Published in final edited form as:

Med Care. 2008 September ; 46(9 0 1): S91–S96. doi:10.1097/MLR.0b013e31817946c8.

Improvement in the Diagnostic Evaluation of a Positive Fecal Occult Blood Test in an Integrated Health Care Organization

Diana L. Miglioretti, PhD¹, Carolyn M. Rutter, PhD¹, Susan Carol Bradford, MS², Ann G. Zauber, PhD³, Larry G. Kessler, ScD⁴, Eric J. Feuer, PhD⁵, and David C. Grossman, MD, MPH^{1,2}

¹Group Health Center for Health Studies, Group Health Cooperative, Seattle, WA ²Department of Clinical Improvement and Prevention, Group Health Cooperative, Seattle, Washington

³Department of Epidemiology and Biostatistics, Memorial Sloan-Kettering Cancer Center, New York, New York ⁴Office of Science and Engineering Laboratories, Center for Devices and Radiologic Health, Food and Drug Administration, Silver Spring, Maryland ⁵Statistical Research and Applications, Division of Cancer Control and Population Sciences, National Cancer Institute, Bethesda, Maryland

Abstract

Background—Screening for fecal occult blood can be effective in reducing colorectal cancer mortality only if positive tests are appropriately followed up with complete diagnostic evaluation (*i.e.*, colonoscopy or flexible sigmoidoscopy with double contrast barium enema) and treatment.

Objectives—To examine whether rates of complete diagnostic evaluation following a positive fecal occult blood test (FOBT) have improved over time after the implementation of tracking systems and physician guidelines within a large integrated health care organization.

Research Design—From 1993 to 2005, 8513 positive FOBTs were identified on 8291 enrollees aged 50–79 of a large health care system. Automated records were used to identify repeat FOBTs, colonoscopy, flexible sigmoidoscopy, and double-contrast barium enema within one year after the positive FOBT. National rates of complete diagnostic evaluation were estimated from the 2005 National Health Interview Survey.

Correspondence: Diana L. Miglioretti, PhD, Group Health Center for Health Studies, 1730 Minor Avenue, Suite 1600, Seattle, WA 98101. Phone: (206) 287-4266; Fax: (206) 287-2017; miglioretti.d@ghc.org.

Diana L. Miglioretti, PhD, Group Health Center for Health Studies, 1730 Minor Avenue, Suite 1600, Seattle, WA 98101. Phone: (206) 287-4266; Fax: (206) 287-2017; miglioretti.d@ghc.org

Carolyn M. Rutter, PhD, Group Health Center for Health Studies, 1730 Minor Avenue, Suite 1600, Seattle, WA 98101. Phone: (206) 287-2900; Fax: (206) 287-2017; rutter.c@ghc.org

Susan Carol Bradford, MS, Department of Clinical Improvement and Prevention, Group Health Cooperative, 1600 E. John St., CEB 223, Seattle, WA 98112. Phone: (206) 326-3472; Fax: (206) 326-2617; bradford.s@ghc.org

Ann G. Zauber, PhD, Department of Epidemiology and Biostatistics, Memorial Sloan-Kettering Cancer Center, 307 East 63rd Street Room 357, New York, NY 10021. Phone: (646) 735-8160; Fax: (646) 735-0012; zauber.a@mskcc.org

Larry G. Kessler, ScD, Office of Science and Engineering Laboratories, Center for Devices and Radiologic Health, Food and Drug Administration, 10903 New Hampshire Ave., Bldg. 62, Room 3214, Silver Spring, MD 20993. Phone: 301-796-2530; Fax: 301-796-9959; larry.kessler@fda.hhs.gov

Eric J. Feuer, PhD, Statistical Research and Applications, Division of Cancer Control and Population Sciences, National Cancer Institute, Bethesda, MD

David C. Grossman, MD, MPH, Group Health Center for Health Studies, 1730 Minor Avenue, Suite 1600, Seattle, WA 98101. Phone: (206) 287- 2948; Fax: (206) 287-2017; grossman.d@ghc.org 3

Results—In this integrated health care organization, the percentage of positive FOBTs followed by complete diagnostic evaluation within one year increased from 57%–64% in 1993–1996 to 82%–86% from 2000–2005. Use of repeat FOBT following a positive FOBT decreased from 28–31% in 1993–1996 to 6–11% in 2000–2005. Based on the National Health Interview Survey, only 52% of positive FOBTs from 2000–2005 were followed by complete diagnostic evaluation nationally.

