

# Automated Telephone Calls to Enhance Colorectal Cancer Screening: Economic Analysis

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Colorectal cancer (CRC) is a common and often lethal disease with a lifetime risk of about 1 in 20; it causes more than 51,000 deaths annually in the United States. When diagnosed at late stages the 5-year survival rate is less than 12%, but patients with localized tumors have a 5-year survival rate greater than 90%.<sup>1</sup> Early detection is clearly a key to improving survival, and screening has been shown to be cost-effective (eg, at a commonly used threshold of \$50,000 per year of life gained), with some analyses even suggesting that screening is cost-saving.<sup>2</sup> While CRC screening rates have increased in recent years, they are still below 60% for people aged ≤64 years and below 75% for those aged ≥65 years.<sup>3</sup>

Because the favorable cost-effectiveness of CRC screening is now established, attention has shifted to optimizing methods for increasing adherence with CRC screening. The cost-effectiveness of several intervention types has been reported, including mailing stool cards with and without targeted calls, where the cost per additional patient screened has ranged from about \$100 to more than \$6000 depending on the intensity of the intervention<sup>4,5</sup>; and physician education efforts,<sup>6,7</sup> where the cost per additional patient screened has ranged from about \$100 to \$1000.

Automated telephone calls have been used to remind and inform patients about a wide range of preventive and therapeutic healthcare interventions.<sup>8-11</sup> A recently reported pragmatic trial by our group showed that automated telephone reminders significantly improved CRC screening rates.<sup>9</sup> Using data from that randomized control trial, this report focuses on the cost-effectiveness of telephone reminders compared with usual care per additional patient screened.

## METHODS

We used findings from a practical randomized control trial that enrolled patients due for CRC screening (as defined by the National Council for Quality Assurance) to estimate the cost-effectiveness of an automated telephone intervention for CRC screening relative to usual care. The cost analysis focused on replication costs<sup>12</sup> from the perspective of a health maintenance organization (HMO) and included any method of screening rather than

**Objectives:** To estimate the cost-effectiveness of an automated telephone intervention for colorectal cancer screening from a managed care perspective, using data from a pragmatic randomized controlled trial.

**Methods:** Intervention patients received calls for fecal occult blood testing (FOBT) screening. We searched patients' electronic medical records for any screening (defined as FOBT, flexible sigmoidoscopy, double-contrast barium enema, or colonoscopy) during follow-up. Intervention costs included project implementation and management, telephone calls, patient identification, and tracking. Screening costs included FOBT (kits, mailing, and processing) and any completed screening tests during follow-up. We estimated the incremental cost-effectiveness ratio (ICER) of the cost per additional screen.

**Results:** At 6 months, average costs for intervention and control patients were \$37 (25% screened) and \$34 (19% screened), respectively. The ICER at 6 months was \$42 per additional screen, less than half what other studies have reported. Cost-effectiveness probability was 0.49, 0.84, and 0.99 for willingness-to-pay thresholds of \$40, \$100, and \$200, respectively. Similar results were seen at 9 months. A greater increase in FOBT testing was seen for patients aged ≥70 years (45/100 intervention, 33/100 control) compared with younger patients (25/100 intervention, 21/100 control). The intervention was dominant for patients aged ≥70 years and was \$73 per additional screen for younger patients. It increased screening rates by about 6% and costs by \$3 per patient.

**Conclusions:** At willingness to pay of \$100 or more per additional screening test, an automated telephone reminder intervention can be an optimal use of resources.

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**In this article**  
Take-Away Points / p692  
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### Take-Away Points

Colorectal cancer screening has been shown to be a cost-effective intervention, but uncertainty remains over the most efficient methods for increasing screening rates.

- Automated phone calling increased screening rates by about 6% and costs by \$3 per patient.
- The incremental cost-effectiveness ratio per additional screen of \$40 is less than half what other studies have reported.
- At a willingness to pay of \$100 or higher per additional screening test, our study suggests an automated telephone reminder intervention can be an optimal use of resources.

just fecal occult blood testing (FOBT). Our follow-up was less than 1 year, so costs and effects were not discounted; costs were inflated to reflect 2008 dollars.<sup>13</sup>

### Trial Design

A complete description of the trial has been reported elsewhere.<sup>9</sup> The trial was conducted at Kaiser Permanente Northwest, a not-for-profit, group-model HMO, and was approved by its institutional review board. **Figure 1** details how patients were selected in the randomized control trial; 6000 patients (out of 32,320) were randomly allocated to automated telephone contact or usual care. Consistent with US Preventive Services Task Force CRC screening guidelines in place at the time of trial initiation,<sup>14</sup> we selected average-risk patients aged 51 to 80 years who were eligible for screening (eg, had no evidence of relevant screening in the HMO's records and did not have risk factors indicating need for disease monitoring).

