A Resect and Discard Strategy Would Improve Cost-Effectiveness of Colorectal Cancer Screening

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BACKGROUND & AIMS: A "resect and discard" policy has been proposed for diminutive polyps detected by screening colonoscopy, because hyperplastic and adenomatous polyps can be distinguished, in vivo, by using narrow-band imaging (NBI). We modeled the cost-effectiveness of this policy. **METHODS:** Markov modeling was used to compare the cost-effectiveness of universal pathology evaluations with a resect and discard policy for colonoscopy screening. In a resect and discard approach, diminutive lesions (≤5 mm), classified by endoscopy with high confidence, were not analyzed by a pathologist. Base case assumptions of an 84% rate of high-confidence classification, with a sensitivity and specificity for adenomas of 94% and 89%, respectively, were used. Census data were used to project outputs of the model onto the US population, assuming 23% as the current rate of adherence to a colonoscopy screening. **RESULTS:** With universal referral of resected polyps to pathology, colonoscopy screening costs an estimated $3222/person, with a gain of 51 days/person. Endoscopic polypectomy accounted for $179/person, of which $46/person was related to pathology examination. Adoption of a resect and discard policy for eligible diminutive polyps resulted in a savings of $25/person, without any meaningful effect on screening efficacy. Projected onto the US population, this approach would result in an undiscounted annual savings of $33 million. In the sensitivity analysis, the rate of high-confidence diagnosis and the accuracy for endoscopic polyp determination were the most meaningful variables. **CONCLUSIONS: In a simulation model, a resect and discard strategy for diminutive polyps detected by screening colonoscopy resulted in a substantial economic benefit without an impact on efficacy.**

Keywords: Colorectal Cancer Screening; NBI; Diminutive Polyps; Cost-Effectiveness.

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Colorectal cancer (CRC) is a major cause of morbidity and mortality worldwide.[1] Colonoscopy has been shown to be highly effective in detecting advanced neoplasia, and CRC prevention by endoscopic polypectomy has been shown to reduce disease-specific mortality, despite some uncertainty still remaining on the prevention of right-side CRC mortality.[2] As such, its use as a preferred screening strategy is supported by official guidelines.[3]

Similar to breast and cervical cancer screening programs for women, CRC screening needs to be delivered to millions of adults in the United States. In a period of economic hardship and budget constraints, minimizing the costs related to a mass population screening appears to be desirable.

A substantial portion of the cost of a colonoscopic CRC screening program is represented by endoscopic polypectomy, especially given the high prevalence of subcentimeter polyps.[4] Polypectomy costs are partially related to the cost of pathologic examination. When considering diminutive polyps (≤5 mm in size), which represent more than 60% of all polyps detected by colonoscopy at average-risk screening,[4] the main usefulness of pathologic examination is to differentiate between benign adenomatous and hyperplastic polyps, an endoscopic follow-up being recommended only for the former. This is because of the very low prevalence of advanced neoplasia and invasive cancer among diminutive polyps.[4]

Recently, improvements in colonoscopy techniques have opened the door for in vivo histologic determination of colorectal polyps. In particular, narrow-band imaging (NBI) without magnification has been shown to allow for characterization of polyp histology with high levels of accuracy.[5–7] This advance could conceivably avoid the necessity for post-polypectomy histologic assessment, with future management decisions being driven only by the in vivo endoscopic assessment, the so-called resect and discard policy.[8] However, the specificity of such in vivo histologic assessment could remain suboptimal, such that subjects with only tiny hyperplastic polyps might be misclassified as having adenomas, and therefore incurring the cost of unnecessary post-polypectomy surveillance.[5–7]

The primary aim of this cost-effectiveness simulation was to calculate the potential savings and drawbacks of a resect and discard policy for diminutive colorectal lesions in a simulated CRC screening cohort and to project these results onto the US population.

Materials and Methods

Structure of the Model

A mathematical Markov model was constructed, and simulation was performed on a hypothetical cohort of 100,000 male and female US citizens ranging from 50–100 years of age. In a Markov model, medical events are modeled as transitions across a predefined set of health states. The occurrence of each transition is governed by a probability value. Baseline assumptions and ranges used in the model are provided in Supplementary Table 1. Calibration details are provided in Supplementary

Abbreviations used in this paper: CRC, colorectal cancer; NBI, narrow-band imaging; OC, optical colonoscopy.

