Original Article

Comparative Cost-Effectiveness of Mailed Fecal Immunochemical Testing (FIT)-Based Interventions for Increasing Colorectal Cancer Screening in the Medicaid Population

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BACKGROUND: Mailed reminders to promote colorectal cancer (CRC) screening by fecal immunochemical testing (FIT) have been shown to be effective in the Medicaid population, in which screening is underused. However, little is known regarding the cost-effectiveness of these interventions, with or without an included FIT kit. **METHODS:** The authors conducted a cost-effectiveness analysis of a randomized controlled trial that compared the effectiveness of a reminder + FIT intervention versus a reminder-only intervention in increasing FIT screening. The analysis compared the costs per person screened for CRC screening associated with the reminder + FIT versus the reminder-only alternative using a 1-year time horizon. Input data for a cohort of 35,000 unscreened North Carolina Medicaid enrollees ages 52 to 64 years were derived from the trial and microcosting. Inputs and outputs were estimated from 2 perspectives—the Medicaid/state perspective and the health clinic/facility perspective—using probabilistic sensitivity analysis to evaluate uncertainty. **RESULTS:** The anticipated number of CRC screenings, including both FIT and screening colonoscopies, was higher for the reminder + FIT alternative (n = 8131; 23.2%) than for the reminder-only alternative (n = 5533; 15.8%). From the Medicaid/state perspective, the reminder + FIT alternative dominated the reminder-only alternative, with lower costs and higher screening rates. From the health clinic/facility perspective, the reminder + FIT versus the reminder-only alternative resulted in an incremental cost-effectiveness ratio of $116 per person screened. **CONCLUSIONS:** The reminder + FIT alternative was cost saving per additional Medicaid enrollee screened compared with the reminder-only alternative from the Medicaid/state perspective and likely cost-effective from the health clinic/facility perspective. The results also demonstrate that health departments and state Medicaid programs can efficiently mail FIT kits to large numbers of Medicaid enrollees to increase CRC screening completion. ***Cancer* 2020;0:1-12**. © *2020 American Cancer Society*.

KEYWORDS: costs and cost analysis, early detection of cancer, mass screening, Medicaid, preventive health services.

INTRODUCTION

Colorectal cancer (CRC) is among the most commonly diagnosed malignancies nationally, with an estimated 140,250 incident diagnoses in 2018.[1] Fortunately, timely screening can prevent unnecessary morbidity and mortality associated with CRC. The US Preventive Services Task Force provides its strongest "A" endorsement for CRC screening among average-risk individuals ages 50 to 75 years, delivered by multiple modalities, including annual fecal testing.[2]

Despite this evidence base, however, more than one-third of age-eligible Americans are not up to date with CRC screening,[3] and subpopulation-specific studies indicate especially low screening among Medicaid and other low-income populations.[4-6] The reasons for low screening rates are multifactorial and relate to the perceived inconvenience associated with CRC screening, competing time demands, lack of provider recommendation, lack of understanding about screening benefits, and perceived high cost.[7,8] Many of these concerns are uniquely associated

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See editorial on pages 1-4, this issue.

The funding sources had no role in study design; data collection, analysis, and interpretation; writing of the article; or the decision to submit the report for publication.

The findings and interpretation in this report represent the authors' own work and are not intended to represent the views of the Centers for Disease Control and Prevention or the National Cancer Institute.

Additional supporting information may be found in the online version of this article.

DOI: 10.1002/cncr.32992, **Received:** January 13, 2020; **Revised:** February 6, 2020; **Accepted:** February 20, 2020, **Published online** Month 00, 2020 in Wiley Online Library (wileyonlinelibrary.com)

with colonoscopy, which requires substantial preparation time, accompanied transportation, time away from work, and significantly higher cost than fecal testing. For these reasons, fecal testing is a preferred testing modality by many low-income individuals.[9-11]

Consequently, programs to increase CRC screening in low-income populations have leveraged the relatively simple and low-cost fecal test to encourage participation.[9,12,13] Multiple studies have demonstrated the effectiveness of such strategies, including mailing reminders and mailing fecal immunochemical test (FIT) kits to age-eligible individuals who are not up to date with screening.[12] However, the identification of potentially eligible individuals requires a robust health care informatics infrastructure as well as timely tracking and referral pathways for follow-up colonoscopy among those who test positive for blood in the stool with an FIT kit. These programmatic requirements can be resource-intensive but may be high-value given the considerable health benefits associated with CRC screening, particularly within underserved, low-income populations, which shoulder a heavier burden of late-stage diagnoses, inability to obtain treatment once diagnosed, and higher CRC mortality.[14,15]

As payers and providers endeavor to increase the proportion of age-eligible adults who are up to date with CRC screening, according to the National Colorectal Cancer Roundtable target of 80% screened,[16] understanding the comparative value of mailed FIT-based programs in low-income populations is urgently needed. We sought to estimate the cost-effectiveness of 2 mailed strategies (reminder + FIT kit and reminder only), relative to each other, in a Medicaid population in which patient records enabled the identification of potentially eligible intervention targets and patient navigators were in place to ensure appropriate referral of FIT-positive results to colonoscopy providers. Furthermore, we partnered with a local safety-net provider in a large urban setting—the county public health department—to deliver the intervention and track resource use throughout the intervention. By estimating the cost per additional person screened for CRC when comparing these strategies, our objective was to inform decision makers about the efficiency of methods for improving CRC screening uptake from a public health and Medicaid perspective.