### Intervention Group

Intervention group patients were exposed to calls prompting FOBT screening (call type 1) and FOBT return reminder calls (call type 2); while these calls were not personalized, they were directed toward specific individuals. **Figure 2** details the timing of these calls. Call type 1 was brief (1 minute), provided information about the benefits of CRC screening, and encouraged FOBT as a relatively simple and low-risk method of cancer screening. Recipients who answered could immediately request a mailed FOBT kit by touch-tone. A detailed message that included a telephone number to call for FOBT kit requests was left via voice mail for unanswered calls. Patients who did not get CRC screening received up to 2 "general" automated reminder calls, 6 weeks apart. One additional reminder call (call type 2) was made to patients who had requested an FOBT kit but did not return it within 5 weeks from the date of request; those patients were given the opportunity to request an additional FOBT kit. All FOBT kits used the guaiac method (Hemocult II; Beckman Coulter, Inc, Brea, California), which requires samples from 3 consecutive stools, and were delivered via standard mail.

### Usual Care

Patients randomized to usual care did not receive the telephone contact intervention. Their CRC screening, if any, occurred via normal care processes. At the time of the study, clinicians had access to national guidelines, Intranet-based screening guidelines, and a "panel support tool" (an electronic prompt system embedded in the electronic medical record that informed clinicians which patients were due for preventive services, including CRC screening). For usual care patients, FOBT kits were obtained after a clinician order by picking the kit up either from the laboratory at the clinic where they received their care or from the HMO's influenza immunization service, located in primary care clinics.

