uncertainty using the local required range.

Results

Clinical screening outcomes

The model estimated 36 100 CRC deaths in Slovakia in a situation without screening between 2018 and 2050. The model further estimated that the programs required 10–18.6 million FIT tests and 569 200–971 400 follow-up colonoscopies for biennial FIT and annual FIT, respectively, in the period of 2018–2050 (Table 5). The model predicted that biennial FIT would detect 29 600 CRC cases and annual FIT 37 800 CRC cases, compared to no screening. Colorectal cancer mortality estimates showed benefits for both evaluated strategies in the selected screening population from 2018 till 2050 with 17,38% reduction in biennial FIT and 24,67% reduction in annual FIT approach, in both cases compared to no screening (Table 5).

Cost-effectiveness analysis

Both screening programs were more costly as well as more effective compared to no screening. The incremental costs compared to no screening ranged from EUR 22.5 million for biennial FIT to EUR 46.6 million for annual FIT, while associated QALYs were 12 661 and 18 462 compared to no screening, respectively. Direct comparison between strategies showed 107% higher incremental costs and 46% higher effects in annual FIT test strategy compared to biennial FIT. Biennial FIT strategy showed ICER 1776 EUR per 1 QALY and annual FIT 3991 EUR per 1 QALY, which is below the 2020 cost-effectiveness threshold valid for Slovakia (35 455 EUR/QALY) (Table 3).

Table 4 Sensitivity analysis results with ±30% range (Table 1) in cost per QALY in EUR

	Biennial FIT	Annual FIT
Base case	1776	2472
Test NOT included into invitation	1323	1878
Program investment costs	1768–1784	2466–2477
Screening invitation letter	1694–1857	2365–2578
FOBT kit	1694–1857	2365–2578
Analysis of the FOBT	1776–1776	2472
FIT kit	1694–1857	2365–2578
Analysis of the FIT	1586–1966	2229–2714
Colonoscopy wo polypectomy	1671–1880	2341–2602
Colonoscopy w polypectomy	1637–1914	2326–2617
Communication of test result	1531–2020	2160–2783
Treatment of CRC stage I	1653–1898	2379–2564
Treatment of CRC stage II	1217–2334	2105–2839
Treatment of CRC stage III	614–2938	1742–3201
Treatment of CRC stage IV	852–2699	1904–3040
Adherence and invitation		
Adherence –25%	2785	2413
Adherence –10%	1964	2575
Adherence +10%	2415	2415
Adherence +25%	2413	2413
Invitation +30%	1816	2546

CRC, colorectal cancer; FOBT, fecal occult blood test; FIT, fecal immunochemical test.

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Table 5 Costs, effects and cost-effectiveness of colorectal cancer screening programs over a lifetime horizon in Slovak Republic

Strategy	Costs (EUR)	Effects (QALY)	Incremental costs (mil. EUR)	Incremental effects (QALYs)	ICER	Mortality decrease
No screening	133 483 180	18 110 522	–	–		
Biennial FIT	155 964 714	18 123 183	22 481 534	12 661	1776	17.38%[a]
Annual FIT	179 117 717	18 128 984	46 634 537	18 462	3991	24.67%[a]

[a]Colorectal cancer mortality reduction (%, age group 50–74) compared to no screening, screening outcomes for each simulated scenario in individuals between 2018–2050.

Sensitivity analyses

The results of the one-way sensitivity analyses showed moderate impact of costs associated with the test inclusion into the invitation, communication of results, FIT test or FIT test analysis for both strategies (Table 4). The higher impact on results had adherence changes (biennial FIT) and CRC treatment costs of stages III and IV (biennial and annual FIT). Major attributes of the model parameters did not substantially influence the ICERs. Both biennial and annual FIT screening were below the Slovak cost-effectiveness threshold and none of the variables tested within the sensitivity analyses violated the cost-effectiveness threshold (Table 4).

Discussion

This study provides the first comprehensive evaluation of potential nationwide programmatic CRC screening programs in Slovakia, using a widely validated simulation model. Both screening strategies showed important long-term mortality reduction for the Slovak population and positive cost-effectiveness results. It is very relevant due to the high burden of colorectal cancer in Slovakia. The MISCAN-colon model enabled comparison of two screening strategies with no screening for the population between 50- and 75 years old, from the payer perspective. Our results indicate that the CRC screening strategies included in our analysis are cost-effective compared to no screening. Both calculated ICERs (Table 4) are currently below the cost-effectiveness threshold which means that allocating additional funds to the intervention will increase population health (Woods *et al.*, 2016). Results were moderately sensitive to the screening cost attributes, treatment and adherence to screening, similarly to other studies (Melnitchouk *et al.*, 2018). None of the sensitivity analyses changed the conclusion, even if sometimes the numbers changed. The reduction in CRC mortality with both biennial FIT and annual FIT screening is similar to reductions published previously using MISCAN-colon or Markov models (Knudsen *et al.*, 2016; Peterse *et al.*, 2018; Senore *et al.*, 2019).