Conclusions—Adherence to recommendations for complete diagnostic evaluation following a positive FOBT has greatly improved over time in an integrated group medical practice. Through the use of tracking systems and screening guidelines, it may be possible to reach levels of follow-up that are comparable to those observed in randomized trials.

Keywords

Fecal occult blood test; colorectal cancer screening; diagnostic follow-up

Introduction

Colorectal cancer is the third leading cause of cancer death in the United States.¹ Based on randomized clinical trial results,^{2–5} annual screening for fecal occult blood is recommended for detecting colorectal cancer and precancerous adenomas among average-risk individuals starting at age 50.^{6–9} However, screening for fecal occult blood can be effective for reducing colorectal cancer mortality only if individuals who test positive are followed up with appropriate diagnostic evaluation and treatment. Previous studies report that only 25–59% of patients with a positive fecal occult blood test (FOBT) received complete diagnostic evaluation, typically defined as colonoscopy or double-contrast barium enema with flexible sigmoidoscopy, within one year.^{10–19} By contrast, in randomized trials, 83% individuals received a complete diagnostic evaluation following a positive result for fecal occult blood.^{4,5}

In this study, we examined trends from 1993 to 2005 in the proportion of individuals receiving a complete diagnostic evaluation following a positive FOBT at Group Health Cooperative, a large, nonprofit, consumer-governed health care system in Washington State that integrates care and coverage. During 2003–2005, rates of colorectal cancer screening were between 58–63% for the Group Health Medicare population and 45–53% for the commercial Group Health enrollees ages 50–80 years, using the National Committee for Quality Assurance's Healthcare Effectiveness Data and Information Set (HEDIS) criteria. These rates are comparable or higher than national screening rates based on self-report.⁸ In 1997, Group Health released its first formal colorectal cancer screening guidelines explaining recommendations for both colorectal cancer screening and follow-up procedures following an abnormal screening test. In November 1998, Group Health implemented an automated colorectal cancer follow-up registry, which informs physicians of their patients who have not received follow-up within four months after a positive FOBT according to automated records. In the fall of 2003, Group Health's automated colorectal cancer registry was supplemented with a manual audit system. Our goal was to determine whether rates of follow-up have improved after the implementation of these systems.

Methods

Study Setting

We evaluated trends in complete diagnostic evaluation following a positive FOBT among members of Group Health's integrated group practice in the Puget Sound Region of Washington State. Sociodemographic characteristics of Group Health members are similar to the area's population. Longitudinal electronic automated data systems captured the comprehensive health care services provided to the approximately 350,000 members who received their care from one of the 29 regional Group Health owned and operated clinics. Group Health's Institutional Review Board approved this study.

Group Health released its first formal colorectal cancer screening guidelines in 1997. From 1997 until 2004, these guidelines recommended screening with FOBT every two years and with flexible sigmoidoscopy every 10 years for people of average risk. Guidelines were updated in 2004 to recommend FOBT every one to two years, and again in 2006 to recommend annual FOBT. Colonoscopy is not recommended as an initial screening tool for average-risk patients; however, when a patient requests a screening colonoscopy, shared decision making is recommended. Since 1997, Group Health guidelines have stated that colonoscopy is the recommended standard of care following a positive FOBT. If a colonoscopy is contraindicated, a combination of flexible sigmoidoscopy plus double-contrast barium enema may be used.