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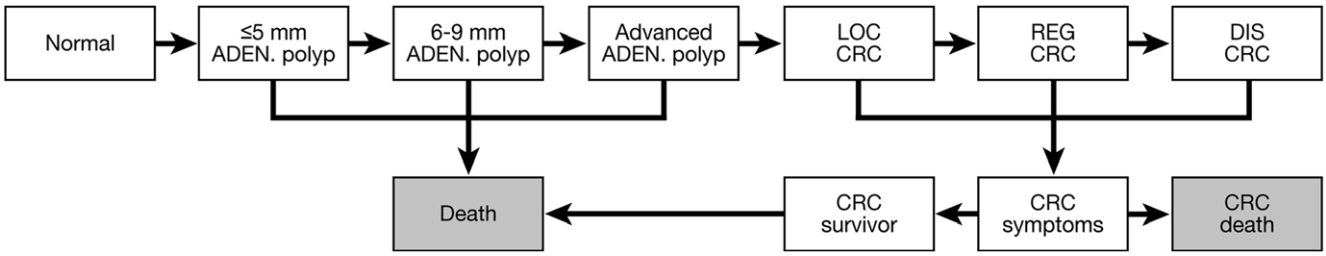

Figure 1. The model has been constructed to simulate the progression from no lesions to death related to CRC through all the polypoid phases. Of note, an alternate pathway to cancer from the classic adenoma-carcinoma sequence was assumed for 15% of CRC. ADEN, adenomatous; DIS, distant; LOC, localized; REG, regional.

Materials and Methods. The principal health states in the model are as follows: no colorectal neoplasia; diminutive (≤5 mm), small (6–9 mm), or large (≥10 mm) adenomatous polyps; localized, regional, or distant CRC; and CRC-related death (Figure 1). Hyperplastic polyps were also simulated. We assumed that 85% of CRCs develop from a polypoid precursor; the remaining 15% are represented by non-polypoid *de novo* cancers.

Assumptions for Resect and Discard Strategy

Feasibility and accuracy of NBI without optical magnification in differentiating between diminutive adenomatous and hyperplastic polyps were averaged by 3 recently published series in the medical literature,[5–7] in which there was a high degree of homogeneity in the estimates of sensitivity and specificity (Table 1). According to 2 of these series, a high-confidence in vivo assessment was possible in 79%–87% of diminutive lesions,[5,6] whereas high-confidence assessment was feasible in 100% of cases according to the remaining series.[7] In order not to overestimate the efficacy of NBI, we assumed an 84% high-confidence rate for the base-case analysis, representing an average of the 2 series reporting a rate less than 100%. This rate indicates the percentage of diminutive polyps for which histologic assessment could be avoided,[5,6] reserving the 100% high-confidence scenario for the sensitivity analysis. The main assumption of the present analysis is that a resect and discard policy was instituted for all the cases in which a high-confidence diagnosis was achieved by NBI.[5–7] We also assumed that all diminutive polyps in which a high-confidence diagnosis was not possible were removed and sent for formal histologic evaluation.

Table 1. Pooled Data Analysis From Published Studies of the Main Input Variables for the Resect and Discard Strategy

	In vivo differentiation of polyps ≤5 mm		
Study	Feasibility	Sensitivity	Specificity
Rex[5]	79%	95%	91%
Ignjatovic et al[6]	87%	93%	88%
Rastogi et al[7]	100%	95%	88%

NOTE. Feasibility refers to rate of high-confidence in vivo differentiation between hyperplastic and adenomatous diminutive polyps by using NBI without magnification. Accuracy was defined as the ability to correctly classify adenomatous (true positive) and hyperplastic (true negative) diminutive polyps.

The input assumptions for the sensitivity and specificity of NBI for diagnosing diminutive adenomas were based on the mean values of the 3 published series (Table 1), corresponding to values of 94% and 89%, respectively.