In our model, annual FIT shows a slightly higher reduction in CRC mortality when compared with the biennial FIT. To our knowledge, there are currently no randomized clinical trials on long-term outcomes such as reduction in CRC mortality comparing different frequencies of FIT testing (annual vs. biennial). Detection of colorectal neoplasia is similar when annual and biennial FIT are compared (IARC, 2017). Based on systematic reviews and meta-analyses biennial FIT or highly sensitive gFOBT are associated with 12% relative reduction in CRC mortality over 15 years, compared with no screening (Buskermolen *et al.*, 2019). Biennial FIT yields lower burden of screening compared with annual FIT (Kapidzic *et al.*, 2014).

Multiple studies demonstrated the cost effectiveness of CRC screening (Goede *et al.*, 2013; Wong *et al.*, 2015; Lansdorp-Vogelaar *et al.*, 2018; Mendivil *et al.*, 2019). Screening interventions are usually reported to be cost-effective when their ICER is less than $50 000 per QALY. Our findings are consistent with cost-effectiveness studies done in Europe and in the world, where these strategies and other were proven to be cost-effective or even cost-saving, contribute to health and decrease CRC mortality (Patel and Kilgore, 2015; Abdolahi *et al.*, 2018; Ran *et al.*, 2019; Ladabaum, 2020). Slovakia is in the region of Europe where cancer survival rates are lower compared to EU average including those for colorectal cancer (Vrdoljak *et al.*, 2016; Melnitchouk *et al.*, 2018). High affordability, positive effects of CRC epidemiology, low investment costs and the noninvasive nature of our strategies are prerequisites for improved CRC control and prevention in Slovakia.

The analysis has several limitations. Slovakia is missing validated CRC epidemiology data since 2011 and several model parameters, which were not available for Slovakia, were calibrated by using the prescreen data from reference country, Slovenia, including the CRC relative survival specific to age and cancer stage. Costs were calculated from the major healthcare payer perspective; however, costs can vary across the country due to different contract conditions with insurance companies. Opportunistic CRC screening program was not considered due to inability to unequivocally validate participation percentage in target population.

Notwithstanding these limitations, this work has important policy implications and generalizability across our borders. Our results support already published results on colorectal cancer screening strategies and strongly promote the installment of population-based programmatic screening programs that have clear potential to gradually decrease colorectal cancer mortality and deaths in connection with innovative drug influx and adequate resources dedicated to the preventive programs. Additionally, it reinforces the importance of the key component of screening effectiveness – adherence to screening. In the current analysis, we conservatively assumed a 34% participation rate based on the observed rate in a recent real-life pilot. In this pilot, only individuals eligible

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for screening received the invitation, which included the FIT kit. There is convincing evidence that inclusion of the kit leads to higher participation rates compared to those cases when the kit needs to be collected at the general practitioner (Van Roosbroeck *et al*., 2012; Rat *et al*., 2018). Nevertheless, there are other mechanisms as well that have been shown to further increase participation including advance notification letters, and sending reminder letters to nonresponders (Rat *et al*., 2018). Recent analyses comparing different invitation strategies in Hungary and France (Csanádi *et al*., 2021; Peterse *et al*., 2021), showed that even at minimal increases in participation, all investigated strategies to enhance participation were cost-effective. With observed adherence only slightly above 30% in the pilot, these studies provide a strong argument for policymakers to consider improving the invitation strategies in Slovakia and support the implementation of these changes with further cost-effectiveness analyses.

Conclusion

To our knowledge, this is the first cost-effectiveness analysis focusing on multiple national CRC screening strategies in Slovakia. Both screening strategies, annual and biennial FIT, demonstrated cost-effectiveness compared to no screening which is consistent with previously published data from the countries where programmatic screening programs are implemented.

Positive model results are however only part of the equation when considering the implementation of population-based programmatic screening. For the optimal strategy, the policymakers should consider human resources availability, current network of general practitioners and specialists, acceptability of screening tests among the population, adherence to screening or additional resources including the screening funding. From a cost-effectiveness perspective it seems that annual FIT is a better fit for our country. From the reality and feasibility perspective, the biennial FIT is a more pragmatic choice.

These new results have the potential to greatly contribute to strategy policymaking at the field of cancer screening policies as well as support regionally available CRC cost-effectiveness data. With respect to health care resource allocation, our results are important contribution to the available knowledge base for establishing a nation-wide programmatic CRC screening strategy.

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Conflicts of interest

There are no conflicts of interest.

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