MATERIALS AND METHODS

Pragmatic Randomized Controlled Trial

Our study team conducted a pragmatic randomized controlled trial (RCT) in Mecklenburg County, North Carolina, among more than 2100 average-risk Medicaid enrollees aged 52 to 64 years who were overdue for CRC screening between October 2016 and July 2017.[13] We previously reported details about the study design and results.[13] Briefly, the enrollees received either a reminder + FIT or only a reminder based on random assignment. We identified individuals as potentially eligible for screening based on age and past screening in claims, excluding those who had a prior history of CRC or full colectomy. Reminder letters noted that the individual's medical record indicated they may be due for CRC screening and provided information about how to access CRC screening; for the reminder + FIT packages, a FIT kit was sent with the reminder, whereas, for the reminder-only alternative, patients could request a mailed FIT kit and received information about how and where to undergo colonoscopy. An included postcard allowed targeted participants or their proxies to respond that they had already been screened (n = 226 across both arms) or to opt out because of loss of Medicaid insurance (n = 4), language barriers (n = 2), relocation (n = 6), or death (n = 6). In the parent study, the FIT completion rate was significantly higher for the reminder + FIT intervention compared with the reminder-only intervention (21.1% vs 12.3%; $P < .01$). We expect that these interventions also encouraged some individuals to complete screening by colonoscopy; based on estimates from the literature,[17-19] we estimate that these additional colonoscopy screenings resulted in overall CRC screening rates of 23.3% for the reminder + FIT and 15.8% the reminder-only interventions. In the parent study, in total, 18 individuals received positive FIT results (11 in the reminder + FIT group and 7 in the reminder-only group) and were navigated to follow-up colonoscopy; notably, none of those 18 individuals lost Medicaid insurance before follow-up. The RCT was carried out in partnership between the Mecklenburg County Health Department (MCHD) and Community Care of North Carolina (CCNC), the state's medical home model for coordinating care of Medicaid beneficiaries. The CCNC local care network, Community Care Partners of Greater Mecklenburg, provided patient navigation to follow-up services and colonoscopy, as needed, according to its customary care coordination role. The study was approved by the University of North Carolina Institutional Review Board.

Study Design

We conducted a population-level decision analysis following best practices[20] (Fig. 1) using Microsoft Excel 2016 (version 16.14.1; Microsoft Corporation), in which the

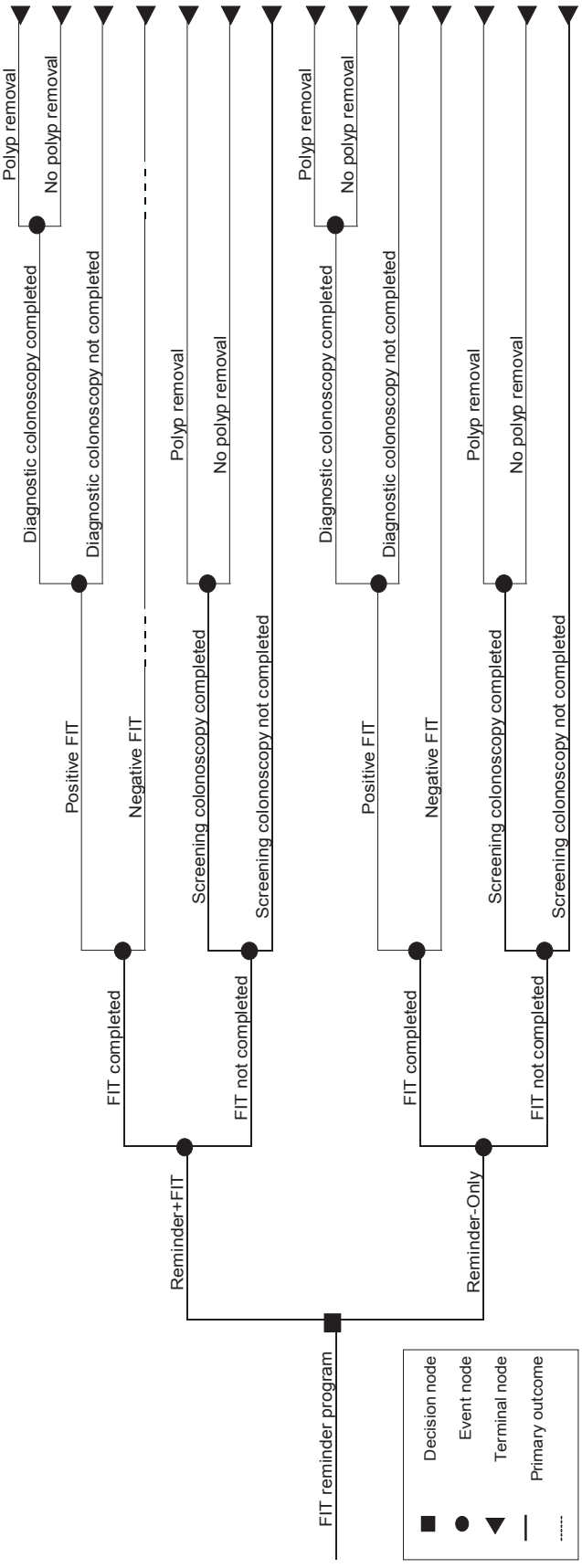

FIGURE 1. Decision analytic tree for colorectal cancer (CRC) screening. The primary outcome is completion of CRC screening by fecal immunochemical testing (FIT) or colonoscopy. Secondary outcomes are additional health outcomes beyond CRC screening, including the FIT result, completion of a recommended diagnostic colonoscopy after an abnormal FIT, and polyp removal.

cohort moved through a decision tree from left to right through 14 possible pathways. The decision node, controlled by the randomized experiment in the parent study, determined which intervention to provide: reminder + FIT or reminder only. Event nodes, or probabilistic events that happen by chance, were derived from data collected in the parent study and included whether individuals completed FIT, and if so, whether they received a positive (abnormal) result, underwent a diagnostic colonoscopy if positive, and had polyps removed. Event nodes also included whether individuals were screened by colonoscopy instead of FIT and whether polyps were removed during the screening colonoscopy. The terminal node was polyp detection and removal.