FOBT screening is currently based on unhydrated Hemoccult® SENSAs® test kits that are given to enrollees during an office visit. Test kits are returned by mail to the Group Health laboratory. The primary care provider or ordering physician is notified of positive test results through the electronic medical record system laboratory results in-basket and is responsible for referring the patient for diagnostic evaluation. Enrollees are notified of test results by either letter or phone.

In November 1998, Group Health started an electronic registry to track enrollees who had not received a complete diagnostic evaluation (colonoscopy or a flexible sigmoidoscopy plus double-contrast barium enema) within four months after a positive FOBT, based on automated medical records. In the fall of 2003, Group Health implemented a centralized manual audit system to supplement the electronic system. A nurse auditor or primary care provider reviews cases in the automated system to determine if the medical record contains any documentation that follow-up tests were already completed, contraindicated, or determined to be unnecessary, or that the patient refused follow-up or is deceased. If follow-up tests were completed, the information is documented on the audit form. Otherwise, the primary care provider determines appropriate follow-up and documents his or her actions on the audit sheet. The results of the completed audit are tracked centrally. If a patient is referred for follow-up but does not comply, a new audit sheet is sent during the next audit until either the patient completes the follow-up or the provider indicates that the patient refused follow-up.

No other major efforts to improve colorectal cancer screening rates such as systematic training or focused continuing medical education courses occurred during this time period. Providers were not given feedback on screening or follow-up rates.

Study Population and Initial Fecal Occult Blood Test Result

We used automated electronic medical records to identify all FOBTs performed on enrollees aged 50 to 79 and processed by a Group Health laboratory from January 1, 1993 to December 31, 2005. We did not include FOBTs performed by a physician during an office visit or as part of inpatient care. A positive FOBT was defined as at least one of three slides positive for occult blood. (Each slide had two samples from the same day.) To ensure we included only the first FOBT performed in a sequence, we excluded FOBTs that followed a prior positive FOBT within nine months in the initial sample ($N=397$). We also excluded FOBTs performed among members with a prior colonoscopy or flexible sigmoidoscopy in the automated medical records ($N=3251$) or a colorectal cancer diagnosis identified by the Puget Sound Surveillance Epidemiology and End Results (SEER) program starting in 1974 ($N=75$), as individuals with a history of polyps or colorectal cancer may have different follow-up rates. We excluded tests performed on members who died or disenrolled from Group Health within one year of the positive FOBT ($N=2351$).

Diagnostic Evaluation

We used automated electronic medical records to identify all follow-up evaluations by repeat FOBT, colonoscopy, flexible sigmoidoscopy, or double-contrast barium enema performed within 365 days of the initial FOBT. Colorectal cancer diagnoses within 365 days following the positive FOBT were obtained from the Puget Sound SEER program. An individual was considered to have complete diagnostic evaluation if either colonoscopy or both sigmoidoscopy and double-contrast barium enema were performed within 365 days of the positive FOBT. We assumed the small number of enrollees with a colorectal cancer diagnosis within 365 days of the positive FOBT but no record of colonoscopy or flexible sigmoidoscopy with double-contrast barium enema within the automated records had obtained a complete diagnostic evaluation elsewhere ($N = 80$, $<1\%$).

Statistical Analysis

We calculated descriptive statistics by year, number of positive slides per array for occult blood, patient age at initial FOBT, and patient sex. We were unable to determine whether the indication for the initial FOBT was for screening or diagnostic purposes. Therefore, we calculated the positive predictive value of FOBT for detecting colorectal cancer, defined as the percentage of individuals with a positive FOBT who were diagnosed with colorectal cancer within 365 days, to compare with values reported for pure screening populations. We used logistic regression to evaluate whether time, number of positive slides, and patient age and sex were associated with the performance of complete diagnostic evaluation or other testing within one year of the positive FOBT. We examined reasons patients did not receive a complete diagnostic follow-up based on the manual audit. For comparison, we also calculated national rates of complete diagnostic evaluation obtained by self-report in the 2005 National Health Interview Survey (<http://www.cdc.gov/nchs/nhis.htm>). We included

survey participants aged 50 to 79 who reported that the result was not normal for their most recent home blood stool test, performed between 2000 and 2005.