Screening

The input assumptions for NBI above were applied to a previously validated cost-effectiveness model to simulate the efficacy and costs of CRC screening in an average-risk population with the adoption of the resect and discard policy (see Supplementary Materials and Methods). The health interventions superimposed on the natural history model were colonoscopy every 10 years, both with and without the resect and discard policy. Regardless of the screening strategy, after either pathologic evaluation of all resected polyps or in vivo histologic differentiation of diminutive polyps, 2 surveillance schedules were simulated according to polyp size: (1) patients in follow-up for a diminutive adenoma were allowed to go back to the routine screening compartment after one subsequent negative colonoscopy, and (2) those in follow-up for an adenomatous polyp ≥6 mm remained in the 5-year surveillance program until the end of the simulation. No follow-up was simulated for subjects diagnosed with hyperplastic polyps.

Costs

Medicare reimbursement data for screening and surveillance procedures and for CRC treatment were derived from Medicare reimbursement rates (Supplementary Table 1). Cost of polypectomy was separated from the cost of post-polypectomy pathologic examination to allow for analysis of the economic advantages of the resect and discard policy. No incremental cost for NBI was simulated, because it is standard feature in current generation colonoscopies.

Cost-Effectiveness Analysis

Clinical effectiveness of screening is measured in terms of life-years gained through prevention or down-staging of all the included diseases. Both future costs and future life-years saved were discounted by using an annual rate of 3%. An incremental cost-effectiveness ratio of $50,000 per life-year gained was used as the willingness-to-pay threshold to differentiate an efficient procedure from an inefficient procedure.

Projection on the United States Population

To project the outcomes of our simulation on the US population, we assumed a steady state for population size and age distribution, represented by the 2009 US census data.[9]

Adherence to CRC screening was estimated to be 23%, because it has been reported that nearly 50% of the US population underwent a colonoscopy within a 10-year period, and that 46% of the colonoscopies in the United States are performed for screening indications.[10,11] To assess what the actual effects would be if this strategy were adopted, we assumed no change in rates at which people undergo colonoscopy screening. Because it is unknown how many US subjects undertaking a screening colonoscopy within a 10-year period already had a previous colonoscopy 10 years before, we conservatively assumed the prevalence of polyps at different colonoscopy rounds to be unaffected by eventual previous colonoscopy screening rounds. Adding the results for all ages under each strategy yielded national estimates. No discounting was used in these national projections because the model outputs reflected all persons aged 50–100 years of age at a given point in time in the steady state, as opposed to a cohort aging from 50–100 years over 50 years. The model was simulated by using Excel spreadsheets (Microsoft Corp, Redmond, WA) and @risk 5.0 (Palisade Corp, Ithaca, NY).

Sensitivity Analysis

Sensitivity analysis was performed by using 2 different methods. First, the model parameters were varied simultaneously and randomly for 10,000 iterations in a Monte Carlo simulation. This provides estimates on the variability in cost-effectiveness, expressed as 5%–95% percentiles, which arise when all variables in the model are allowed to take on distributions. Second, a systematic sensitivity analysis was performed for all the variables of the model (Supplementary Table 1), with the most relevant results being reported.

Results

No Screening

Without any screening, the simulated hypothetical cohort of 100,000 50-year-old persons will experience the loss of 31,839 life-years as a result of the 2,482 deaths arising from 5,903 cases of CRC (Table 2). The 3% discounted cost associated with CRC treatment in the no screening strategy was estimated to be $3390/person. When projecting the undiscounted cost on the entire age-appropriate US population, the annual expenditure for CRC treatment was estimated to be $14.8 billion.

Cost-Effectiveness of Colonoscopy Without the Resect and Discard Strategy

Simulation of colonoscopy screening in the cohort of 100,000 subjects resulted in a 75% and 79% reduction in CRC incidence and mortality, respectively, with the latter result also due to the down-staging of already developed CRC. Colonoscopy efficacy resulted in 13,999 life-years gained, corresponding to 51 days/person. Colonoscopy screening also resulted in a dramatic decrease in CRC treatment costs ($821/person vs $3390/person at 3% discounting rate). This was partially offset by the cost of screening and follow-up testing ($2401/person at 3% discounting rate). Of note, the overall discounted cost of the colonoscopy screening strategy ($3222/person) resulted to be less than that of the no screening, suggesting that colonoscopy screening not only is cost-effective but actually cost-saving.