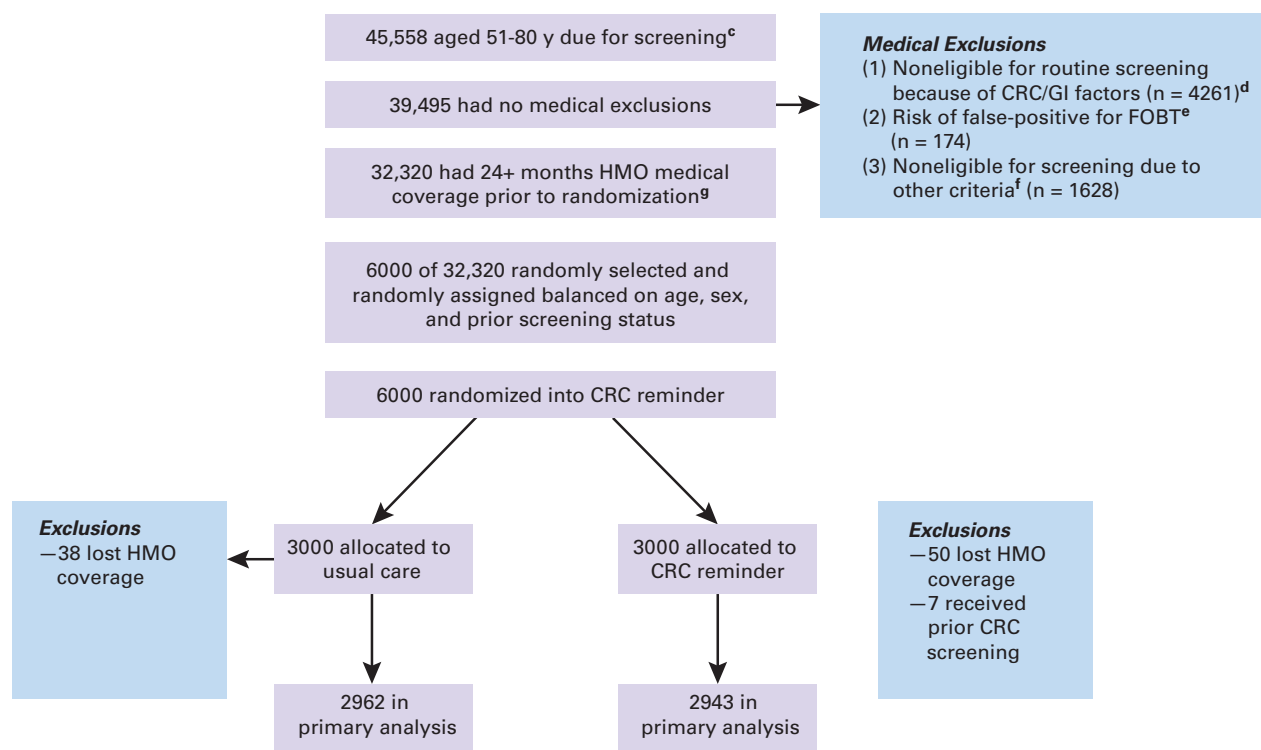
### Outcome Measures

We used the HMO's electronic data systems to identify patient outcomes. We specified 2 outcomes for the analysis: the cost per any completed screen and the cost per positive FOBT screen. Even though the intervention promoted FOBT, we defined a completed screen as a record of any US Preventive Services Task Force-recognized screening test (FOBT, flexible sigmoidoscopy, double-contrast barium enema [DCBE], or colonoscopy) during follow-up. For both outcomes, a patient was counted as screened only once, even if he or she had multiple tests; but as detailed below, costs for all screening tests during follow-up were included. We used the term "nonfecal tests" to collectively refer to those more invasive testing methods including flexible sigmoidoscopy, DCBE, and colonoscopy. We examined the effect of the intervention on both FOBT and nonfecal tests separately.

### Costs

We estimated staff costs associated with the intervention from clinical trial records and study staff time estimates. These costs included project management time to oversee the entire process and computer programming efforts for patient identification, electronic file preparation for the automated telephone call vendor, and patient tracking (eg, for repeat calls to nonresponders). To improve generalizability to other systems, salary costs were taken from the US Bureau of Labor and Statistics.<sup>15</sup> To fully allocate the costs we added a fringe benefit rate of 30% and overhead rate of 20%. The cost of the calls and their content was based on vendor charges. The cost of developing and maintaining the automated telephone system was embedded in the vendor charge to the HMO. FOBT kit mailing costs were estimated based on bulk mailing rates.

■ **Figure 1.** Study Design and Population Selection<sup>a,b</sup>



CRC indicates colorectal cancer; DCBE, double-contrast barium enema; FOBT, fecal occult blood test; GI, gastrointestinal; HIV, human immunodeficiency virus; HMO, health maintenance organization.

<sup>a</sup>Reprinted with permission from Mosen et al.<sup>9</sup>

<sup>b</sup>Eligible patients were due for routine CRC screening (specifically patients for whom stool occult blood testing was a clinically appropriate option).

<sup>c</sup>Had not had (1) colonoscopy within 10 years, (2) flexible sigmoidoscopy or DCBE within 5 years, (3) FOBT screening within past 12 months, or (4) order for FOBT/DCBE in past 3 months.

<sup>d</sup>Did not have (1) active colon cancer/risk factors that would indicate need for disease monitoring, diagnostic testing, or nonroutine screening frequency (defined as GI referral for chronic diarrhea, esophageal reflux, iron deficiency, polyp follow-up, or rectal surgery in past 12 months); (2) prior diagnosis of adenomatous polyps or HIV/AIDS; or (3) referral for colonoscopy or sigmoidoscopy in past 3 months.

<sup>e</sup>Did not have risk for a false-positive stool occult blood test due to receipt of Plavix or warfarin medications in past 4 months.

<sup>f</sup>Were not eligible for screening because they had total colectomy or end-stage renal disease, or were in hospice care.

<sup>g</sup>Had continuous enrollment in HMO 24 months prior to randomization.