Results

As Table 1 shows, we identified 8513 positive FOBTs performed from 1993 to 2005 on 8291 enrollees aged 50–79 at the time of the test. Half (49%) of the tests were performed on women, with roughly equal distribution among the 50–59, 60–69, and 70–79 age groups. The overall positive predictive value for colorectal carcinoma among all individuals with a positive FOBT was 5.7% [95% confidence interval (CI) = 5.2%, 6.2%]. When restricted to individuals who received a complete diagnostic evaluation, the positive predictive value increased to 7.9% (95% CI = 7.3%, 8.6%). Among these individuals, the positive predictive value increased with age and the number of positive slides per array for occult blood (see Table 1 for details).

The percentage of positive FOBTs followed by complete diagnostic evaluation within one year was 57–64% in 1993–1996, before the implementation of the tracking system and formal screening guidelines. Rates of follow-up increased significantly to 82%–86% in 2000–2005 ($p < 0.0001$, Table 2 and Figure 1). As Figure 1 and Table 3 show, the probability of complete diagnostic evaluation increased significantly with increasing number of positive slides per array ($p < 0.001$), adjusting for year, age at test, and sex. Females were significantly less likely to have complete diagnostic evaluation ($p = 0.017$), and younger individuals tended to have lower rates of complete diagnostic evaluation, though this was only borderline significant ($p = 0.079$, Table 3).

Among those who had a complete diagnostic evaluation within 1 year of a positive FOBT, the percentage of evaluations performed by colonoscopy increased from 78% in 1993 to 98% in 2000, remaining between 98% and 100% through 2005. The median time to the first procedure was 58 days during all years (data not shown).

Table 2 also shows that the use of sigmoidoscopy without double-contrast barium enema decreased from 3–6% in 1993–1996 to 1–2% in 2000–2005 ($p < 0.0001$), and use of double-contrast barium enema alone decreased from 2–4% in 1993–1996 to <1% in 2000–2005 ($p < 0.0001$). Results from the multivariable logistic regression models in Table 3 show that older individuals were significantly more likely to receive only a double-contrast barium enema ($p = 0.0079$), and younger individuals and individuals with fewer positive slides per array were more likely to receive only flexible sigmoidoscopy (age: $p = 0.0005$; number of positive slides: $p = 0.035$). Use of these procedures did not differ by patient sex and the use of barium enema alone did not differ significantly by number of positive slides per array ($p > 0.30$ in all cases).

The use of a repeat FOBT as the first follow-up test after a positive FOBT result decreased significantly from 28–31% in 1993–1996 to 6–11% in 2000–2005 ($p < 0.0001$, data not shown), and the use of a FOBT as the only follow-up test decreased from 17–19% to 3–5% in the same time period ($p < 0.0001$, Table 2). Use of a repeat FOBT decreased with increasing number of positive slides ($p < 0.0001$, Table 3). Older patients were more likely to

receive a repeat FOBT ($p=0.010$, Table 3), but we found no difference by sex ($p=0.83$, Table 3). Among the 1700 individuals who received a repeat FOBT as the first follow-up test, only 362 (21%) had a second positive result. Among those with a second positive FOBT, 69% went on to have a complete diagnostic evaluation within one year of the initial FOBT, compared to only 14% of those with a negative result on their second FOBT ($p<0.0001$).

From 1993–1996, 12–16% of individuals had no follow-up (Table 2). The rate of no follow-up decreased to 9–12% from 2000–2005 ($p<0.001$, Tables 2 and 3). Younger individuals and females were significantly more likely to have no follow-up (age: $p=0.0022$, gender: 0.016, Table 3).

