A Systematic Review of Repeat Fecal Occult Blood Tests for Colorectal Cancer Screening

Caitlin C. Murphy[1,2], Ahana Sen[3], Bianca Watson[4], Samir Gupta[5], Helen Mayo[6], and Amit G. Singal[2,3]

ABSTRACT

Screening with fecal occult blood tests (FOBT) reduces colorectal cancer mortality. Failure to complete repeat tests may compromise screening effectiveness. We conducted a systematic review of repeat FOBT across diverse health care settings. We searched MEDLINE, Embase, and the Cochrane Library for studies published from 1997 to 2017 and reported repeat FOBT over ≥2 screening rounds. Studies ($n = 27$ reported in 35 articles) measured repeat FOBT as (i) proportion of Round 1 participants completing repeat FOBT in Round 2; (ii) proportion completing two, consecutive FOBT; or (iii) proportion completing ≥3 rounds. Among those who completed FOBT in Round 1, 24.6% to 89.6% completed repeat FOBT in Round 2 [median: 82.0%; interquartile range (IQR): 73.7%–84.6%]. The proportion completing FOBT in two rounds ranged from 16.4% to 80.0% (median: 46.6%; IQR: 40.5%–50.0%), and in studies examining ≥3 rounds, repeat FOBT ranged from 0.8% to 64.1% (median: 39.2%; IQR: 19.7%–49.4%). Repeat FOBT appeared higher in mailed outreach (69.1%–89.6%) compared with opportunistic screening (24.6%–48.6%). Few studies examined correlates of repeat FOBT. In summary, we observed a wide prevalence of repeat FOBT, and prevalence generally declined in successive screening rounds. Interventions that increase and maintain participation in FOBT are needed to optimize effectiveness of this screening strategy.

Introduction

Colorectal cancer incidence and mortality has declined in the United States since the late 1980s (1), largely due to increasing uptake of screening (2, 3). Guidelines recommend screening with colonoscopy, sigmoidoscopy, fecal occult blood test with high-sensitivity guaiac (gFOBT), or fecal immunochemical test (FIT) starting at age 50 for average-risk adults (4). gFOBT and FIT (hereafter collectively referred to as "FOBT") have become increasingly common in population-based screening programs in Europe (5), as well as large U.S. health care systems implementing mailed outreach (6, 7). FOBT also plays a critical role in colorectal cancer screening for underserved or rural populations (8, 9), where access to colonoscopy may be limited (10).

Stool-based screening strategies rely on patients completing regular, on-schedule tests (11–13), and failure to complete repeat exams may compromise effectiveness (14). Most European countries, Canada, and Australia recommend stool-based screening every two years, while annual screening is recommended in the United States and Asian countries (15). Compared with the 80%–85% of participants in randomized trials of screening efficacy completing two or more exams (11–13), repeat FOBT in clinical practice settings may be very low or vary widely (16). Repeat FOBT in clinical practice is also complex because it involves reassessing eligibility, considering recommended intervals (annual vs. biennial), and identifying patients due for screening at each round.

Few have characterized repeat FOBT patterns in real-world settings, particularly in light of the growing number of health care systems transitioning to stool-based screening strategies (17) for population health. To address this gap, we conducted a systematic review of the literature to estimate prevalence of repeat FOBT across diverse health care settings and populations.

Materials and Methods

Data sources and searches

We conducted all search methods according to the Preferred Reporting of Systematic Reviews and Meta-Analysis (PRISMA) Statement guidelines (18). With the assistance of a health sciences librarian, we searched MEDLINE (via Ovid; 1997 to September Week 4 2017, in-process and other nonindexed citations September 28, 2017 and Epub ahead of print September 28, 2017, searched September 29, 2017), Embase (via Ovid; 1997 to September Week 4, searched September 29, 2017), and the Cochrane Library (via Wiley; Cochrane Database of Systematic Reviews and Cochrane Central Register of Controlled Trials, Issue 9 of 12 September 2017, searched September 29, 2017) for articles published between 1997 and 2017. General concepts that comprised the search included: colorectal cancer, mass screening, screening program, and patient adherence. We adapted search terms for each database's unique keywords and subject headings; strategies were pretested and refined through an iterative process by screening citations for relevance to our eligibility criteria. Search strategies for each database are listed as Supplementary Material. We also hand searched reference lists from eligible articles and Scopus (via Elsevier) to determine whether eligible articles had been cited by others not identified by our search strategy.

Study selection

We considered articles eligible if they: (i) were written in English; (ii) reported data from a primary study (i.e., not a review, commentary, or

[1]Department of Population and Data Sciences, UT Southwestern Medical Center, Dallas, Texas. [2]Harold C. Simmons Comprehensive Cancer Center, UT Southwestern Medical Center, Dallas, Texas. [3]Department of Internal Medicine, UT Southwestern Medical Center, Dallas, Texas. [4]Department of Psychiatry and Behavioral Sciences, Tulane School of Medicine, New Orleans, Louisiana. [5]Veterans Affairs San Diego Healthcare System, UC San Diego, San Diego, California. [6]Health Sciences Digital Library and Learning Center, UT Southwestern Medical Center, Dallas Texas.

Note: Supplementary data for this article are available at Cancer Epidemiology, Biomarkers & Prevention Online (http://cebp.aacrjournals.org/).

Corresponding Author: Caitlin C. Murphy, University of Texas Southwestern Medical Center, 5323 Harry Hines Boulevard, Dallas, TX 75390. Phone: 214-648-9551; Fax: 214-648-3934; E-mail: Caitlin.Murphy@UTSouthwestern.edu

Cancer Epidemiol Biomarkers Prev 2020;29:278–87

doi: 10.1158/1055-9965.EPI-19-0775

Table 1. Definition of repeat FOBT outcomes across studies.