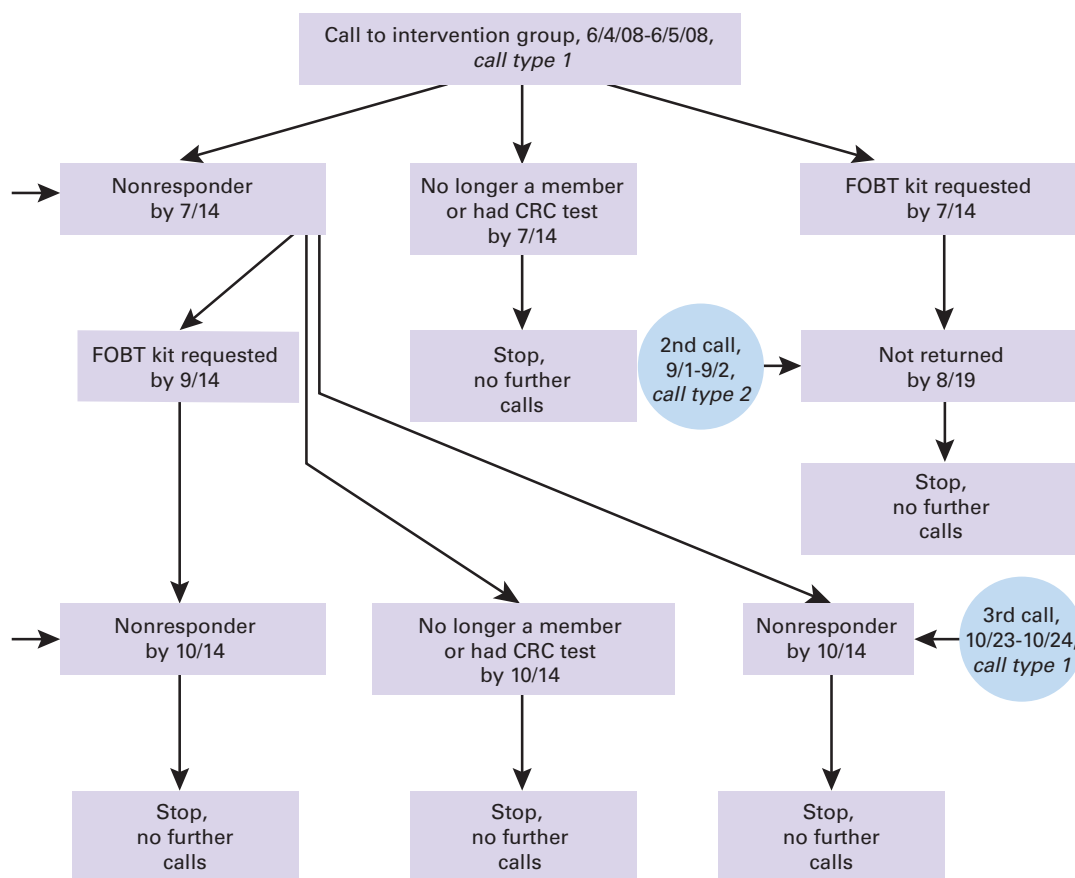
For patients in both groups, the costs associated with the FOBT testing kit, processing, and reporting was estimated from the HMO's laboratory charges to nonmembers. Clinician time and cost associated with FOBT laboratory result review and follow-up with patients was estimated from a previous economic evaluation in laboratory medicine<sup>16</sup> and from interviews with those doing the work. Costs for other types of testing, including DCBE, flexible sigmoidoscopy, and endoscopy, came from the HMO's accounting database. While a patient was counted as screened only 1 time, all CRC testing-related costs during the follow-up were enumerated and assigned to that patient. We did this because the intervention may have had knock-on effects for other types of CRC testing, including both diagnostic (eg, following a positive FOBT) and screening (eg, encouraging a patient to request colonoscopy screening), and we wanted to more fully account for the economic consequences of the

intervention. For example, if a patient was screened with FOBT at month 1 and then subsequently had a colonoscopy during month 8, the cost of both tests was counted in the 9-month analysis. We made no attempt to discern the clinical rationale for a given screening test (eg, a screening vs a diagnostic colonoscopy); rather, we conservatively included all tests for both outcomes and costs. Usual care patients may have gotten their screening advice at an office visit, but we assumed CRC screening advice was unlikely to be the chief reason for the visit, so we did not attempt to include those costs. Any resulting bias from that decision would make usual care appear less costly.

### Clinical Trial Findings

In the clinical trial, the mean age in both groups was about 60 years, with an even female/male split. There were 2943 patients in the intervention group, and 2962 patients in the

■ **Figure 2.** Type and Timing of Calls to Intervention Group



CRC indicates colorectal cancer; FOBT, fecal occult blood test.

usual care group. In the intervention group, 22.5% completed FOBT within 6 months, compared with 16.0% in the usual care group. Screening by any method was completed for 23.9% in the intervention versus 17.6% in the usual care group. In the intervention group, 2943 (100%) received the initial call type 1 (general reminder), 2406 (81.8%) received a second type 1 call, and 1632 (55.5%) received a total of 3 calls of type 1. Call type 2 (FOBT return reminder) was made to 18.3% of the intervention group.