Outcomes

We estimated the cost-effectiveness of interventions with respect to the number of individuals screened for CRC either by FIT or by colonoscopy within a Medicaid population. Although the interventions were FIT-based, enrollees may be more likely to initiate CRC screening by any modality as a result of being notified that they are overdue for screening.

In the decision tree, primary outcomes (Fig. 1, dark lines) were related to program reach and screening, whereas secondary outcomes (Fig. 1, light, dotted lines) included additional health outcomes beyond screening, such as completion of diagnostic examinations and removal of polyps during colonoscopy. Although these secondary outcomes are important for assessing compliance with recommended follow-up after FIT and longer term health outcomes, we focused on the incremental gain in persons screened.

Analytic Perspective

We assessed the reminder + FIT versus reminder-only comparison from 2 perspectives: 1) Medicaid or the state, grouped together because state governments cover a large portion of Medicaid expenses and make decisions about Medicaid administration and public health programmatic offerings; and 2) the health clinic/facility, which may include county health departments, federally qualified health centers, small primary care providers, or larger integrated health care systems. We assumed that, if Medicaid launched an FIT-based intervention, the programmatic materials, equipment, and personnel costs would be borne by Medicaid or its care coordination entity.

Population and Setting

The cohort included 35,000 average-risk North Carolina Medicaid enrollees aged 52 to 64 years who were not up to date with CRC screening. We focused on individuals aged ≥52 years to allow for 2 years to schedule and receive CRC screening after becoming age-eligible at age 50 years. We excluded individuals who were age-eligible for Medicare and dual Medicare enrollees because they have different CRC screening patterns than Medicaid-only enrollees.[5] The cohort size was based on estimates of the size of the age-eligible Medicaid population in North Carolina, the percentage of this population enrolled in Medicaid only, and the percentage of enrollees expected to be screened for CRC.

Time Horizon

The time horizon was 1 year. We selected this relatively short horizon because the study period for the pragmatic RCT was also 1 year.

Model Inputs

The input parameters for the reminder + FIT and reminder-only alternatives—transition probabilities and costs—were largely obtained from the RCT results reported elsewhere.[13] We used existing literature to inform the ranges (ie., minimum, maximum) of plausible estimates[17,18,21-27] for a probabilistic sensitivity analysis (PSA). All transition probabilities are reported in Table 1.[13,17-19,21-26]

The cost parameters included materials and equipment costs, such as the mailing supplies and FIT kits, personnel costs associated with implementing the interventions and communicating test results, and Medicaid reimbursement rates for completed screenings (Table 2). To the Medicaid/state perspective, we assigned the materials and equipment costs, plus the reimbursement costs paid out for externally processed FIT and colonoscopy screenings, which would be outsourced to a provider and reimbursed by Medicaid. In contrast, to the health clinic/facility perspective, we assigned all relevant material, equipment, and personnel costs minus the recovered Medicaid reimbursements for completed FIT screenings. For the health clinic/facility perspective, we also assigned an administrative overhead cost to account for the time and resources involved with ensuring that appropriate patients were identified for the screening program, notified of results, and followed, whether through the electronic health records or, in this case, working with CCNC to review Medicaid claims. We did not assign a similar overhead cost to the Medicaid/state perspective, however, because these activities were assumed to be routine aspects of Medicaid care coordination. We excluded patient-level costs, such as travel and missed employment, from this analysis because these would not be relevant to either perspective. Because

TABLE 1. Transition Probabilities for Decision Analytic Tree

Probability	Base-Case	Min	Max	Distribution	Sources
Proportion screened by FIT in a 1-y period					
Reminder + FIT	.211	.210	.407	Triangular	Brenner 2018,[13] Charlton 2014,[21] Gupta 2013[22]
Reminder only	.123	.047	.163	Triangular	Brenner 2018,[13] Lewis 2012,[23] Leone 2013[24]
Proportion screened by colonoscopy in 1-y period					
Reminder + FIT	.027	.020	.050	Triangular	Baker 2014,[13] assumption, Singal 2016[18]
Reminder only	.040	.027	.133	Triangular	Assumption, Baker 2014,[13] Green 2013[19]
Proportion with positive FIT after completing 1 FIT					
Reminder + FIT	.072	.049	.120	Triangular	Brenner 2018, Tiro 2014,[27] Charlton 2014[21]
Reminder only	.072	.049	.120	Triangular	Brenner 2018,[13] Tiro 2014,[27] Charlton 2014[21]
Proportion completed diagnostic colonoscopy after positive FIT					
Reminder + FIT	.667	.443	.813	Triangular	Brenner 2018,[13] Baker 2014,[17] Chubak 2016[25]
Reminder only	.667	.443	.813	Triangular	Brenner 2018,[13] Baker 2014,[17] Chubak 2016[25]
Proportion with polyps removed after diagnostic colonoscopy					
Reminder + FIT	.729	.487	1.000	Triangular	Kligman 2018[26]
Reminder only	.729	.487	1.000	Triangular	Kligman 2018[26]
Proportion with polyps removed after screening colonoscopy					
Reminder + FIT	.500	.369	.826	Triangular	Kligman 2018[26]
Reminder only	.500	.369	.826	Triangular	Kligman 2018[26]

Abbreviations: FIT, fecal immunochemical test; Max, maximum; Min, minimum.