Outcome	Screening rounds	Numerator	Denominator	Key example
Proportion of Round 1 participants who completed repeat FOBT in Round 2	2	Completed FOBT in Round 2	Completed FOBT with negative result in Round 1	Baker, 2015 (26)
Proportion of patients who completed two, consecutive FOBT	2	Completed consecutive FOBT in Rounds 1 and 2	Eligible to complete FOBT in two screening rounds; negative result or did not complete FOBT in Round 1	Singal, 2018 (20)
Proportion of patients who completed FOBT in all screening rounds	≥3	Completed FOBT in all screening rounds	Eligible to complete FOBT in three or more screening rounds; negative result or did not complete FOBT in all but final round	Denis, 2015 (48)

editorial); and (iii); measured repeat FOBT over at least two screening rounds. We focused on studies conducted in average-risk populations (e.g., no personal history of inflammatory bowel disease, colorectal cancer, hereditary syndromes, or polyps/adenomas, no family history of colorectal cancer or polyps/adenomas), for whom guidelines at the time recommended initiating screening with FIT or gFOBT at age 50 years (19). To best characterize repeat FOBT in real-world settings, we excluded trials of screening efficacy or intervention studies requiring informed patient consent. We also excluded studies in which the primary outcome was test performance (i.e., sensitivity and specificity).

We screened articles in a multistep process. First, two authors (A. Sen and B. Watson) independently reviewed the titles and abstracts of all articles identified by the search strategy, assigning a rating of "not eligible" or "potentially eligible" for inclusion. A third author (C.C. Murphy) reviewed the title and abstracts of all "potentially eligible" abstracts. Discrepancies in "potentially eligible" ratings across co-authors occurred in fewer than 5% of all abstracts reviewed; all discrepancies were discussed until consensus was reached. Finally, two authors independently evaluated full-text articles of all "potentially eligible" abstracts.

In cases where eligible articles reported data from the same or overlapping patient cohorts, we selected the most recently published article or the article with the most complete data. For example, we identified three articles of overlapping cohorts in the Kaiser Permanente health care system (6, 20, 21), and we report results from the most recent of the three articles (20).

Data extraction and quality assessment

Using an abstraction form created for this review, two authors (A. Sen and B. Watson) extracted relevant information from all eligible articles, including: study setting, sample size, eligibility criteria, and outcome measures. A third author (C.C. Murphy) was available to resolve any discrepancies between the two sets of extracted data. Discrepancies in coding occurred in <5% of all studies and were adjudicated through discussion until consensus was reached across the three co-authors.

Repeat FOBT and relevant outcomes were reported in a variety of ways (e.g., completion of all screening rounds, completion of subsequent screening rounds) across studies. The considerable heterogeneity between studies (I^2 = 99%) precluded the use of meta-analysis to aggregate effect sizes of repeat FOBT. Therefore, we used reported numbers to manually calculate repeat FOBT as the: (i) proportion of Round 1 participants who completed repeat FOBT in Round 2; (ii) proportion of patients who completed two, consecutive FOBT; or (iii) proportion of patients who completed FOBT in three or more screening rounds (**Table 1**). When possible, we excluded from our calculation patients with a positive index test, prior colonoscopy, or prior sigmoidoscopy and who would therefore be ineligible for repeat FOBT.

Using the STROBE checklist (22), two authors (A.G. Singal and C.C. Murphy) assessed completeness of reporting on nine selected aspects of internal and external validity related to representativeness, intervention, outcome ascertainment, follow-up period, and eligibility criteria. Each characteristic was assigned a rating (23, 24) of "Y, reported by authors," "N, not reported by authors," or "I, inferred by raters but not explicitly reported by authors." We resolved any discrepancies in rating by discussion until consensus was reached.

There was considerable heterogeneity between studies (I2), and the wide-ranging prevalence estimates precluded the use of meta-analysis to aggregate effect sizes of repeat FOBT.

Results

Study selection and patient characteristics

Our search strategy identified 6,258 potentially eligible articles, of which we reviewed the full text of 312 (see Supplementary Fig. S1 for PRISMA flow diagram). Common reasons for exclusion included evaluating screening performance or efficacy and requiring patient consent. From the full-text review, we identified 35 articles that met inclusion criteria, representing 27 unique studies. As described above, for the eight articles reporting overlapping cohorts, we selected the most recently published article or the article with the most complete data.

Study characteristics are shown in **Table 2**. Studies were conducted in Europe (n = 12), United States (n = 8), Asia (n = 2), Australia (n = 3), and Canada (n = 2) and represented a variety of health care systems (59.3% mailed, population-based screening outreach, 18.5% mailed outreach in integrated systems, and 25.9% opportunistic screening). Most studies measured repeat FOBT using government health plan or population registry data (n = 17, 63.0%), while others used electronic health records (n = 9, 33.3%). Only one study (25) relied on patient self-report. Studies examined repeat FOBT over a range of 2 to 5 screening rounds. About half (n = 13, 48.1%) of the studies evaluated repeat FOBT across three or more screening rounds, and the remaining studies (n = 14, 51.9%) evaluated repeat FOBT in only two rounds.

Table 2. Characteristics of included studies ($n = 27$ unique studies reported in 35 articles).