When projecting the results of this strategy with a 23% adherence rate on the US population, the total annual undiscounted cost was estimated to be $14.3 billion, corresponding to a net annual savings of $451 million, as compared with no screening.

Table 2. Cost and Efficacy for the Included Screening Strategies

Cost-effectiveness characteristics	No screening	Colonoscopy	Colonoscopy with resect and discard policy
Cost/person	$3390	$3222	$3197
Relative efficacy	—	51 days/person	51 days/person

Cost-Effectiveness of Colonoscopy With Resect and Discard Strategy

In the simulated cohort of 100,000 subjects undertaking a 10-year optical colonoscopy (OC) strategy (4 rounds between 50 and 80 years of age), 65,263 total polypectomies were performed, corresponding to a discounted cost of $179/person, including pathologic examination of the resected polyps. When separating the cost of polypectomy from that of pathology, the discounted cost as a result of pathologic examination was equal to $46/person. The rate of diminutive polypectomies ranged from 64%–81% from the first to the last round. The increasing trend toward more diminutive polypectomies was mainly related to the efficacy of previous rounds in shifting the polyp population toward smaller lesions.

We assumed an 83% rate for high-confidence in vivo differentiation between adenomatous and hyperplastic diminutive adenomas with NBI technique (Table 1). This means that in 17% of diminutive lesions the endoscopist will send the resected diminutive polyp to pathologic examination, irrespective of the true nature of the lesion. Regarding the 83% of diminutive polyps in which high-confidence differentiation was feasible, we assumed a sensitivity and specificity for correctly diagnosing adenomas of 94% and 89%, respectively. On the basis of these assumptions, the discounted benefit as a result of a resect and discard strategy was equal to $25/person. In theory, the resect and discard strategy could also affect the efficacy of colonoscopy screening. On one hand, the imperfect NBI sensitivity for diminutive adenomas would misclassify some polyps as hyperplastic, preventing the standard follow-up strategy; whereas on the other hand, the misclassification of hyperplastic polyps as adenomatous lesions caused by the suboptimal specificity would lead to a more intensive and inappropriate 5-year colonoscopy surveillance in some individuals. However, the net effect of these 2 opposing forces was found to be meaningless, mainly because of the marginal efficacy associated with post-polypectomy surveillance, especially for diminutive lesions, compared with the substantial efficacy associated with polypectomy in preventing CRC.

When projecting the results on the US population, the undiscounted annual benefit of colonoscopy screening with the resect and discard strategy compared with the standard colonoscopy screening approach was estimated to be $33 million.

Sensitivity Analysis

As shown in Figure 2, there was a linear relationship between the feasibility rate of high-confidence differentiation between adenomatous and hyperplastic diminutive polyps and the undiscounted savings projected on the US population.

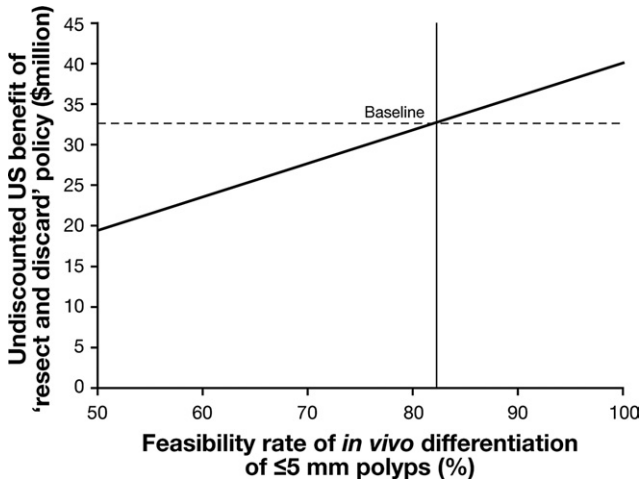

Figure 2. Simulated undiscounted annual benefit for the US population with the resect and discard policy compared with standard colonoscopy screening according to the feasibility rate of NBI for differentiating between hyperplastic and adenomatous diminutive lesions.

Assuming a 100% (best-case scenario) and 50% (worst-case scenario) feasibility rate, the undiscounted benefit for the US population would be $40 million and $20 million, respectively.