TABLE 2. Cost Inputs for Decision Analytic Tree by Perspective

	Medicaid/State Perspective, $		Health Clinic/Facility Perspective, $	
Item or Unit	Reminder + FIT	Reminder-Only	Reminder + FIT	Reminder-Only
Materials and equipment costs				
Postage, printed materials, and mailer for reminder + FIT	9.69	9.69	9.69	9.69
Postage, printed materials, and envelope for reminder only	—	0.68	—	0.75
Administrative overhead[a]	—	—	8.00	8.00
FIT kit	—	—	2.04	2.04
Equipment cost for FIT kit laboratory processing (nonpersonnel)[b]	—	—	3.57	3.57
Personnel costs				
Assembling mailed packets	0.58	0.58	0.58	0.58
Processing FIT kits	—	—	1.94	1.94
Conducting reminder mailings	1.09	1.09	1.09	1.09
Conducting reminder phone calls	6.09	6.09	6.09	6.09
Communicating negative FIT results	2.67	2.67	2.67	2.67
Communicating positive FIT results	3.76	3.76	3.76	3.76
Preparing additional FIT kits	—	—	2.61	2.61
Providing patient navigation to FIT-positive patients	37.65	37.65	37.65	37.65
Attending trainings and intervention meetings	0.39	0.39	0.39	0.39
Medicaid reimbursement rates				
FIT	17.65	17.65	−17.65	−17.65
Colonoscopy without polypectomy[c]	462.63	462.63	—	—
Colonoscopy with polypectomy[c]	624.39	624.39	—	—
Polyp pathology[c]	74.21	74.21	—	—

Abbreviation: FIT, fecal immunochemical test.

[a]Administrative overhead includes the time and resources required to ensure that appropriate patients are identified for the intervention, notified of results, and followed, whether by using electronic health records or reviewing Medicaid claims. We assumed the health clinic/facility would need to allocate new resources for these activities, whereas for Medicaid they would be part of routine care coordination.

[b]We assumed that FIT kit and processing costs are borne by the health clinic/facility and reimbursed by Medicaid, whereas we assumed that Medicaid outsources these and pays only the reimbursement for the kit itself.

[c]We assumed that the primary care health clinic/facility providing screening is not also providing colonoscopies and getting reimbursed for them.

the CCNC navigation program was already in existence, we also assumed there were no start-up costs involved with developing a new navigation process (ie, recruiting and training navigators). However, we did include the labor costs associated with patient navigation to follow-up colonoscopy for those individuals with a positive FIT result.

The MCHD provided the per-person material and equipment costs that were incurred during the implementation of the RCT. We obtained Medicaid reimbursement rates from the North Carolina Medicare Fee Schedule,[28] assuming that Medicaid reimbursed at 95% the rate of Medicare. We used microcosting to estimate the personnel costs. Specifically, throughout the RCT, the project team, which was comprised of a laboratory manager, a patient navigator, and 28 support staff, each of whom dedicated a minimal full-time equivalent and tracked their hours by type of activity on an ongoing, weekly basis in a REDCap database (Vanderbilt University) for a total of 27 weeks. This prospective data collection mitigated issues such as recall bias and staff turnover that commonly plague retrospective estimates of labor-related costs.[29] In addition, to ensure data quality, a local supervisor managed the data-collection process and conducted regular check-ins with the staff related to data quality. We included only non-research, intervention-specific activities in this analysis, which involved a combined 456.5 hours across staff members, and assigned mean hourly wages for equivalent positions in North Carolina from the Bureau of Labor Statistics.[30] Personnel costs are reported per enrollee who would require each service. For example, to determine the cost per enrollee of communicating positive FIT results, we divided the total staff cost associated with communicating positive results by the number of enrollees with a positive FIT. We reported all costs in 2018 dollars, using the Consumer Price Index medical care component inflation factor.[31]

Base-Case Analyses

We estimated the incremental cost-effectiveness ratio (ICER) for each perspective, using base-case values for each of the input parameters. We calculated the ICER as the difference in costs divided by the difference in effectiveness, in terms of enrollees screened by either FIT or colonoscopy. The reported ICER indicates the cost per additional person screened (PPS) in the reminder + FIT alternative compared with the reminder-only alternative.

Sensitivity Analyses

We conducted a PSA using Crystal Ball (Oracle; 2018), running a simulation of 1000 trials for each comparison, to examine uncertain input parameters. To fully evaluate the potential role of these sources of uncertainty in our analysis, we assigned triangular distributions to the transition probabilities associated with FIT or colonoscopy screening, using minimum and maximum values from prior research, and to the costs. We varied all personnel-related cost estimates by ±20% and used ranges of fixed costs from existing research. For each perspective, we reported the results in an ICER plane; each point on the 4-quadrant graph represents the change in effectiveness (eg, incremental gain in individuals screened) and the incremental cost of the reminder + FIT alternative compared with the reminder-only alternative for 1 of the 1000 simulated trials, providing a visual depiction of the potential range in cost-effectiveness estimates. We also created a cost-effectiveness acceptability curve (CEAC) for each perspective, displaying the likelihood that the reminder + FIT alternative would be cost-effective relative to the reminder-only alternative at a particular willingness-to-pay (WTP) threshold in terms of dollars expended PPS.