Author, year	Study setting	Eligibility criteria	Sample size	FOBT/FIT	Screening delivery
Tazi, 1997 (40)	Burgundy, France 1988–1996	Age 45–74 years	45,642	Biennial	Mailed outreach Population-based
Weller, 2007 (39)	UK Colorectal Cancer Screening Pilot Evaluation, England 2000–2004	Age 50–69 years; completed negative index test	107,434	Biennial Hema-screen	Mailed outreach Population-based
Fenton, 2010 (16)	Group Health Cooperative, Seattle, WA 2000–2003	Age 52–78 years; completed negative index test; continuously enrolled in health plan	10,132	Biennial Hemoccult II SENSA	Opportunistic
Janda, 2010 (38)	Queensland, Australia 2000–2002	Age 50–74 years; completed negative index test Excluded hx SIG or COL	3,406	Biennial	Mailed outreach Population-based
Gellad, 2011 (51)	Veterans Health Administration (136 sites), USA 1999–2005	Age 50–75 years Excluded hx SIG, COL, or colorectal cancer	394,996	Annual	Opportunistic
Cole, 2012 (27)	National Bowel Cancer Screening Pilot Program, Australia 2003–2005	Age 55–74 years	16,433	Annual Detect	Mailed outreach Population-based
Crotta, 2012 (50)	Aosta Valley, Italy 2001–2008	Age 50–74 years Excluded hx SIG, COL, IBD, polyps, colorectal cancer, or severe comorbid conditions	2,959	Biennial OC-Sensor	Mailed outreach Population-based
Garcia, 2012 (37)	Catalonia, Spain 2004–2006	Age 50–69 years; completed negative index test	11,969	Biennial	Mailed outreach Population-based
Liss, 2013 (35)	Erie Family FQHC, Chicago, IL 2010–2011	Age 50–74 years; completed negative index test Excluded hx SIG, COL, IBD, colorectal cancer, or lower GI symptoms	281	Annual	Opportunistic
Bae, 2014 (25)	University Hospital at Gangdong, South Korea 2002–2011	Age $\geq$50 years; completed $\geq$1 FOBT in prior decade; completed baseline survey	237	Biennial	Opportunistic
Baker, 2014 (36)	Erie Family FQHC, Chicago, IL 2010–2011	Age 51–75 years; completed negative index test Excluded hx SIG, COL, IBD, or lower GI symptoms	225	Annual OC-Light	Opportunistic
Baker, 2014 (36)	Erie Family FQHC, Chicago, IL 2010–2011	Age 51–75 years; completed negative index test Excluded hx SIG, COL, IBD, or lower GI symptoms	225	Annual OC-Light	Mailed outreach
Duncan, 2014 (49)	Bowel Health Service, Australia 2008–2010	Age 50–75 years; completed baseline survey Excluded hx SIG, COL, IBD, or colorectal cancer, family hx colorectal cancer	1,540	Annual OC-Sensor	Mailed outreach Population-based
McNamara, 2014 (28)	Tallaght Hospital-Trinity College Colorectal Cancer Screening Program, Ireland 2008–2012	Age 50–75 years Excluded hx COL, serious illness, or colorectal cancer	9,863	Biennial OC-Sensor	Mailed outreach
Steele, 2014 (34)	UK Colorectal Cancer Screening Pilot Evaluation, Scotland 2000–2006	Age 50–69 years	251,578	Biennial Hema-screen	Mailed outreach Population-based
Wong, 2014 (30); Wong, 2013 (31)	Hong Kong 2008–2012	Age 50–70 years Excluded hx SIG, COL, IBD, colorectal cancer, or lower GI symptoms	5,832	Annual Hemosure	Mailed outreach Population-based
Baker, 2015 (26)	Erie Family FQHC, Chicago, IL 2012–2013	Age 51–75 years; completed negative index test Excluded hx SIG, COL, or colorectal cancer in Round 1	225	Annual OC-Light	Mailed outreach

(Continued on the following page)

Table 2. Characteristics of included studies ($n = 27$ unique studies reported in 35 articles). (Cont'd)

Author, year	Study setting	Eligibility criteria	Sample size	FOBT/FIT	Screening delivery
Bujanda, 2015 (33)	Basque, Spain 2009–2013	Age 50–69 years; completed negative index test Excluded hx SIG, COL, IBD, or colorectal cancer, family hx colorectal cancer	100,135	Biennial OC-Sensor	Mailed outreach Population-based
Denis, 2015 (48); Pornet, 2014 (52)	Haut-Rhin, France 2003–2012	Age 50–74 years Excluded hx of SIG, COL, serious illness, or high-risk colorectal cancer features	242,271	Biennial Hemoccult II	Mailed outreach Population-based
Lo, 2015 (29); Lo, 2016 (72); Lo, 2015 (73)	NHS Bowel Cancer Screening Program, England 2006–2012	Age 60–64 years	62,099	Biennial Hema-screen	Mailed outreach Population-based
Schlichting, 2015 (32)	Veterans Health Administration, Iowa City, IA 2011–2013	Age <65 years; completed negative index test Excluded self-reported screen up-to-date	159	Annual OC FIT-CHEK	Mailed outreach
Paszat, 2016 (43)	ColonCancerCheck Program, Ontario, Canada 2008–2012	Age 50–74 years; completed negative index test Excluded hx SIG, COL, or colorectal cancer, family hx colorectal cancer	294,329	Biennial Hema-Screen	Opportunistic
Telford, 2016 (42)	Colon Check Program, British Columbia, Canada 2009–2013	Age 50–74 Excluded hx SIG, COL, colorectal cancer, IBD, or rectal bleeding	16,234	Biennial OC-Auto Micro	Mailed outreach Population-based
Knudsen, 2017 (41)	Bowel Cancer Screening in Norway, Southeast Norway 2012–2016	Age 50–74 years; completed negative index test; completed lifestyle survey Excluded hx SIG, COL, or colorectal cancer	3,114	Biennial	Mailed outreach Population-based
Saraste, 2017 (45)	Stockholm-Gotland Region, Sweden 2008–2015	Age 60–69 years; invited to ≥3 screening rounds	48,959	Biennial Hemoccult	Mailed outreach Population-based
Singal, 2017 (47)	Parkland Health & Hospital System, Dallas, TX 2013–2016	Age 50–64 years; not up-to-date with screening Excluded hx SIG, COL, colorectal cancer, or IBD	1,199	Annual Hemoccult ICT	Opportunistic
Singal, 2017 (47)	Parkland Health & Hospital System, Dallas, TX 2013–2016	Age 50–64 years; not up-to-date with screening Excluded hx SIG, COL, colorectal cancer, or IBD	2,400	Annual FIT-CHEK	Mailed outreach
van der Vlugt, 2017 (47); Denters, 2013 (74); Grobbee, 2017 (75)	Southwest and Northwest Netherlands 2006–2014	Age 50–74 years; eligible for ≥2 screening rounds Excluded hx SIG, COL, IBD, colorectal cancer, or severe comorbid conditions	17,132	Biennial OC-Sensor	Mailed outreach Population-based
Singal, 2018 (20); Jensen, 2016 (6); Gordon, 2015 (21)	Parkland Health & Hospital System, Dallas, TX; Kaiser Permanente Washington, Seattle, WA; Kaiser Permanente Northern and Southern California 2010–2013	Age 50–71 years; completed negative index test; 2–3 years follow-up Excluded hx SIG, COL, or colorectal cancer	273,182	Varied across sites	Varied across sites
Singal, 2018 (20); Jensen, 2016 (6); Gordon, 2015 (21)	Parkland Health & Hospital System, Dallas, TX; Kaiser Permanente Washington, Seattle, WA; Kaiser Permanente Northern and Southern California 2010–2013	Age 50–71 years; completed negative index test; ≥3 years follow-up Excluded hx SIG, COL, or colorectal cancer	344,103	Varied across sites	Varied across sites

Abbreviations: COL, colonoscopy; GI, gastrointestinal; hx, history; IBD, irritable bowel disease; SIG, sigmoidoscopy.