### Statistical Analysis

We calculated the incremental cost-effectiveness ratio (ICER) as  $(\text{cost}_i - \text{cost}_c) / (\text{effect}_i - \text{effect}_c)$ , where  $i$  = intervention,  $c$  = control, and  $\text{effect}$  = number of patients with a screening test. We used net benefit regression methods<sup>17-19</sup> to estimate the intervention's probability of being cost-effective. We report the probability of the intervention being cost-effective at several relevant thresholds of willingness to pay for an additional outcome (eg, additional screen) to aid decision makers' translation of the results to their own setting and spe-

cific considerations. We also computed bootstrapped 95% confidence intervals on total costs using the percentile method.

The parent clinical trial revealed a significant intervention effect that depended on patient age, so we undertook a similar subgroup analysis. As was done in the clinical trial, we followed patients for 6 months in our primary analysis. Since fecal screening is recommended annually, the health plan encourages screening on that basis; therefore, we also wanted to examine a time period more compatible with that interval. To accomplish this goal and to avoid the potential overlapping effects from the next annual screening efforts, we undertook a secondary analysis and followed patients for completed tests up to 9 months after their index date. SAS version 9.1 (SAS Institute, Cary, North Carolina) and STATA versions 10 and 11 (STATA Corporation, College Station, Texas) were used for all analyses.

## RESULTS

**Table 1** enumerates the resources necessary to implement and sustain the automated calling program in the interven-

**Table 1. Resource and Unit Costs**

Resource Use Category	Unit Cost	Source	Comment
Project management–related staff time (intervention group)	\$0.42 per person	Clinical trial, HMO costs, Bureau of Labor and Statistics	Coordination effort required to maintain the program
Patient identification, tracking, and reporting–related staff time (intervention group)	\$0.66 per person	Clinical trial, HMO costs, Bureau of Labor and Statistics	Analyst time to write and maintain programs, transfer to phone vendor, reporting, and tracking
Automated telephone call (intervention group)	\$0.54 per person	Clinical trial	Estimated cost from in-house vendor of phone messaging services
FOBT kit, including mailing to patient (intervention group patients who requested one; usual care group patients with a completed test)	\$0.84 per test	Clinical trial	HMO nonmember charge
FOBT test processing (both groups)	\$1.77 per test	Laboratory charge	HMO nonmember charge
Clinician follow-up for positive FOBT test (both groups)	\$12 per person	Expert opinion	5 minutes; review chart, refer and contact patient for follow-up testing
DCBE (both groups)	\$277 per test	HMO cost	Scheduling, performing, and interpreting the test
Flexible sigmoidoscopy (both groups)	\$374 per test	HMO cost	Scheduling, performing, and interpreting the test
Endoscopy (both groups)	\$745 per test	HMO cost	Scheduling, performing, and interpreting the test

DCBE indicates double-contrast barium enema; FOBT, fecal occult blood test; HMO, health maintenance organization.

tion arm and to carry out all types of CRC screening tests in both arms. **Table 2** shows the resource use and average cost per person in both groups at 6 and 9 months and by age. Accounting for the staff time associated with project management, computer programming, patient tracking and reporting, and the calls themselves, the intervention cost was about \$4.20 per person.

For patients of all ages, the average cost per patient for FOBT testing (kits and their processing) was slightly higher in the intervention group, while the per patient cost associated with nonfecal tests (endoscopy, DCBE, and flexible sigmoidoscopy) was slightly higher in the usual care group. We found that the number of FOBT tests completed at 9 months was markedly higher in the intervention group (ie, 812 vs 669). On the other hand, we observed similar overall proportions of patients with nonfecal tests (3.2% intervention and 3.0% usual care, data not shown). But there were differences by age; intervention patients aged 70 years or older had 5.6 nonfecal tests per 100 persons compared with 7.8 per 100 persons in usual care. However, for patients younger than 70 years, nonfecal test use was similar in both groups (7.9 and 8.0 nonfecal tests per 100 persons in the intervention and usual care groups, respectively). FOBT testing increased in both age groups, but the FOBT increase was greater in the older age group (45/100 intervention patients and 33/100 control

patients) than in the younger age group (25/100 intervention patients and 21/100 control patients). As shown in **Table 2**, these observed differences by age in the use of FOBT and nonfecal tests translated into notable differences in costs at both 6 and 9 months. For example, at 9 months the average costs of FOBT and nonfecal tests were similar for patients younger than 70 years in the intervention and usual care groups. However, at 9 months, for patients 70 years or older, the costs of FOBT were 25% higher in the intervention group (\$1.50 vs \$1.20), while the costs for nonfecal tests were more than 40% lower in the intervention group (\$34.60 vs \$48.70). While these component costs showed some variation, total costs were similar in both groups, as evidenced by the overlapping confidence limits.