As a secondary analysis, we considered the cost-effectiveness of each type of mailed FIT intervention compared with usual care (ie, no intervention) from both analytic perspectives. To simulate the usual care scenario, we identified a range of plausible estimates for the transition probabilities from published studies in similar populations and assigned the relevant costs provided by the MCHD and as estimated through microcosting, as shown in Supporting Tables 1 and 2.

RESULTS

Compared with the reminder-only alternative, the reminder + FIT alternative yielded more CRC screenings and saved money from the Medicaid/state perspective but cost more from the health clinic/facility perspective. The total number among 35,000 enrollees expected to be screened by FIT or colonoscopy was 8131 for the reminder + FIT alternative (23.2%) and 5533 for the reminder-only alternative (15.8%). Thus the reminder + FIT alternative resulted in 2598 more screenings than the reminder-only alternative.

Medicaid/State Perspective

The total and incremental costs as well as the ICER from the Medicaid/state perspective are reported in Table 3. Total CRC screening costs for the reminder + FIT and reminder-only were estimated to be $1.40M and $1.45M, respectively. Notably, compared with the reminder-only alternative, the reminder + FIT alternative was cost saving or dominant from this perspective because it yielded more screenings at lower cost.

TABLE 3. Colorectal Cancer Screenings, Costs, and Incremental Cost-Effectiveness Ratios

Probability (Event)	Population Total Screenings[a]	Population Total Screening Costs, $	Total Cost Per Person Screened, $	No. of Incremental Screenings	Incremental Screening Costs, $	ICER per Person Screened, $
Medicaid/state perspective						
Reminder + FIT	8131	1,400,584	172	2598	cost-saving	Dominant
Reminder only	5533	1,447,311	262	Reference	Reference	Reference
Health clinic/facility perspective						
Reminder + FIT	8131	926,589	114	2598	302,102	116
Reminder only	5533	624,487	113	Reference	Reference	Reference

Abbreviations: FIT, fecal immunochemical test; ICER, incremental cost-effectiveness ratio.
[a]Colorectal cancer screenings include both FITs and colonoscopies.

Health Clinic/Facility Perspective

Table 3 also presents the results of the cost-effectiveness analysis from the health clinic/facility perspective. Implementing the reminder + FIT intervention statewide for 35,000 eligible Medicaid beneficiaries was estimated to cost $926,589, whereas the reminder-only intervention cost $624,487, an incremental cost difference of just over $302,000. The cost PPS for CRC by FIT or colonoscopy was $114 for the reminder + FIT alternative and $113 for the reminder-only alternative. Because the reminder + FIT intervention resulted in 2598 more screenings than the reminder-only intervention, the ICER comparing these 2 active interventions was $116 PPS.

Sensitivity Analyses

ICER planes are presented in Figure 2A for the Medicaid/state perspective and in Figure 2B for the health clinic/facility perspective, respectively, providing the results of the 1000 simulated trials of the PSA. From the Medicaid/state perspective, at a WTP level of $150 PPS, the reminder + FIT alternative dominated the reminder-only alternative in 83% of the trials. At the same WTP level of $150 PPS from the health/clinic perspective, the reminder + FIT alternative was found to be cost-effective in 92% of the trials compared with the reminder-only alternative.

Figure 3 presents CEACs for the Medicaid/state and health clinic/facility perspectives. The CEAC indicates the probability that the reminder + FIT intervention, relative to the reminder-only intervention, would be cost-effective at various WTP thresholds in terms of increasing CRC screening. For example, from the health clinic/facility perspective, the reminder + FIT intervention was expected to be cost-effective >50% of the time at a WTP level of $70 PPS. At a higher WTP level of $100 PPS, the reminder + FIT intervention was expected to be cost-effective 75% of the time.

Because patient navigation can involve multiple phone contacts with a patient, with time spent explaining the need for a follow-up colonoscopy, scheduling the appointment, and helping to address potential patient-level barriers, the amount of time spent navigating individual patients varies. Therefore, we conducted a deterministic sensitivity analysis for this parameter in which we varied the time estimate per FIT-positive individual, finding that even tripling the number of hours per patient resulted in small cost differences (approximately $5-$7 more PPS by arm), with the overall implications remaining the same.

Finally, through our secondary analysis, we found that both the reminder + FIT and reminder-only interventions were cost-effective compared with usual care from both perspectives. If implemented by Medicaid or the state, the estimated ICERs PPS relative to usual care were $123 for the reminder + FIT and $211 for the reminder-only (see Supporting Table 3a). From the health clinic/facility perspective, the ICERs PPS were $137 for the reminder + FIT alternative and $150 for the reminder-only alternative compared with usual care (see Supporting Table 3b). The CEACs for these comparisons by perspective are presented in Supporting Figure 1.

DISCUSSION

We have reported the cost-effectiveness of 2 variations of mailed FIT-based reminder programs to increase CRC screening among Medicaid enrollees. We have demonstrated that the reminder + FIT intervention saved costs compared with the reminder-only intervention from the Medicaid/state perspective and only required an incremental cost PPS of $116 from the health clinic/facility perspective. This ICER fell within the range of what decision makers typically would be willing to pay for an additional person screened for CRC, previously shown to include ICERs as high as several hundred dollars or more.[32-34] Given the attention to CRC screening as a National Committee for Quality Assurance Healthcare Effectiveness Data and Information Set metric, practices and payers are increasingly interested in evidence-based