Table 3. Prevalence of repeat FOBT across studies ($n = 27$ unique studies reported in 35 articles) by screening delivery.

Author, year	Data source	Screening rounds	Relevant outcome	Sample size	Prevalence (95% CI)
Mailed outreach, population-based					
Tazi, 1997 (40)	Population registry	5	% completed among Round 1 participants	36,573/43,852	83.4% (83.1%–83.7%)
			% completed across all screening rounds	13,951/37,502	37.2% (36.7%–37.7%)
Weller, 2007 (39)	Government health plan	2	% completed among Round 1 participants	87,129/107,434	81.1% (80.9%–81.3%)
Janda, 2010 (38)	Population registry	2	% completed among Round 1 participants	874/1,163	75.2% (72.7%–77.6%)
			% completed two, consecutive tests	874/3,406	25.7% (24.2%–27.1%)
Cole, 2012 (27)	Government health plan	2	% completed among Round 1 participants	6,656/8,345	79.8% (78.9%–80.6%)
			% completed two, consecutive tests	6,656/16,433	40.5% (39.8%–41.3%)
Crotta, 2012 (50)	Population registry	4	% completed across all screening rounds	713/2,109	33.8% (31.8%–35.8%)
Garcia, 2012 (37)	Population registry	2	% completed among Round 1 participants	10,415/11,969	87.0% (86.4%–87.6%)
			% completed two, consecutive tests	10,415/63,685	16.4% (16.1%–16.6%)
Duncan, 2014 (49)	Government health plan	3	% completed across all screening rounds	860/1,540	55.8% (53.4%–58.3%)
Steele, 2014 (34)	Government health plan	3	% completed among Round 1 participants	114,063/139,274	81.9% (81.7%–82.1%)
			% completed two, consecutive tests	114,063/251,578	45.3% (45.1%–45.5%)
			% completed across all screening rounds	98,494/251,578	39.2% (39.0%–39.3%)
Denis, 2015 (48); Pornet, 2014 (52)	Government health plan	4	% completed across all screening rounds	34,556/242,271	14.3% (14.1%–14.4%)
Wong, 2014 (30); Wong, 2013 (31)	Government health plan	3	% completed among Round 1 participants	4,426/5,391	82.1% (81.1%–83.1%)
			% completed two, consecutive tests	4,426/5,534	80.0% (78.9%–81.0%)
			% completed across all screening rounds	3,519/5,488	64.1% (62.9%–65.4%)
Bujanda, 2015 (33)	Government health plan	2	% completed among Round 1 participants	69,193/100,135	69.1% (68.8%–69.4%)
Lo, 2015 (29); Lo, 2016 (72); Lo, 2015 (73)	Government health plan	3	% completed among Round 1 participants	30,182/35,611	84.8% (84.4%–85.1%)
			% completed two, consecutive tests	30,182/62,099	48.6% (48.2%–49.0%)
			% completed across all screening rounds	27,587/62,099	44.4% (44.0%–44.8%)
Telford, 2016 (42)	Population registry	2	% completed among Round 1 participants	5,378/6,255	86.0% (85.1%–86.8%)
Knudsen, 2017 (41)	Population registry	2	% completed among Round 1 participants	2,574/3,114	82.7% (81.3%–84.0%)
Saraste, 2017 (45)	Population registry	3	% completed among Round 1 participants	26,098/29,113	89.6% (89.3%–90.0%)
			% completed two, consecutive tests	26,098/48,959	53.3% (52.9%–53.7%)
			% completed across all screening rounds	24,373/48,959	49.8% (49.3%–50.2%)
van der Vlugt, 2017 (47); Denters, 2013 (74); Grobbee, 2017 (75)	Population registry	4	% completed two, consecutive tests	2,561/5,232	48.9% (47.6%–50.3%)
			% completed across all screening rounds	4,345/8,795	49.4% (48.4%–50.4%)
			% completed in 3 of 3 screening rounds	1,365/3,285	41.6% (39.9%–43.2%)
Mailed outreach, integrated health care systems					
Baker (intervention), 2014 (36)	EHR	2	% completed among Round 1 participants	185/219	84.5% (79.7%–89.3%)
McNamara, 2014 (28)	EHR	2	% completed among Round 1 participants	3,767/4,549	82.8% (81.7%–83.9%)
			% completed two, consecutive tests	3,767/9,359	40.3% (39.3%–41.2%)
Baker, 2015 (26)	EHR	2	% completed among Round 1 participants	114/129	88.4% (82.8%–93.9%)
			% completed two, consecutive tests	114/189	60.3% (53.3%–67.3%)

(Continued on the following page)

Table 3. Prevalence of repeat FOBT across studies ($n = 27$ unique studies reported in 35 articles) by screening delivery. (Cont'd)

Author, year	Data source	Screening rounds	Relevant outcome	Sample size	Prevalence (95% CI)
Schlichting, 2015 (32)	EHR	2	% completed among Round 1 participants	126/159	79.2% (72.9%–85.5%)
Singal (intervention), 2017 (47)	EHR	3	% completed across all screening rounds	395/2,007	19.7% (17.9%–21.4%)
Opportunistic					
Fenton, 2010 (16)	EHR	2	% completed among Round 1 participants	4,928/10,132	48.6% (47.7%–49.6%)
Gellad, 2011 (51)	EHR	5	% completed in 4 of 5 screening rounds	55,652/394,996	14.1% (14.0%–14.2%)
Liss, 2013 (35)	EHR	2	% completed among Round 1 participants	69/281	24.6% (19.5%–29.6%)
Bae, 2014 (25)	Self-report	5	% completed across all screening rounds	105/237	44.3% (38.0%–50.6%)
Baker (usual care), 2014 (36)	EHR	2	% completed among Round 1 participants	84/219	38.3% (31.9%–44.8%)
Paszat, 2016 (43)	Government health plan	2	% completed among Round 1 participants	101,526/294,329	34.5% (34.3%–34.7%)
Singal (usual care), 2017 (47)	EHR	3	% completed across all screening rounds	8/1,044	0.8% (0.2%–1.3%)
Varied					
Singal, 2018 (20); Jensen, 2016 (6); Gordon, 2015 (21)	EHR	2	% completed two, consecutive tests	127,188/273,182	46.6% (46.4%–46.7%)
Singal, 2018 (20); Jensen, 2016 (6); Gordon, 2015 (21)	EHR	3	% completed two, consecutive tests	160,252/344,103	46.6% (46.4%–46.7%)