The net effect of sensitivity and specificity of the NBI approach for the correct diagnosis of adenomatous diminutive lesions on the efficacy of colonoscopy screening was meaningless, as anticipated by the base-case scenario. Even assuming broad ranges of sensitivity and specificity from 50%–100%, the net discounted effect was unaltered at 51 days/person. However, changes in NBI accuracy did influence the overall cost of the program. For example, 100% specificity increased the projected undiscounted benefit for the US population to $42 million, because additional subjects with only hyperplastic diminutive polyps were prevented from unnecessary and costly endoscopic follow-up. In contrast, an assumed 100% sensitivity was associated with a $25 million savings. This reduction in savings was due to the higher cost of follow-up caused by the identification of additional adenomatous diminutive polyps, compounded by the relatively minor benefit from CRC prevention related to follow-up of diminutive adenomas.

The undiscounted benefit of a resect and discard policy depends on the initial sensitivity of standard colonoscopy (ie, with white light) for diminutive polyps and on the absolute number of these lesions. A reduction in sensitivity of colonoscopy for diminutive polyps from 80% to 50% would reduce the net benefit for the US population to $20 million, whereas an increase in sensitivity to 90% would lead to a net benefit of $37 million. Changes in the natural history assumptions for transition rates from no polyp to ≤5-mm polyp would result in an absolute variation of the number of diminutive polyps, thereby affecting the economic savings of the resect and discard strategy. In detail, 30% reduction of this transition rate would reduce the undiscounted US benefit to $30 million, whereas a 30% increase would increase it to $38 million.

As shown in Figure 3, an increase in the cost of pathology examination from the baseline $101.60 to $150 resulted in an increase of the undiscounted benefit for the US population from the baseline $33 million to $49 million, whereas a pathology cost reduction to $50 decreased the US benefit to $16 million.

In the reference-case scenario we assumed a 23% adherence to colonoscopy screening to compute the actual benefit achievable with the resect and discard policy. An increase in initial adherence to 50%/75%/100% would increase the undiscounted US benefit to $72/$107/$143 million, respectively.

At Monte Carlo analysis, the 5% and 95% percentiles of the undiscounted benefit of the resect and discard policy by using the baseline assumptions were $15 million and $54 million, respectively.

Discussion

According to our model, a resect and discard policy for diminutive polyps would result in an annual undiscounted benefit of $33 million at baseline assumptions when applied to colonoscopy screening of the US population. This would correspond to an overall savings of $330 million, assuming 10 years as the cumulative period required to screen 23% of the US population, as suggested by current estimates.[10,11] The net economic benefit is largely due to the savings related to fewer pathologic examinations for diminutive lesions. These results do not appear to be meaningfully affected by the marginal increase in follow-up costs as a result of the suboptimal specificity of the NBI-based in vivo differentiation.

The results of our modelling study are not unexpected. Without the resect and discard strategy by using NBI, standard white-light colonoscopy is assumed to be inaccurate for differentiating between neoplastic and non-neoplastic diminutive lesions, requiring definitive diagnosis with histologic examination, which adds significant cost. By relying solely on endoscopic technology for such histologic differentiation, there is no need for invoking additional costly medical resources. This aspect is particularly relevant because specificity plays a major role in a screening setting, where a low prevalence of disease is expected.

The substantial economic benefit showed by our analysis is also related to the high prevalence of diminutive colorectal polyps in the screening setting. In a large US-based series,

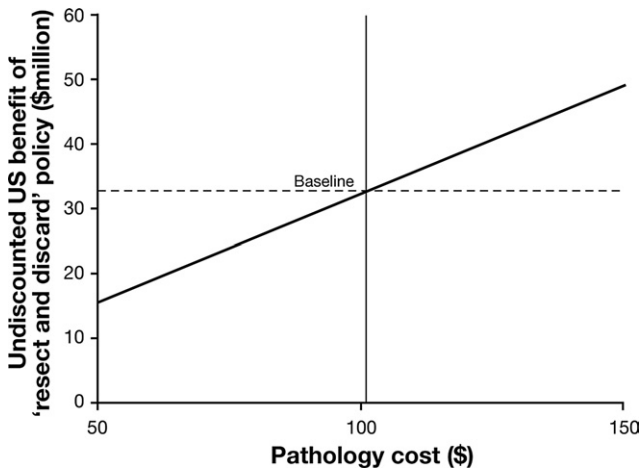

Figure 3. Simulated undiscounted benefit for the US population of the resect and discard policy compared with standard colonoscopy screening according to the cost of the post-polypectomy pathologic examination.