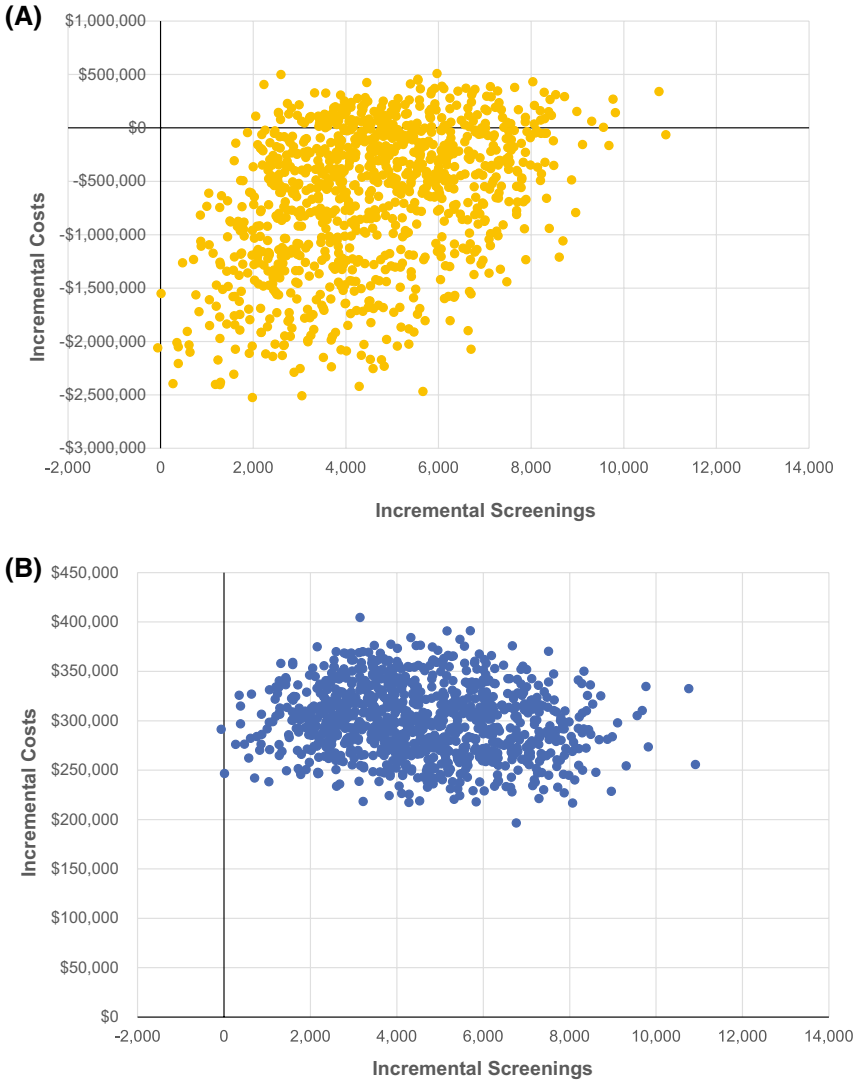

FIGURE 2. (A) The incremental cost-effectiveness ratio (ICER) plane for reminder + fecal immunochemical testing (FIT) versus the reminder-only alternative is illustrated from the Medicaid/state perspective. This ICER plane presents the probabilistic sensitivity analysis (PSA) results from the Medicaid/state perspective in terms of incremental costs and incremental effectiveness. These results indicate that, at a willingness to pay (WTP) of $150, the reminder + FIT alternative is cost saving in 83% of trials relative to the reminder-only alternative. (B) The ICER plane for reminder + FIT versus the reminder-only alternative is illustrated from the health clinic/facility perspective. This ICER plane presents the PSA results from the health clinic/facility perspective in terms of incremental costs and incremental effectiveness. These results indicate that. at a WTP of $150 per person screened, the reminder + FIT alternative is cost-effective in 92% of cases compared with the reminder-only alternative, from the health clinic/facility perspective

strategies that can address the gap in CRC screening in low-income populations at the most affordable cost.

Our analysis showed that, regardless of whether Medicaid or clinics/facilities paid for programming to increase CRC screening, the mailed reminder + FIT intervention was the higher value approach. This approach can quickly reach thousands of age-eligible Medicaid enrollees who are overdue for screening and encourage substantial numbers—nearly 1 in 4 individuals in the reminder + FIT intervention—to get screened for CRC.

From the health/clinic perspective, the reminder-only intervention cost less overall than the reminder + FIT intervention. However, from the Medicaid/state perspective, it was more expensive than the reminder + FIT alternative in terms of total costs. The higher overall cost of the reminder-only alternative from the Medicaid/state perspective largely resulted from induced screening colonoscopies because of the reminder letter, which Medicaid must then reimburse. Importantly, this suggests that the incremental cost difference associated with proactively