Note: For studies with three or more screening rounds (e.g., Saraste, 2017; ref. 45), the outcome describing completion of two, consecutive tests corresponds to FOBT completion in the first two screening rounds (i.e., in Rounds 1 and 2); confidence intervals estimated using Wald method based on a normal approximation.
Abbreviation: EHR, electronic health records.

Prevalence of repeat FOBT

Prevalence of repeat FOBT is described in **Table 3**. Among those who completed FOBT in Round 1, 24.6%–89.6% [median: 82.0%, interquartile range (IQR): 73.7%–84.6%] completed repeat FOBT in Round 2 (16, 26–43). Repeat FOBT appeared higher in mailed outreach programs (26–30, 32, 33, 36–42, 44–46) compared with opportunistic screening (Supplementary Fig. S2; refs. 16, 35, 36, 43). Specifically, the proportion of Round 1 participants who completed repeat FOBT in Round 2 ranged from 69.1% to 89.6% in studies with mailed outreach, whereas repeat FOBT was less than 50% in studies with opportunistic screening. Notably, two pragmatic, randomized controlled trials (36, 47) compared mailed outreach to opportunistic screening in low-income settings. In both trials, a higher proportion of patients randomized to mailed outreach completed repeat FOBT in Round 2 (82.2% vs. 37.3%; ref. 36) and across all screening rounds (30.8% vs. 2.3%; ref. 47) compared with opportunistic screening. There appeared to be only small differences in repeat FOBT in studies with annual (range 34.5%–89.6%) versus biennial (range 24.6%–88.4%) screening (Supplementary Fig. S3), and in studies of FIT versus gFOBT (Supplementary Fig. S4).

The proportion of patients who completed two, consecutive FOBT varied widely across studies, ranging from 16.4% to 80.0% (median: 46.6%, IQR: 40.5%–50.0%; refs. 20, 26–30, 34, 37, 38, 45, 47). Most studies reported repeat FOBT between 40% and 60%. Notable outliers were studies by Garcia and Janda (both <20% completion) and Wong (>80% completion).

Repeat FOBT across all screening rounds also varied, ranging from 0.8% to 64.1% (median: 39.2%, IQR: 19.7%–49.4%; refs. 20, 25, 29, 30, 34, 40, 45–50). Prevalence generally decreased across screening rounds. For example, Gellad and colleagues (51) reported 42.1%, 26.0%, 17.8%, and 14.1% completed one, two, three, and four tests, respectively, over five rounds of screening. Similarly, Pornet and colleagues (52) identified a greater proportion of never (33.6%) or occasional participants (27.7%)—those who completed no or one test over three screening rounds—than consistent participants (38.8%).

Completeness of reporting

Supplementary Table S1 describes the completeness of reporting of each included study. All or the majority of studies described test type, defined repeat FOBT, and used electronic health records (EHR) or registry data to ascertain the outcome. We identified eight studies (6, 20, 21, 25, 35, 37, 38, 40, 41, 47, 51) that did not report type of FOBT, and the study by Bae and colleagues (25) assessed repeat FOBT by patient self-report. Studies were more variable with respect to reporting the number of patients eligible in each screening round or the number who were lost to follow-up, were diagnosed with colorectal cancer or died, or received colonoscopy. Although all studies included patients who were age-eligible for screening (i.e., age 50–75 years), fewer studies made an attempt to exclude patients at higher risk (e.g., family history of colorectal cancer). Some studies (25, 30, 41, 49) required patients to complete a brief questionnaire as part of inclusion criteria.

Discussion

Success of stool-based screening relies on patients completing regular, on-schedule screening, every one to two years. Studies included in our review report a wide range of repeat FOBT—between 14% and 90%—and prevalence generally declined across successive

screening rounds. Our synthesis of data across studies highlight two key challenges: (i) ensuring patients initiate and repeat FOBT consistently as part of stool-based screening strategies; and (ii) increasing the already substantial prevalence of repeat FOBT among patients who have previously initiated screening. As such, interventions that maintain consistent participation in FOBT are needed to optimize the effectiveness of this colorectal cancer screening strategy. Our findings also point to a number of areas for future research and the need for more transparent results reporting.

Although tightly controlled screening efficacy trials report up to 85% of trial participants complete two or more tests, we observed varying prevalence of repeat FOBT across real-world settings. The wide variation in repeat FOBT across studies included in our review underscores potential differences in data collection and quality and highlights the need for better summary measures. Reasons for such wide-ranging prevalence estimates may be related to a variety of factors, including test type and frequency, screening delivery, and intensity of reminders for test completion. Most studies included in our review examined repeat FOBT every two years (i.e., biennial screening), but prevalence in these studies did not appear to differ dramatically from studies of annual screening. Studies also used a variety of test types, and differences in patient handling and collection may have contributed to the wide range of prevalence estimates. In randomized trials of gFOBT versus FIT, participation in FIT screening is about 10% higher than for FOBT (53, 54). Some studies suggest three-sample tests deter patients from completing repeat screening and introduce more opportunity for sampling and collection error (55). Only four studies (16, 45, 47, 48) reported using a three-sample test, and prevalence of repeat FOBT in these studies ranged from 0.8% to 49.8% across all screening rounds. Differences in repeat FOBT by test type (FIT vs. gFOBT) also appeared to be small.