Based on the 2005–2006 manual audit of 514 unique patients with a positive FOBT who had no diagnostic follow-up within four months, we found that diagnostic evaluation was considered unnecessary for 39% (*e.g.*, the patient had a normal colonoscopy within two years before the positive FOBT or had a definitive diagnosis of another source of gastrointestinal bleeding) and was contraindicated for 9% of individuals. An additional 16% of patients refused follow-up.

From the National Health Interview Survey, 118 participants reported having a positive FOBT between 2000 and 2005. Among these individuals, 58 (49%) reported having a colonoscopy or both flexible sigmoidoscopy and barium enema. This rate is increased to 52% when applying the survey weights.

Discussion

Incomplete diagnostic evaluation following a positive FOBT may result in delayed detection of colorectal cancer or a missed opportunity to prevent an adenoma from becoming cancer. Low rates of complete follow-up reduce the potential benefits of a screening program to decrease colorectal cancer incidence and mortality. We found evidence that simple tracking and audit systems and physician guidelines implemented by an integrated health care organization may have resulted in large improvements in the rates of complete diagnostic evaluation following a positive FOBT and may provide effective methods for maximizing the benefits of a screening program.

It is promising, and somewhat surprising, that a community-based health care organization was able to reach levels of complete follow-up comparable to those obtained in randomized trials.^{4,5} Volunteers for screening trials are typically better educated, wealthier, and healthier than the general population.^{20,21} Screening trials target healthier individuals in recruitment and may exclude participants with co-morbid conditions. In addition, trial investigators are highly motivated and employ resources to track individuals and encourage appropriate follow-up.

The observed improvements in health care quality are consistent with the Chronic Care Model, which states that optimizing outcomes requires that clinical teams are part of well designed delivery systems with clinical information systems, decision support, and self-management support systems.^{22–24} The implementation of tracking and audit systems, physician guidelines around screening, and patient education materials within the context of

an integrated multi-specialty group practice were essential steps toward realizing this level of improved quality. In a more traditional, and common, non-integrated clinical environment, abnormal FOBTs would be individually filed in paper charts, and would lead to a referral to a specialist for a diagnostic evaluation. However, if the specialist is not in the same group practice or does not share an information system with the referring physician, patients who do not follow-up cannot be easily identified and contacted. Few incentives exist to pursue this type of follow-up in a traditional fee for service environment and data of this type are rarely reported on a systematic basis. None of the common national quality tracking measures used for health plans or physicians measure the rate of follow-up for abnormal FOBT tests. Without aligned incentives, metrics, and transparency in reporting, it is unlikely that substantial improvements will occur. Small innovative practices that are motivated toward improvement could use clinical information systems to easily configure a similar tracking system with manual reconciliation.

Despite the high rates of complete diagnostic evaluation, opportunities exist for further improvement. In particular, our manual audit showed that 16% of patients who did not have a diagnostic evaluation of a positive FOBT were found to have refused follow-up care. Other researchers have reported similar refusal rates.¹⁴ Future studies should aim to increase understanding of reasons for patient refusal and develop interventions that educate patients about the importance of receiving diagnostic evaluation following a positive screening result.

A potential limitation of our study is the use of electronic medical records for identifying follow-up procedures. A previous study found that automated claims data were 100% specific for determining whether complete diagnostic evaluation had been performed following a positive FOBT.²⁵ Estimates based on electronic medical records may underestimate follow-up since examinations may be missing from automated databases (*e.g.*, a two-worker household may use two different insurance plans with overlapping coverage). In addition, we could not determine based on automated records whether the colonoscopy reached the cecum. Therefore, some of these “complete” evaluations may not have truly been complete. However, the rate of incomplete colonoscopy at Group Health from 2003–2006 was low (3%). Finally, we do not know whether the initial FOBT was used for screening purposes. Some tests may have been performed in symptomatic patients, who might be more motivated to undergo diagnostic evaluation. However, the positive predictive value for carcinoma found in our study population is similar to values reported for screening cohorts,^{18,26,27} suggesting most FOBTs were performed for screening purposes in asymptomatic individuals.