**Table 3** shows the cost-effectiveness at 6 and 9 months by age using each of the 2 measures of effectiveness: any completed screen and the positive FOBT screen. Overall, we found that the cost for an additional screened patient was \$42 at 6 months and \$40 at 9 months. At 6 months, the chance of the intervention being cost-effective was about 50% at a willingness to pay of \$40 for an additional patient screened. It increased to 84% for a willingness to pay of \$100 and 99% for a willingness to pay of \$200.

The intervention was dominant (ie, lower costs with a greater proportion of patients screened) at 6 months for patients 70

■ **Table 2.** Mean per Patient Costs at 6- and 9-Month Follow-up<sup>a</sup>

Type of Service	Intervention Group (n = 2943)	Usual Care Group (n = 2962)
<b>All ages</b>		
<b>6-month follow-up</b>		
Intervention cost <sup>b</sup>	\$4.20 (\$0.40)	NA
FOBT testing and follow-up	\$0.70 (\$1.90)	\$0.60 (\$1.80)
Nonfecal tests <sup>c</sup> and follow-up	\$32.10 (\$142.70)	\$33.80 (\$148.40)
Total cost (95% CI)	\$37.00 (\$31.90-\$42.30)	\$34.40 (\$29.70-\$39.80)
<b>9-month follow-up</b>		
Intervention cost <sup>b</sup>	\$4.20 (\$0.40)	NA
FOBT testing and follow-up	\$0.90 (\$2.10)	\$0.80 (\$2.00)
Nonfecal tests <sup>c</sup> and follow-up	\$46.90 (\$178.80)	\$49.10 (\$180.80)
Total cost (95% CI)	\$52.00 (\$45.70-\$58.50)	\$49.90 (\$44.00-\$56.40)
<b>Age &lt;70 y</b>		
<b>6-month follow-up</b>		
Intervention cost <sup>b</sup>	\$4.10 (\$0.40)	NA
FOBT testing and follow-up	\$0.70 (\$1.80)	\$0.50 (\$1.70)
Nonfecal tests <sup>c</sup> and follow-up	\$33.20 (\$145.40)	\$34.40 (\$150.80)
Total cost (95% CI)	\$37.90 (\$32.70-\$44.10)	\$34.90 (\$28.70-\$40.80)
<b>9-month follow-up</b>		
Intervention cost <sup>b</sup>	\$4.10 (\$0.40)	NA
FOBT testing and follow-up	\$0.80 (\$2.00)	\$0.70 (\$1.90)
Nonfecal tests <sup>c</sup> and follow-up	\$48.70 (\$182.60)	\$49.20 (\$181.20)
Total cost (95% CI)	\$53.60 (\$46.50-\$60.50)	\$49.90 (\$41.90-\$56.10)
<b>Age ≥70 y</b>		
<b>6-month follow-up</b>		
Intervention cost <sup>b</sup>	\$4.30 (\$0.40)	NA
FOBT testing and follow-up	\$1.30 (\$2.40)	\$0.8 (\$2.20)
Nonfecal tests <sup>c</sup> and follow-up	\$24.60 (\$122.50)	\$30.00 (\$130.50)
Total cost (95% CI)	\$30.10 (\$17.90-\$43.00)	\$30.80 (\$18.70-\$46.90)
<b>9-month follow-up</b>		
Intervention cost <sup>b</sup>	\$4.30 (\$0.40)	NA
FOBT testing and follow-up	\$1.50 (\$2.60)	\$1.20 (\$2.50)
Nonfecal tests <sup>c</sup> and follow-up	\$34.60 (\$150.30)	\$48.70 (\$178.90)
Total cost (95% CI)	\$40.40 (\$26.60-\$55.00)	\$49.90 (\$32.00-\$67.90)

CI indicates confidence interval; FOBT, fecal occult blood test; NA, not applicable.

<sup>a</sup>Values are mean (SD) unless otherwise specified.

<sup>b</sup>Includes all components needed to deliver the intervention.