We also observed variability in the proportion of patients completing repeat FOBT depending upon how the outcome was defined. For example, when defined as the proportion of Round 1 participants completing FOBT in Round 2, approximately 75% of patients completed repeat screening. Repeat FOBT was much lower when defined as completion across multiple screening rounds—about 45% of patients completed FOBT in two, consecutive rounds. Repeat FOBT appeared even lower when considering patterns over three or more rounds. These differences in outcome suggest two possible phenomena: (i) prior cancer screening experience predicts repeat, on-schedule screening; and (ii) those who initially refuse are unlikely to participate in subsequent rounds. In the context of interventions, the former suggests FOBT participants should be actively engaged to encourage repeat screening, and nonparticipants may instead benefit from an alternate screening test (56). This variability in outcome is also important when comparing results across studies, which used different definitions for repeat FOBT.

Few studies examined correlates of repeat FOBT, and those that did generally included nonmodifiable factors (e.g., age, sex). This is consistent with studies on correlates and predictors of FOBT *initiation*, in which sociodemographic variables such as younger age, nonwhite race/ethnicity, low socioeconomic status, poor educational attainment, and lack of insurance are negatively associated with screening uptake (57–59). Although demographic factors may help identify a target population in which to promote screening, they do not identify strategies that can be used to modify or change behavior. Repeat FOBT may depend highly on patient behavior. For example, in our review, Duncan and colleagues (49) found greater perceived barriers and lower levels of response efficacy were associated with drop-out from FOBT screening. Others have shown self-efficacy distinguishes patients engaged in consistent, on-schedule screening from those never screened (49, 60).

Repeat FOBT was generally higher in studies of mailed outreach (either in integrated health care systems or population-based programs) compared with studies of opportunistic screening. Our search strategy also identified two pragmatic trials (36, 47) of screening outreach; both demonstrated the effectiveness of mailed FOBT outreach (i.e., test kits with postage-paid return envelope) to increase patient adherence to two or more tests over multiple screening rounds. Other trials not included in our review similarly show mailed FOBT kits increase one-time screening, regardless of patient factors or preferences (8, 61–64). Incorporating elements of mailed outreach may optimize efforts to implement population health and cancer screening programs. Learning from system-level interventions (65) to promote repeat breast (66) and cervical cancer screening, such as tracking screening utilization and reports to primary care providers, may also help achieve comparable adherence for repeat FOBT.

Our findings also underscore the importance of transparent results reporting to facilitate comparison among studies and health care systems. For example, few studies reported the number of persons eligible at each screening round, and confusion surrounding the appropriate denominator can make it difficult to determine prevalence of repeat FOBT and compare prevalence estimates across studies. Others failed to describe the number of patients completing a prior screening test, creating challenges for measuring the true yield of screening programs. Allison and colleagues (67–69) have developed

Table 4. Proposed checklist for reporting studies of repeat stool-based screening.

Outcome variable	
	• Explicitly defined, with numerator and denominator
Test characteristics	
	• Test name, manufacturer • Quantitative or qualitative • Number of samples • Cutoff concentration
Study population	
	• Age at study entry • Number with high-risk features: family history, personal history, IBD, or UC • Proportion previously screened
Screening round	
	• Number of screening rounds • Follow-up period • Distinguish new invitees from previous participants • Number ineligible: positive FOBT or diagnostic colonoscopy in prior screening round, aged out, moved away from health care system or geographic region, colonoscopy for other reason, colorectal cancer diagnosis, death
Screening delivery	
	• Organized outreach versus opportunistic • Frequency, timing, and intensity of patient reminders • Patient education materials (if any) • Out-of-pocket costs or financial incentives

Abbreviations: IBD, inflammatory bowel disease; UC, ulcerative colitis.

several standards to improve FIT results reporting, including fecal hemoglobin concentration, sample handling, storage, and transport. Adapting these standards, we have proposed a checklist (**Table 4**) to strengthen reporting of FOBT screening completion, particularly when assessed across multiple screening rounds. Most importantly, studies of repeat FOBT should report the number eligible at each screening round, including those who become ineligible for a repeat test due to colorectal cancer diagnosis, death, move away from health care system or geographic region, prior positive FOBT and/or diagnostic colonoscopy, and prior colonoscopy for some other reason. These standards will allow researchers to compare and contrast the results of published studies and improve translation of results into clinical practice.

We observed considerable heterogeneity between studies (e.g., different countries, health care systems, test type), and the wide-ranging prevalence estimates precluded the use of meta-analysis to aggregate effect sizes of repeat FOBT. Similarly, because few studies examined correlates, it was not feasible to provide summary estimates. We excluded screening intervention trials requiring informed patient consent, and repeat FOBT may differ in intervention versus clinical practice settings. However, recent *post hoc* analyses (60, 70, 71) of these trials suggest prevalence of repeat screening is similar to what we reported. Furthermore, many of the studies included in our review reflect European or predominantly insured, white American populations, thereby excluding a number of patients at risk of colorectal cancer and among whom screening uptake remains low (e.g., Hispanics, non-Hispanic blacks). Although we have demonstrated that many patients, including those completing an index FOBT, fail to complete repeat screening, these data do not illustrate specific reasons for suboptimal screening.

In summary, adherence to repeat screening is critical to the effectiveness of stool-based tests, but few patients complete regular, on-scheduling testing over multiple screening rounds. Our review of repeat FOBT showed a wide range of repeat FOBT across 27 studies, as well as varying measures and definitions of repeat screening. Understanding reasons for these patterns may identify strategies to promote regular colorectal cancer screening at recommended intervals.

Disclosure of Potential Conflicts of Interest

S. Gupta is an advisor for Freenome, Inc., and Guardant Health, Inc. A.G. Singal is a consultant for Exact Sciences. No potential conflicts of interest were disclosed by the other authors.

Disclaimer

The content is solely the responsibility of the authors and does not necessarily represent the official views of CPRIT, NIH, or AHRQ. The funding agencies had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; or preparation, review, and approval of the manuscript.

Acknowledgments

This study was supported by Cancer Prevention Research Institute of Texas under award number PP160075 (to A.G. Singal, C.C. Murphy), the National Center for Advancing Translational Sciences at the NIH under award number KL2TR001103 (to C.C. Murphy), and Agency for Healthcare Research and Quality under award number R24HS022418 (to A.G. Singal, H. Mayo).