Our study has several strengths. Using electronic medical records facilitated the longitudinal tracking of many individuals over a 13 year period. This large number of subjects facilitated the examination of rates across subgroups, including by age and sex. In addition, we were able to include information before and after the release of screening guidelines and the implementation of the tracking and audit systems. Links to the SEER registry allowed us to exclude individuals with prior diagnosis of colorectal cancer, who were ineligible for screening.

In conclusion, adherence to guidelines for complete diagnostic evaluation following a positive FOBT has greatly improved over time in a large integrated health care organization. Rates of complete diagnostic evaluation in this organization were higher than the national average as determined from self-reports in the National Health Interview Survey, and higher than rates reported in previous studies of FOBT screening performed in a variety of populations and settings.^{10,11} With the use of tracking systems and physician guidelines, it may be possible to reach levels of follow-up in clinical settings that are comparable to those observed in randomized trials. Such strategies may enable health care organizations to maximize the potential benefit of a screening program in reducing colorectal cancer incidence and mortality.

Acknowledgments

National Cancer Institute U01 CA-97427 and U01 CA-97426 supported this work.

References

1. Howe HL, Wu X, Ries LA, et al. Annual report to the nation on the status of cancer, 1975–2003, featuring cancer among U.S. Hispanic/Latino populations. *Cancer*. 2006; 107:1711–42. [PubMed: 16958083]
2. Scholefield JH, Moss S, Sufi F, Mangham CM, Hardcastle JD. Effect of faecal occult blood screening on mortality from colorectal cancer: results from a randomised controlled trial. *Gut*. 2002; 50:840–4. [PubMed: 12010887]
3. Hewitson P, Glasziou P, Irwig L, Towler B, Watson E. Screening for colorectal cancer using the faecal occult blood test, Hemoccult. *Cochrane Database Syst Rev*. 2007:CD001216. [PubMed: 17253456]
4. Jorgensen OD, Kronborg O, Fenger C. A randomised study of screening for colorectal cancer using faecal occult blood testing: results after 13 years and seven biennial screening rounds. *Gut*. 2002; 50:29–32. [PubMed: 11772963]
5. Mandel JS, Church TR, Ederer F, Bond JH. Colorectal cancer mortality: effectiveness of biennial screening for fecal occult blood. *J Natl Cancer Inst*. 1999; 91:434–7. [PubMed: 10070942]
6. Winawer S, Fletcher R, Rex D, et al. Colorectal cancer screening and surveillance: clinical guidelines and rationale-Update based on new evidence. *Gastroenterology*. 2003; 124:544–60. [PubMed: 12557158]
7. US Preventive Services Task Force. *AHRQ*; 2002.
8. Smith RA, Cokkinides V, Eyre HJ. Cancer screening in the United States, 2007: a review of current guidelines, practices, and prospects. *CA Cancer J Clin*. 2007; 57:90–104. [PubMed: 17392386]
9. Winawer SJ, Fletcher RH, Miller L, et al. Colorectal cancer screening: clinical guidelines and rationale. *Gastroenterology*. 1997; 112:594–642. [PubMed: 9024315]
10. Fisher DA, Jeffreys A, Coffman CJ, Fasanella K. Barriers to full colon evaluation for a positive fecal occult blood test. *Cancer Epidemiol Biomarkers Prev*. 2006; 15:1232–5. [PubMed: 16775188]
11. Myers RE, Turner B, Weinberg D, et al. Impact of a physician-oriented intervention on follow-up in colorectal cancer screening. *Prev Med*. 2004; 38:375–81. [PubMed: 15020170]
12. Etzioni DA, Yano EM, Rubenstein LV, et al. Measuring the quality of colorectal cancer screening: the importance of follow-up. *Dis Colon Rectum*. 2006; 49:1002–10. [PubMed: 16673056]
13. Garman KS, Jeffreys A, Coffman C, Fisher DA. Colorectal cancer screening, comorbidity, and follow-up in elderly patients. *Am J Med Sci*. 2006; 332:159–63. [PubMed: 17031239]
14. Baig N, Myers RE, Turner BJ, et al. Physician-reported reasons for limited follow-up of patients with a positive fecal occult blood test screening result. *Am J Gastroenterol*. 2003; 98:2078–81. [PubMed: 14499791]