<sup>c</sup>Endoscopy, double-contrast barium enema, and flexible sigmoidoscopy.

years or older, but it had an ICER of \$73 for younger patients. In both age groups the intervention had a high probability (≥95%) of being cost-effective at a willingness to pay of \$200 for an additional screened patient at 6 months, but cost-effectiveness was markedly different at willingness-to-pay thresholds of \$100 (0.97 and 0.64 for older and younger patients, respec-

tively) and \$40 (0.75 and 0.35 for older and younger patients, respectively). We found a similar pattern of results at 9 months.

The cost per additional positive FOBT screen was \$1156 at 9 months. The probability of cost-effectiveness was 0.47 at a willingness to pay of \$1000 and increased to 0.70 at a willingness to pay of \$7000.



**Table 3.** Incremental Cost-Effectiveness per 100 Patients at 6 Months and 9 Months Postintervention

Time and Type of Analysis	Total Cost <sup>a</sup>	Total Screens	Incremental Costs	Incremental Screens	ICER	Probability of Cost-Effectiveness for Maximum Willingness to Pay		
<b>6 months postintervention</b>								
<b>Any completed screen analysis<sup>b</sup></b>						\$40	\$100	\$200
Intervention group	\$3701	25.076						
Usual care group	\$3438	18.805	\$263	6.27	\$42	0.49	0.84	0.99
<b>Age ≥70 y</b>								
Intervention group	\$3014	38.667						
Usual care group	\$3084	24.397	-\$69	14.27	Intervention dominant	0.75	0.97	1.00
<b>Age &lt;70 y</b>								
Intervention group	\$3793	22.555						
Usual care group	\$3449	17.860	\$344	4.69	\$73	0.35	0.64	0.95
<b>Positive FOBT screen<sup>c</sup></b>								
Intervention group	\$3701	1.053						
Usual care group	\$3438	1.047	\$263	0.006757	\$38,924	NC	NC	NC
<b>9 months postintervention</b>								
<b>Any completed screen analysis<sup>b</sup></b>						\$40	\$100	\$200
Intervention group	\$5196	30.751						
Usual care group	\$4990	25.625	\$206	5.13	\$40	0.51	0.76	0.97
<b>Age ≥70 y</b>								
Intervention group	\$4036	46.400						
Usual care group	\$4990	34.316	-\$954	12.08	Intervention dominant	0.88	0.97	1.00
<b>Age &lt;70 y</b>								
Intervention group	\$5337	27.984						
Usual care group	\$4875	24.194	\$462	3.79	\$122	0.26	0.42	0.74
<b>Positive FOBT screen<sup>c</sup></b>						\$1000	\$3000	\$7000
Intervention group	\$5196	1.495						
Usual care group	\$4990	1.317	\$206	0.18	\$1156	0.47	0.64	0.70

## DISCUSSION

Depending on one’s willingness to pay for an additional screen, we found that automated telephone calls can be cost-effective. For example, at a willingness to pay of \$100 per additional screen, the probability of cost-effectiveness is 0.84 and increases to near-certainty (0.99) at a willingness to pay of \$200 per additional screen. But at lower willingness-to-pay levels (ie, \$40 per additional screen), there is considerable uncertainty about the cost-effectiveness (probability of being cost-effective was 0.49).

A recent systematic review noted that, compared with no screening, all types of CRC screening are cost-effective at common thresholds (eg, \$50,000 per year of life gained) and some are even estimated to be cost-saving.<sup>2</sup> Our study focused on the cost and cost-effectiveness of using automated telephone calling to promote FOBT screening relative to usual care. We found that automated calls were low cost and compared favorably with other reported CRC screening programs at about \$40 per additional patient screened with any test. For example, a recent report reviewed several studies that analyzed the cost-effectiveness of comparable interventions to in-

crease CRC screening.<sup>5</sup> Those authors noted that the cost per additional patient screened ranged from more than \$6000 to \$94 for a range of interventions including physician communication training and patient education, physician feedback, and patient mailings.

Our intervention differed from previous interventions in several important ways that may have had a direct effect on the differential program costs. First, we did not send stool cards unless the patient requested the kit. By requiring a patient request before mailing a kit (and thus before incurring associated costs), a relatively costly component of the intervention was avoided by presumably targeting those patients most likely to complete testing. Additionally, by requiring a patient commitment (ie, a positive response to the call), the intervention potentially further enhanced patient follow-through. Our results suggest that future reviews on this topic might usefully compare the costs and cost-effectiveness of patient-directed versus provider-directed interventions and consider whether automated systems are more cost-effective, perhaps in a stepped approach.