Received July 1, 2019; revised August 29, 2019; accepted November 12, 2019; published first November 18, 2019.

References

1. Siegel RL, Miller KD, Fedewa SA, Ahnen DJ, Meester RGS, Barzi A, et al. Colorectal cancer statistics, 2017. CA Cancer J Clin 2017;67:177–93.
2. Murphy CC, Sandler RS, Sanoff HK, Yang YC, Lund JL, Baron JA. Decrease in incidence of colorectal cancer among individuals 50 years or older after recommendations for population-based screening. Clin Gastroenterol Hepatol 2017;15:903–9.
3. Edwards BK, Ward E, Kohler BA, Eheman C, Zauber AG, Anderson RN, et al. Annual report to the nation on the status of cancer, 1975–2006, featuring colorectal cancer trends and impact of interventions (risk factors, screening, and treatment) to reduce future rates. Cancer 2010;116:544–73.
4. Rex DK, Boland CR, Dominitz JA, Giardiello FM, Johnson DA, Kaltenbach T, et al. Colorectal cancer screening: recommendations for physicians and patients from the U.S. Multi-Society Task Force on colorectal cancer. Gastroenterology 2017;153:307–23.
5. Zavoral M, Suchanek S, Zavada F, Dusek L, Muzik J, Seifert B, et al. Colorectal cancer screening in Europe. World J Gastroenterol 2009;15:5907–15.
6. Jensen CD, Corley DA, Quinn VP, Doubeni CA, Zauber AG, Lee JK, et al. Fecal immunochemical test program performance over 4 rounds of annual screening: a retrospective cohort study. Ann Intern Med 2016;164:456–63.
7. El-Serag HB, Petersen L, Hampel H, Richardson P, Cooper G. The use of screening colonoscopy for patients cared for by the Department of Veterans Affairs. Arch Intern Med 2006;166:2202–8.
8. Gupta S, Halm EA, Rockey DC, Hammons M, Koch M, Carter E, et al. Comparative effectiveness of fecal immunochemical test outreach, colonoscopy outreach, and usual care for boosting colorectal cancer screening among the underserved: a randomized clinical trial. JAMA Intern Med 2013;173:1725–32.
9. Gupta S, Sussman DA, Doubeni CA, Anderson DS, Day L, Deshpande AR, et al. Challenges and possible solutions to colorectal cancer screening for the underserved. J Natl Cancer Inst 2014;106:dju032.
10. Haas JS, Brawarsky P, Iyer A, Fitzmaurice GM, Neville BA, Earle C, et al. Association of local capacity for endoscopy with individual use of colorectal cancer screening and stage at diagnosis. Cancer 2010;116:2922–31.
11. Hardcastle JD, Armitage NC, Chamberlain J, Amar SS, James PD, Balfour TW. Fecal occult blood screening for colorectal cancer in the general population. Results of a controlled trial. Cancer 1986;58:397–403.
12. Hardcastle JD, Chamberlain JO, Robinson MH, Moss SM, Amar SS, Balfour TW, et al. Randomised controlled trial of faecal-occult-blood screening for colorectal cancer. Lancet 1996;348:1472–7.
13. Hardcastle JD, Thomas WM, Chamberlain J, Pye G, Sheffield J, James PD, et al. Randomised, controlled trial of faecal occult blood screening for colorectal cancer. Results for first 107,349 subjects. Lancet 1989;1:1160–4.
14. Goede SL, Rabeneck L, van Ballegooijen M, Zauber AG, Paszat LF, Hoch JS, et al. Harms, benefits and costs of fecal immunochemical testing versus guaiac fecal occult blood testing for colorectal cancer screening. PLoS One 2017;12:e0172864.
15. Schreuders EH, Ruco A, Rabeneck L, Schoen RE, Sung JJ, Young GP, et al. Colorectal cancer screening: a global overview of existing programmes. Gut 2015;64:1637–49.
16. Fenton JJ, Elmore JG, Buist DS, Reid RJ, Tancredi DJ, Baldwin LM. Longitudinal adherence with fecal occult blood test screening in community practice. Ann Fam Med 2010;8:397–401.
17. Levin TR, Jamieson L, Burley DA, Reyes J, Oehrli M, Caldwell C. Organized colorectal cancer screening in integrated health care systems. Epidemiol Rev 2011;33:101–10.
18. Moher D, Liberati A, Tetzlaff J, Altman DG; PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. Ann Intern Med 2009;151:264–9.
19. Lin JS, Piper MA, Perdue LA, Rutter CM, Webber EM, O'Connor E, et al. Screening for colorectal cancer: updated evidence report and systematic review for the US Preventive Services Task Force. JAMA 2016;315:2576–94.
20. Singal AG, Corley DA, Kamineni A, Garcia M, Zheng Y, Doria-Rose PV, et al. Patterns and predictors of repeat fecal immunochemical and occult blood test screening in four large health care systems in the United States. Am J Gastroenterol 2018;113:746–54.
21. Gordon NP, Green BB. Factors associated with use and non-use of the fecal immunochemical test (FIT) kit for colorectal cancer screening in response to