diminutive polyps accounted for 64% of all the colonoscopy-detected lesions.[4] According to our simulation, the percentage of diminutive lesions increases further after consecutive screening rounds, because each round is associated with a progressive depletion of larger and more advanced polyps. The high relative prevalence of diminutive polyps is relevant for the efficiency of a resect and discard strategy, because this policy appears more controversial when applied to larger polyps, for which the prevalent villous features and high-grade dysplasia are greater and on which some guidelines recommend changes in endoscopic surveillance.[3]

According to our simulation, the loss in efficacy as a result of false-negative results, that is, the misclassification of true adenomatous diminutive polyps as hyperplastic, was shown to be meaningless. This might be related to 2 factors. For one, interrupting the adenoma-carcinoma sequence by the removal of a diminutive adenoma appears to marginalize the impact of subsequent short-term endoscopic surveillance compared with the routine screening interval. In addition, short-term follow-up for patients with only diminutive adenomas at the index colonoscopy might not be warranted, especially when fewer than 3 such lesions are present.

At sensitivity analysis, rate of high-confidence diagnosis for in vivo differentiation of diminutive polyps appeared to be important. In selected studies, reliable differentiation between hyperplastic and adenomatous diminutive polyps was feasible in 79%–100%. Moreover, interobserver and intraobserver variability appeared to be acceptable, suggesting good reproducibility for NBI-based classification.[12]

There are limitations to the present analysis. We did not include any implementation costs for the NBI resect and discard policy. This was related to the fact that NBI is now a standard feature with the current generation of Olympus (Tokyo, Japan) colonoscopes, such that a progressive implementation in the US health care system is to be expected within a relatively short period of time without additional expenditures. Neither the use of NBI nor the photographic record of a resected and discarded polyp was considered to generate any new cost. Second, we assumed a relatively high sensitivity for detection of diminutive polyps, where reduction in this input assumption was shown to reduce the benefit at sensitivity analysis. However, it is anticipated that the adoption of high-definition colonoscopes will actually result in further increases in the sensitivity for tiny lesions. Indeed, diminutive polyps accounted for nearly 90% of all polyps in a recent study with this technology.[13] Third, only a small minority of diminutive polyps are likely to progress to CRC. When considering the added morbidity from endoscopic ablation, further studies on the natural history of these lesions are needed. Fourth, fewer than 10 serrated polyps were detected overall in the pooled series,[5–7] so that further studies are needed to assess the NBI accuracy in classifying these lesions, especially in the right-side colon. Our model tended to overestimate the efficacy of polypectomy, especially in the right colon, according to a recent case-control study.[2] This is likely to have underestimated the potential benefit of a resect and discard policy, because the eventual loss associated with the misclassification of adenomatous in hyperplastic polyps would have been decreased by the assumption of a reduced cancerogenic effect of right-side colorectal polyps.

In conclusion, a colonoscopic screening strategy with a resect and discard policy with NBI evaluation for diminutive polyps resulted in a substantial economic benefit in our model, without affecting screening efficacy.

Supplementary Material

Note: to access the supplementary material accompanying this article, visit the online version of *Clinical Gastroenterology and Hepatology* at www.cghjournal.org, and at doi:10.1016/j.cgh.2010.05.018.