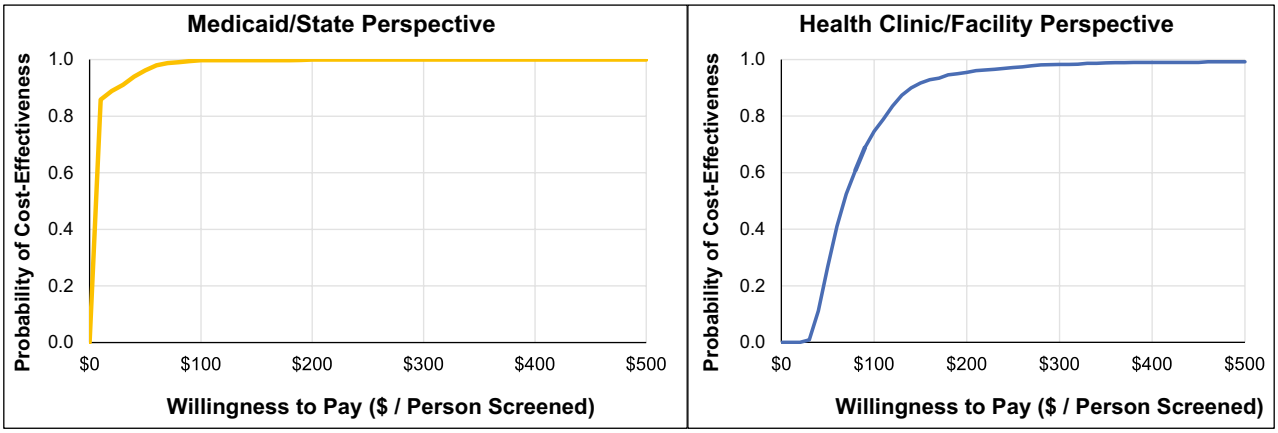

FIGURE 3. Cost-effectiveness acceptability curves for reminder + fecal immunochemical testing (FIT) versus the reminder-only alternative are illustrated by perspective. This panel of cost-effectiveness acceptability curves presents the probability that the reminder + FIT alternative will be cost-effective compared with the reminder-only alternative at various willingness-to-pay (WTP) thresholds from the analytic perspective of Medicaid/state (yellow) or the health clinic/facility (blue). For example, from the Medicaid/state perspective, the reminder + FIT alternative will be cost-effective compared with the reminder-only alternative nearly 90% of the time at a WTP of $20 per additional person screened. From the health clinic/facility perspective, the reminder + FIT alternative will be cost-effective compared with the reminder-only alternative 75% of the time at a WTP of $100 per additional person screened.

mailing FIT kits was more than offset by differences in costs associated with screening colonoscopies in a reminder-only program, consistent with prior research.[36]

Our findings are in line with other studies from different settings, suggesting that mailed reminder campaigns are cost-effective for increasing CRC screening participation in various populations.[37-40] Shankaran and colleagues evaluated the cost-effectiveness of mailing educational reminders to patients referred for colonoscopy and reported a 12 percentage point increase in CRC screening at only $43 PPS.[38] Schlichting et al evaluated mailed FIT kits with an emphasis on understanding whether a high-intensity intervention with introductory and reminder phone calls was worth the additional investment. Those authors reported an ICER of $27 per FIT returned with the high-intensity intervention versus $45 per FIT returned for mailings alone, relative to usual care. They concluded that both approaches were cost-effective and that setting-specific factors should determine which approach is implemented.[39] Lee et al evaluated mailed educational reminders after fecal occult blood test distribution among US veterans and found that reminders increased screening participation by 16 percentage points at $15 PPS.[40] Our study differed from these prior analyses in 2 important ways. First, we focused on Medicaid recipients, who have considerably lower than average CRC screening rates. Second, we evaluated a program consisting of proactively mailed FIT kits targeting potentially eligible patients using Medicaid claims, as opposed to targeting patients already primed for CRC screening through prior referrals or prior fecal occult blood test card dissemination. As such, our study presents an opportunity for health clinics/facilities and payers to evaluate the potential costs and benefits of proactive intervention within low-income populations to increase CRC screening rates.

Our findings differ somewhat from those of Meenan and colleagues, who evaluated a clinic-based, pragmatic RCT comparing an electronic health record-embedded, mailed FIT intervention to usual care. They reported an overall ICER of $483 per screening-eligible, patient-adjusted, completed FIT.[29] Although their overall ICER was higher than our base-case estimate, our ICER values for the reminder-only and reminder + FIT interventions, compared with usual care (our secondary analysis), fell within their reported range. The authors acknowledged that their overall ICER was relatively high compared with other published cost-effectiveness analyses of FIT-based interventions. However, this is likely because of variation in intervention implementation[41] by clinics that differed greatly in their infrastructure and level of resources. The analysis of Meenan et al also accounted for costs associated with data organization and management, such as the time required to analyze claims data records, which helps to facilitate the accurate identification and ongoing monitoring of patients who are eligible and due for screening. Although our analysis included an administrative overhead cost related to these activities for clinics and health departments, our estimate may be lower than what

is needed for administrative-related and data-related costs in other settings. Decision makers should consider how these costs may vary depending on their local data infrastructure and context.

Other studies have evaluated CRC screening navigation and observed that more intensive interaction led to higher initial and repeat screening.[19] Our study reserved the more cost-intensive navigation only for those patients who tested positive on FIT. Medicaid's CCNC care managers, whose roles are well suited for this function, provided these services. This approach may be inherently efficient because it focused limited navigation services on the follow-up and diagnostic needs of higher risk patients who had already screened positive. That said, our study did not evaluate screening navigation. Comparing the cost-effectiveness of screening navigation versus navigation to follow-up/diagnostic care is an important area for future inquiry because screening navigation previously yielded substantial gains in CRC screening uptake relative to the *automated* mailed FIT (ie, no follow-up phone calls) in primary care populations (eg, 65% up to date in the screening navigated group vs 51% in the group receiving mailed FIT only).[19]

Our time horizon of 1 year allowed us to compare our findings with those from other studies on the cost-effectiveness of FIT-based interventions with similarly short time horizons.[29,40] By reflecting the short duration of many Medicaid enrollments, our current analysis provided insight into the expected benefits of a screening intervention in the short-term, whereas the long-term gains associated with screening may result in cost savings for other payers. Policymakers at the state level typically make decisions about how to invest their resources in the short term based on the state's annual Medicaid budget. Evaluating program costs and benefits over a longer time horizon would be difficult to implement analytically because little is known about repeat screening patterns of FIT users with Medicaid insurance; however, future analyses should explore how CRC screening changes over time in Medicaid enrollees. In addition, Medicaid enrollment may be short-lived, with high rates of churning in some subpopulations.[42,43] Nevertheless, Medicaid enrollment was relatively continuous in our population aged 52 to 64 years; among the 2144 patients in the parent study who were identified as eligible and were randomized to receive 1 of the 2 reminder-based programs, only 4 reported not participating because of loss of Medicaid insurance, and none of the 18 FIT-positive patients reported losing Medicaid insurance by the time of follow-up navigation.