15. Ko CW, Dominitz JA, Nguyen TD. Fecal occult blood testing in a general medical clinic: comparison between guaiac-based and immunochemical-based tests. *Am J Med.* 2003; 115:111–4. [PubMed: 12893396]
16. Shields HM, Weiner MS, Henry DR, et al. Factors that influence the decision to do an adequate evaluation of a patient with a positive stool for occult blood. *Am J Gastroenterol.* 2001; 96:196–203. [PubMed: 11197252]
17. Lurie JD, Welch HG. Diagnostic testing following fecal occult blood screening in the elderly. *J Natl Cancer Inst.* 1999; 91:1641–6. [PubMed: 10511591]
18. Levin B, Hess K, Johnson C. Screening for colorectal cancer. A comparison of 3 fecal occult blood tests. *Arch Intern Med.* 1997; 157:970–6. [PubMed: 9140267]
19. Myers RE, Balshem AM, Wolf TA, Ross EA, Millner L. Screening for colorectal neoplasia: physicians' adherence to complete diagnostic evaluation. *Am J Public Health.* 1993; 83:1620–2. [PubMed: 8238690]
20. Pinsky PF, Miller A, Kramer BS, et al. Evidence of a healthy volunteer effect in the prostate, lung, colorectal, and ovarian cancer screening trial. *Am J Epidemiol.* 2007; 165:874–81. [PubMed: 17244633]
21. Ederer F, Church TR, Mandel JS. Sample sizes for prevention trials have been too small. *Am J Epidemiol.* 1993; 137:787–96. [PubMed: 8484370]
22. Glasgow RE, Orleans CT, Wagner EH. Does the chronic care model serve also as a template for improving prevention? *Milbank Q.* 2001; 79:579–612. iv–v. [PubMed: 11789118]
23. Bodenheimer T, Wagner EH, Grumbach K. Improving primary care for patients with chronic illness. *JAMA.* 2002; 288:1775–9. [PubMed: 12365965]
24. Bodenheimer T, Wagner EH, Grumbach K. Improving primary care for patients with chronic illness: the chronic care model, Part 2. *JAMA.* 2002; 288:1909–14. [PubMed: 12377092]
25. Myers RE, Fishbein G, Hyslop T, et al. Measuring complete diagnostic evaluation in colorectal cancer screening. *Cancer Detect Prev.* 2001; 25:174–82. [PubMed: 11341353]
26. Allison JE, Tekawa IS, Ransom LJ, Adrain AL. Improving the fecal occult-blood test. *N Engl J Med.* 1996; 334:1607–8. [PubMed: 8628349]
27. Morris JB, Stellato TA, Guy BB, Gordon NH, Berger NA. A critical analysis of the largest reported mass fecal occult blood screening program in the United States. *Am J Surg.* 1991; 161:101–5. discussion 105–6. [PubMed: 1987842]

Figure 1.

Percentage of positive FOBTs with complete diagnostic evaluation by year of initial positive fecal occult blood test and (a) number of positive slides per array, (b) gender, and (c) age.

Table 1

Positive predictive value (PPV) for colorectal cancer and 95% confidence intervals (CI) among all positive fecal occult blood tests (FOBTs) and among those tests followed by complete diagnostic evaluation.