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Reprint requests

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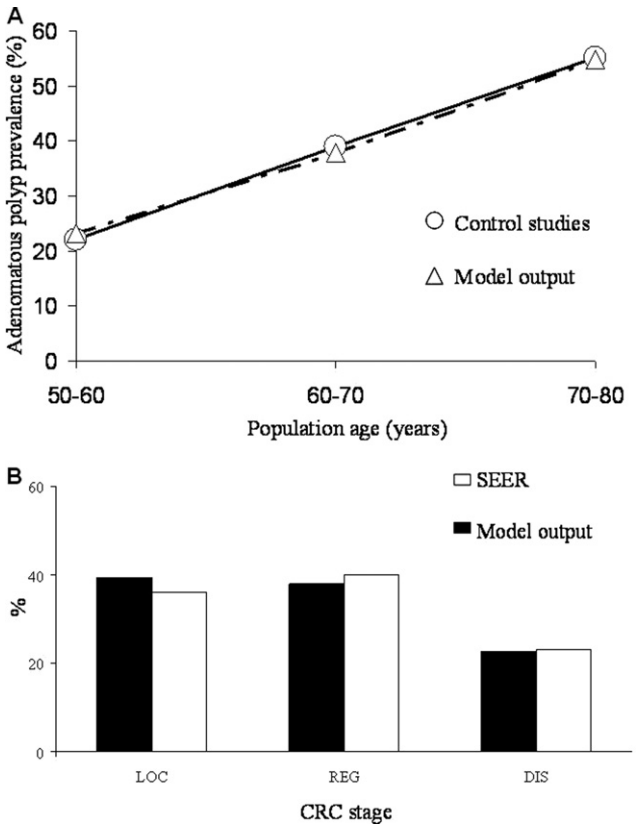
Conflicts of interest

The authors disclose the following: Dr Pickhardt is a consultant for Medicsight, Viatronix, and Philips and co-founder of VirtuoCTC. Dr Rex receives research support from Olympus. Dr Hassan discloses no conflicts.



Supplementary Figure 1. Calibration of the model outputs through comparison with observed values. (*A*) Prevalence of adenomatous polyps computed by the model as compared with that from autopsy and screening studies. (*B*) Stage distribution of CRC in the simulated population compared with SEER data. DIS, distant; LOC, localized; REG, regional; SEER, Surveillance, Epidemiology, and End Results.

Supplementary Materials and Methods

Calibration of the Model

It is important to correlate the model outputs of the unscreened hypothetical population with expected real-life observations to provide validation. A χ^2 statistic was calculated to compare the differences between predicted and natural history rates; small values indicated good calibration. Values exceeding 20 indicate significant lack of calibration. Natural history of colorectal neoplasia was manually calibrated with the age-specific adenomatous prevalence, CRC-stage distribution, and age-specific and sex-specific CRC incidence. Correspondence of the observed age-specific prevalence of adenomas, extracted from autopsy and endoscopic populations,[1–4] with model outputs (χ^2 = 0.7 for the fit of 6 different 5-year age ranges between 50 and 80 years), as well as that between the observed Surveillance Epidemiology and End Results (SEER) stage-specific CRC distribution and the simulation values (χ^2 = 0.1), are shown in Supplementary Figure 1.[5] Regarding the resect and discard strategy, assuming a one-time screening at 60 years of age, the simulated percentage of diminutive polyps over all polyps was equal to 64%, as compared with 63% reported in a large American screening population.[6] In the natural history model, the lifetime CRC risk for an unscreened 50-year-old citizen was 5.7% (6% for men and 5.4% for women), compared with 5.5% (5.8% and 5.3% for men and women) according to the SEER data (χ^2 = 1.7 for the fit of 10 different 5-year ranges) from a pre-screening period (ie, early 1990).[5] Regarding calibration of screening efficacy for CRC prevention, our estimates were similar to that of the only available long-term endoscopic screening case-control study (72%),[7] which is between that of the National Polyp Study (76%) and a large non-screening endoscopic case-control study (60%).[8,9] Moreover, such simulated prevention rate was extremely similar to that of other models on the same topic, such as 75% from Sonnenberg et al,[10] 73% from Ladabaum and Song,[11] and 68% from Vijan et al.[12] Regarding CRC cost, when assuming the same cost used in the model from Ladabaum and Song, the US projection of CRC cost in the no screening strategy would be $8 billion per year, practically analogous to the previous estimate.[11] The much higher estimate achieved in our simulation when including the cost of new chemotherapeutic and biologic agents (such as bevacizumab) is well in line with previous cost-effectiveness models.[13]

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Supplementary Table 1. Model Characteristics and Parameters Used for the Reference Case and Probabilistic Sensitivity Analyses

Model characteristics	
Model type	State transition model (Markov)
Hypothetical population	100,000 US 50-year-old subjects
Perspective	Societal
Time horizon	Lifetime
Intervention	OC every 10 years without and with resect and discard policy for diminutive polyps between 50 and 80 years