Our analysis included limitations. First, we based our input parameter estimates on a pragmatic RCT in a large, urban Medicaid population that may have had different access to care and willingness to engage in CRC screening than populations in other settings. Although our intervention was conducted in a Medicaid medical home setting with care coordination provided by patient navigators, other state Medicaid programs may have less infrastructure in place to support implementation. The implementation of similar programs in different populations and settings should be expected to yield slightly different costs and outcomes, and such variability should be explored in future implementation studies. Nevertheless, we evaluated potential uncertainty in program uptake and costs across a range of plausible values based on the best available data, and our findings remained robust to such changes in assumptions about underlying input data. Second, we omitted potentially relevant patient costs; however, our focus was on incentivizing practices and payers to consider implementing fecal testing-based mailed reminder campaigns and showing the value added to them. Nonetheless, future studies should collect patient-reported data on the associated opportunity costs to patients, which may be more burdensome among low-income individuals with multiple competing demands. Finally, some of our secondary analyses were not planned a priori but emerged with input from our health department and CCNC partners to help us further understand implementation costs as part of sustainability planning.

We conducted this cost-effectiveness analysis primarily as an opportunity to inform decisions about how best to improve CRC screening on an annual basis from the perspective of decision makers like those at Medicaid (who are operating on annual budgets) and individual clinics (who often are tasked with reporting on annual CRC screening). In light of our 1-year time horizon, the costs associated with the detection and treatment of diagnosed cancers were not included. Although the costs per cancer averted or quality-adjusted life-year gained are important outcomes, the cost per additional person screened is often the outcome of most relevance to decision makers at community health clinics.[44-46] Moreover, the association between improved CRC screening through organized programs and substantial reductions in CRC incidence and mortality over longer-term time horizons was previously demonstrated,[47] and multiple other studies have demonstrated the cost-benefit tradeoffs of CRC screening more generally. Our current study focused more narrowly on the most efficient strategies to increase uptake of CRC screening in low-income Medicaid enrollees, as opposed

to the value of screening itself. As future work, we plan to analyze follow-up claims data for the RCT participants, providing a better understanding of repeat FIT screening patterns among Medicaid enrollees to inform future cost-effectiveness analyses with longer time horizons.

Conclusions

Nationally, CRC screening is among the most beneficial, yet underused, preventive services. The Community Guide to Preventive Services has reviewed the evidence base and recommended mailed reminder interventions for CRC screening since 2010 and small-media interventions (eg, educational letters and brochures) to increase colorectal cancer screening since 2005.[48] Despite this endorsement of mailed interventions emphasizing fecal testing, relatively few studies have evaluated the cost-effectiveness of such interventions. To our knowledge, none have done so in the context of outreach from a county public health department for the Medicaid population. Our analyses in this setting demonstrate to health departments and Medicaid organizations that including an FIT kit with a mailed reminder is a good incremental investment of resources. It is potentially cost saving, depending on the payer, relative to a mailed reminder alone. Our findings also support limiting demand for the more resource-intensive colonoscopy and navigation to colonoscopy to those who arguably need it most—individuals with abnormal FIT results. Recognizing such tradeoffs explicitly and acting deliberately to spread scarce resources as broadly as possible across underserved populations will likely yield the greatest gains in public health and the greatest savings in public spending.

FUNDING SUPPORT

This study was supported by the University of North Carolina Lineberger Comprehensive Cancer Center's Carolina Cancer Screening Initiative and the University Cancer Research Fund through a Tier 2 Stimulus Award (Stephanie B. Wheeler and Alison T. Brenner), and through the Cancer Prevention and Control Research Network (CPCRN) (Cooperative Agreement U48-DP005017) from the Centers for Disease Control and Prevention (CDC) Prevention Research Centers Program and the National Cancer Institute. Meghan C. O'Leary is supported by the University of North Carolina at Chapel Hill Cancer Care Quality Training Program (National Cancer Institute grant T32 CA116339). Jeff Y. Yang is supported as a predoctoral trainee under National Institutes of Health (NIH) grant T32 DK007634 and by the University of North Carolina Royster Society of Fellows.

CONFLICT OF INTEREST DISCLOSURES

Stephanie B. Wheeler reports grant funding to her institution from the Pfizer Foundation, outside the submitted work. The remaining authors made no disclosures.

AUTHOR CONTRIBUTIONS

Stephanie B. Wheeler: Conceptualization, formal analysis, funding acquisition, investigation, methodology, supervision, visualization, writing–original draft, and writing– review and editing. **Meghan C. O'Leary:** Formal analysis, investigation, visualization, writing–original draft, and writing–review and editing. **Jewels Rhode:** Data curation, project administration, resources, and writing–review and editing. **Jeff Y. Yang:** Investigation, resources, and writing–review and editing. **Rebecca Drechsel:** Resources and writing–review and editing. **Marcus Plescia:** Resources and writing–review and editing. **Daniel S. Reuland:** Methodology and writing–review and editing. **Alison T. Brenner:** Conceptualization, data curation, funding acquisition, investigation, methodology, supervision, and writing–review and editing.

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