Overall we found that the cost of an additional test was about \$40 at both 6 and 9 months, but the intervention's cost-effectiveness differed markedly by age. We found that among patients 70 years or older, automated calls were associated with higher screening rates and lower costs (about \$0.69 lower per patient at 6 months and about \$10 lower per patient at 9 months). Because we counted all screening costs during the follow-up interval, this suggests that older patients who received the automated calls were more likely to choose FOBT over nonfecal tests. While the overall frequency was small, we did find that among patients 70 years or older, fewer patients in the intervention arm received nonfecal tests compared with usual care patients. The intervention was associated with an apparent substitution effect (ie, FOBT for nonfecal tests). It is known that nonfecal tests have better test performance characteristics (eg, greater sensitivity and specificity) than does FOBT<sup>14</sup>; thus, FOBT might be used preferentially for lower-risk patients. Therefore, one question that arises with the potential substitution effect of FOBT for nonfecal tests is whether the automated telephone intervention is enhancing screening, but among lower-risk patients only. To further explore the possibility, we examined whether the rate of positive tests differed between the intervention and usual care groups. Automated results were only available for FOBT. Among patients 70 years or older, we found that 5.39% of the treatment group's FOBTs and 7.26% of the usual care group's FOBTs were positive at 9 months ( $P > .5$ ), while 5.43% and 5.50% of the intervention and usual care FOBTs, respectively, were positive for younger patients ( $P > .9$ ). So while we did find that older patients in the intervention group who were screened with FOBT were

potentially at lower risk for CRC, the large  $P$  value suggests that finding was due to chance, although the study may have been underpowered for this exploratory subgroup analysis. An important caveat is that the trial was not designed to assess this issue, but it does suggest a possible future direction for study. Such a study might use survey or qualitative methods.

Our finding that the automated phone intervention is more effective in older patients has been noted in other studies,<sup>8</sup> and is also consonant with cost-effectiveness findings from previous CRC screening analyses.<sup>5</sup> The increased rate of screening among older patients highlights that the intervention's promotion of FOBT screening makes CRC screening more readily accessible to a segment of the population that may find it difficult to arrange for nonfecal tests or may have comorbidities that contraindicate nonfecal screening.

Our intervention was carried out in a health system with an electronic medical record that was an integral part of the program's patient identification scheme. Specifically, the HMO's automated systems were used to target age-appropriate patients who were due for CRC screening by examining databases of healthcare encounters for tests and procedures that patients had previously received. Although the intervention and patient identification would likely work most efficiently in a similar system, the existence of an electronic medical record is not critical. However, access to electronically stored data might be critical. For example, a claims-based healthcare insurer would be able to search for candidate patients using claims consistent with receipt of screening and couple that information with their enrollment files to achieve a similar result. The scalability of the intervention is also important. As the number of patients called increases, the marginal cost per patient decreases, leading to even greater efficiency gains. Likewise, fewer patients would lead to higher marginal costs and decreased efficiency.

Our study's strengths include being conducted as part of a randomized trial and being embedded in an integrated healthcare system, allowing us detailed electronic capture of the healthcare resources involved in the intervention. On the other hand, the sample size and follow-up time restricted the ability to observe long-term outcomes such as cancer cases and deaths. However, a trial that could answer questions with those final outcomes would be expensive and very lengthy. Also, while our study did use tactics aimed at increasing CRC screening with a US Preventive Services Task Force–recommended screening modality, namely FOBT, our findings do not speak to interventions that promote other screening methods or use other types of interventions (eg, physician-directed interventions). Additionally, our analysis was limited to the cost per additional screen, and we did not consider possible changes in quality of life or costs associated with cancer detection and



treatment. Because CRC screening is cost-effective at common thresholds, our approach assumed that finding the most cost-effective testing strategy would lead to an economically attractive screening strategy; this assumption might not hold for all populations and situations. Depending on one's willingness to pay for an additional patient screened, automated telephone calls that prompt interested patients to request an FOBT kit and then remind those who requested a kit to return it can be a cost-effective method to promote CRC screening. Furthermore, compared with reports of other methods, the cost per patient screened is lower with automated calls. In particular, we found automated calling is associated with lower costs and improved screening rates in older patients, mainly through a decrease in the use of comparatively more expensive nonfecal tests. Our work adds to the growing literature showing the clinical utility and economic benefits of combining health information technology and medical record information to promote healthy behaviors.

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