	Positive FOBTs (N)	Cancers (N)	PPV (95% CI)	PPV among those with complete diagnostic evaluation (95% CI)
Age (years)				
50–59	3044	117	3.8% (3.2%, 4.6%)	5.4% (4.5%, 6.4%)
60–69	2783	156	5.6% (4.8%, 6.5%)	7.8% (6.6%, 9.0%)
70–79	2686	209	7.6% (6.8%, 8.9%)	11.1% (9.7%, 12.6%)
Positive slides per array (N)				
1	5250	114	2.8% (2.4%, 3.3%)	4.0 (3.4%, 4.7%)
2	1808	108	6.2% (5.1%, 7.4%)	8.3% (6.9%, 10.0%)
3	1455	232	15.3% (13.5%, 17.3%)	20.3% (18.0%, 22.8%)
Total	8513	482	5.7% (5.2%, 6.2%)	7.9% (7.3%, 8.6%)

Table 2

Type of follow-up within one year of a positive FOBT

Year	Positive FOBT (N)	Colonoscopy (%)	Double-contrast barium enema + flexible sigmoidoscopy (%)	Flexible sigmoidoscopy only (%)	Double-contrast barium enema only (%)	Repeat FOBT only (%)	No follow-up (%)
1993	972	44%	13%	6%	4%	18%	14%
1994	933	49%	10%	4%	4%	19%	13%
1995	855	59%	5%	3%	2%	19%	12%
1996	895	54%	5%	3%	3%	17%	16%
1997	692	61%	4%	5%	1%	14%	14%
1998	637	65%	6%	4%	1%	14%	8%
1999	690	74%	4%	3%	1%	6%	11%
2000	549	81%	1%	2%	0%	5%	9%
2001	559	81%	1%	2%	1%	4%	11%
2002	475	83%	0%	2%	0%	3%	12%
2003	490	86%	1%	1%	0%	3%	9%
2004	407	83%	0%	1%	0%	3%	12%
2005	359	82%	0%	2%	0%	4%	11%

An additional 0.2–1.1% of enrollees per year had colorectal cancer diagnosis within 365 days of the positive FOBT but no evidence in the automated records of colonoscopy or flexible sigmoidoscopy with double-contrast barium enema. These individuals were counted as having a complete diagnostic follow-up.

1993–1996: period prior to release of formal screening guidelines and tracking systems.

1997–1999: release of formal guidelines and implementation of tracking systems.

2000–2005: period after release of formal guidelines and tracking systems.

Table 3

Adjusted odds ratios and 95% confidence intervals from multivariable logistic regression models examining predictors of follow-up type following a positive FOBT.

Covariate	Complete diagnostic evaluation	Outcome variable: follow-up type			
		Flexible sigmoidoscopy only	Double contrast barium enema only	Repeat FOBT	No follow-up
Year (1 year increase)	1.17 (1.15, 1.18)	0.88 (0.85, 0.91)	0.74 (0.69, 0.79)	0.84 (0.82, 0.85)	0.96 (0.94, 0.98)
Number of positive slides per array					
1	0.67 (0.58, 0.76)	1.59 (1.11, 2.33)	0.80 (0.54, 1.23)	1.45 (1.25, 1.70)	1.09 (0.91, 1.31)
2	0.89 (0.76, 1.05)	1.48 (0.98, 2.28)	0.79 (0.48, 1.31)	1.01 (0.84, 1.22)	1.00 (0.81, 1.25)
3 (reference group)					
Female gender	0.89 (0.81, 0.98)	1.13 (0.89, 1.43)	0.88 (0.63, 1.22)	1.01 (0.91, 1.13)	1.18 (1.03, 1.34)
Age (10 year increase)	1.05 (0.99, 1.11)	0.78 (0.68, 0.90)	1.30 (1.07, 1.60)	1.09 (1.02, 1.16)	0.89 (0.82, 0.96)