Variable	Reference case value (95% confidence interval)
Natural history	
Adenoma prevalence at age 50 (%)	
<10 mm polyp (%)	8 (5–11)[14]
≥10 mm polyp (%)	6 (4–8)[14]
New adenomatous polyp rate (%/y)	Age-specific 1.9–3.3 (1.3–4.3)[15–17]
Annual transition rate from ≤5 mm to 6–9 mm (%)	Age-specific 2–5 (1.4–6.5)[15–17]
Annual transition rate from 6–9 mm to ≥10 mm (%)	Age-specific 2–4 (1.4–5)[15–17]
Annual transition rate from ≥10 mm to LOC CRC	Age-specific 3–4 (2–5)[15–17]
Annual transition rate from LOC CRC to REG CRC (%)	33 (23–43)[18]
Annual transition rate from REG CRC to DIS CRC (%)	40 (28–52)[18]
Advanced ≥10 mm/advanced <10 mm rate (%)	90 (63–100)[15–17]
Proportion of CRC arising by polypoid precursors (%)[a]	85 (59–100)[19]
Annual transition rate to *de novo* cancer (%)	Age-specific-rate, 0.008–0.16 (0.006–0.2)[20]
Symptomatic presentation of LOC CRC (%)	20 (14–26)[18]
Symptomatic presentation of REG CRC (%)	65 (45–85)[18]
Symptomatic presentation of DIS CRC (%)	100 (70–100)[18]
Annual mortality rate for LOC CRC in first 5 years (%/y)	1.7 (1.2–2.2)[5]
Annual mortality rate for REG CRC in first 5 years (%/y)	8.6 (6–11)[5]
Mean survival from DIS CRC (*y*)	1.9 (1.4–2.6)[5]
Hyperplastic polyp prevalence at age 50 (%)	10 (7–13)[14]
Annual hyperplastic polyp incidence rate (%)	5 (3–7)[14]
Screening	
Adherence (%)	23 (30–100)
Colonoscopy sensitivity for ≤5 mm polyps (%)	80 (70–90)[10,11]
Colonoscopy sensitivity for 6–9 mm polyps (%)	85 (78–92)[21,22]
Colonoscopy sensitivity for ≥10 mm polyps (%)	90 (82–97)[21,22]
Colonoscopy sensitivity for CRC (%)	95 (91–99)[21,22]
Colonoscopy specificity (%)	99 (95–100)[21,22]
Feasibility of resect and discard policy ≤5 mm polyps (%)[b]	83 (50–100)[23–25]
Sensitivity of resect and discard policy ≤5 mm polyps (%)[c]	94 (50–100)[23–25]
Specificity of resect and discard policy for polyps (%)[c]	89 (50–100)[23–25]
Colonoscopy perforation rate (%)	0.06 (0.04–0.08)[26]
Polypectomy bleeding (%)	0.48 (0.3–0.6)[26]
Polypectomy perforation (%)	0.11 (0.07–0.15)[26]
Colonoscopy bleeding (%)	0.001 (0.0007–0.0013)[26]
Costs	
Colonoscopy ($)	630 (543–725)[27]
Colonoscopy with polypectomy ($)	925 (593–1237)[27]
Pathologic examination ($)	102 (50–200)[27]
Bleeding ($)	5494 (3740–7152)[14]
Perforation ($)	16,380 (12,310–20,600)[14]
Indirect cost colonoscopy ($)[d]	210 (133–281)[28]
LOC CRC treatment ($)	50,000 (33,200–66,900)[29]
REG CRC treatment ($)	100,000 (61,500–140,000)[29]
DIS CRC treatment ($)	200,000 (160,000–240,000)[29]

Point estimates and 95% confidence limits of the parameter distributions are reported. LOC, localized; REG, regional; DIS, distant.

[a]Cancers not arising through the polypoid pathway are considered to be *de novo* cancers. *De novo* pathogenesis implies that some CRCs arise from non-polypoid lesions of colorectal mucosa, such as flat or depressed neoplasia.

[b]On the basis of the use of NBI to differentiate hyperplastic from adenomatous diminutive polyps.

[c]Defined as accuracy for correctly identifying the adenomatous histotype in diminutive polyps.

[d]Indirect costs for colonoscopy were computed as follows: 8 hours for the patient + 4 hours for an escort.