a 2012 outreach screening program: a survey study. BMC Public Health 2015; 15:546.
22. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP, et al. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. J Clin Epidemiol 2008;61:344–9.
23. Carpentier MY, Vernon SW, Bartholomew LK, Murphy CC, Bluethmann SM. Receipt of recommended surveillance among colorectal cancer survivors: a systematic review. J Cancer Surviv 2013;7:464–83.
24. Murphy CC, Bartholomew LK, Carpentier MY, Bluethmann SM, Vernon SW. Adherence to adjuvant hormonal therapy among breast cancer survivors in clinical practice: a systematic review. Breast Cancer Res Treat 2012;134: 459–78.
25. Bae N, Park S, Lim S. Factors associated with adherence to fecal occult blood testing for colorectal cancer screening among adults in the Republic of Korea. Eur J Oncol Nurs 2014;18:72–7.
26. Baker DW, Brown T, Goldman SN, Liss DT, Kollar S, Balsley K, et al. Two-year follow-up of the effectiveness of a multifaceted intervention to improve adherence to annual colorectal cancer screening in community health centers. Cancer Causes Control 2015;26:1685–90.
27. Cole SR, Gregory T, Whibley A, Ward P, Turnbull D, Wilson C, et al. Predictors of re-participation in faecal occult blood test- based screening for colorectal cancer. Asian Pac J Cancer Prev 2012;13:5989–94.
28. McNamara D, Leen R, Seng-Lee C, Shearer N, Crotty P, Neary P, et al. Sustained participation, colonoscopy uptake and adenoma detection rates over two rounds of the Tallaght-Trinity College colorectal cancer screening programme with the faecal immunological test. Eur J Gastroenterol Hepatol 2014;26:1415–21.
29. Lo SH, Halloran S, Snowball J, Seaman H, Wardle J, von Wagner C, et al. Colorectal cancer screening uptake over three biennial invitation rounds in the English bowel cancer screening programme. Gut 2015;64: 282–91.
30. Wong MCS, Ching JYL, Chan VCW, Lam TY, Luk AK, Ng SC, et al. Informed choice vs. no choice in colorectal cancer screening tests: a prospective cohort study in real-life screening practice. Am J Gastroenterol 2014;109:1072–9.
31. Wong MCS, Ching JYL, Lam TYT, Luk AK, Hirai HW, Griffiths SM, et al. Prospective cohort study of compliance with faecal immunochemical tests for colorectal cancer screening in Hong Kong. Prev Med 2013; 57:227–31.
32. Schlichting JA, Mengeling MA, Makki NM, Malhotra A, Halfdanarson TR, Klutts JS, et al. Veterans' continued participation in an annual fecal immunochemical test mailing program for colorectal cancer screening. J Am Board Fam Med 2015;28:494–7.
33. Bujanda L, Sarasqueta C, Castells A, Pellisé M, Cubiella J, Gil I, et al. Colorectal cancer in a second round after a negative faecal immunochemical test. Eur J Gastroenterol Hepatol 2015;27:813–8.
34. Steele RJC, McClements PL, Libby G, Carey FA, Fraser CG. Patterns of uptake in a biennial faecal occult blood test screening programme for colorectal cancer. Colorectal Dis 2014;16:28–32.
35. Liss DT, Petit-Homme A, Feinglass J, Buchanan DR, Baker DW. Adherence to repeat fecal occult blood testing in an urban community health center network. J Community Health 2013;38:829–33.
36. Baker DW, Brown T, Buchanan DR, Weil J, Balsley K, Ranalli L, et al. Comparative effectiveness of a multifaceted intervention to improve adherence to annual colorectal cancer screening in community health centers: a randomized clinical trial. JAMA Intern Med 2014;174:1235–41.
37. Garcia M, Borras JM, Binefa G, Milà N, Espinàs JA, Moreno V. Repeated screening for colorectal cancer with fecal occult blood test in Catalonia, Spain. Eur J Cancer Prev 2012;21:42–5.
38. Janda M, Hughes KL, Auster JF, Leggett BA, Newman BM. Repeat participation in colorectal cancer screening utilizing fecal occult blood testing: a community-based project in a rural setting. J Gastroenterol Hepatol 2010;25: 1661–7.
39. Weller D, Coleman D, Robertson R, Butler P, Melia J, Campbell C, et al. The UK colorectal cancer screening pilot: results of the second round of screening in England. Br J Cancer 2007;97:1601–5.
40. Tazi MA, Faivre J, Dassonville F, Lamour J, Milan C, Durand G. Participation in faecal occult blood screening for colorectal cancer in a well defined French population: results of five screening rounds from 1988 to 1996. J Med Screen 1997;4:147–51.
41. Knudsen MD, Berstad P, Hjartaker A, Gulichsen EH, Hoff G, de Lange T, et al. Lifestyle predictors for non-participation and outcome in the second round of faecal immunochemical test in colorectal cancer screening. Br J Cancer 2017;117: 461–9.
42. Telford J, Gentile L, Gondara L, McGahan C, Coldman A. Performance of a quantitative fecal immunochemical test in a colorectal cancer screening pilot program: a prospective cohort study. CMAJ Open 2016; 4:E668–E73.
43. Paszat L, Sutradhar R, Tinmouth J, Baxter N, Rabeneck L. Interval colorectal cancers following guaiac fecal occult blood testing in the Ontario ColonCancerCheck Program. Can J Gastroenterol Hepatol 2016;2016: 4768728.
44. Steele RJ, McDonald PJ, Digby J, Brownlee L, Strachan JA, Libby G, et al. Clinical outcomes using a faecal immunochemical test for haemoglobin as a first-line test in a national programme constrained by colonoscopy capacity. United European Gastroenterol J 2013;1:198–205.
45. Saraste D, Ohman DJ, Sventelius M, Elfström KM, Blom J, Törnberg S. Initial participation as a predictor for continuous participation in population-based colorectal cancer screening. J Med Screen 2018;25:126–33.
46. Van Der Vlugt M, Grobbee EJ, Bossuyt PMM, Bongers E, Spijker W, Kuipers EJ, et al. Adherence to colorectal cancer screening: four rounds of faecal immunochemical test-based screening. Br J Cancer 2017;116:44–9.
47. Singal AG, Gupta S, Skinner CS, Ahn C, Santini NO, Agrawal D, et al. Effect of colonoscopy outreach vs. fecal immunochemical test outreach on colorectal cancer screening completion: a randomized clinical trial. JAMA 2017; 318:806–15.
48. Denis B, Gendre I, Perrin P. Participation in four rounds of a French colorectal cancer screening programme with guaiac faecal occult blood test: a population-based open cohort study. J Med Screen 2015;22:76–82.
49. Duncan A, Turnbull D, Wilson C, Osborne JM, Cole SR, Flight I, et al. Behavioural and demographic predictors of adherence to three consecutive faecal occult blood test screening opportunities: a population study. BMC Public Health 2014;14:238.
50. Crotta S, Segnan N, Paganin S, Dagnes B, Rosset R, Senore C. High rate of advanced adenoma detection in 4 rounds of colorectal cancer screening with the fecal immunochemical test. Clin Gastroenterol Hepatol 2012;10: 633–8.
51. Gellad ZF, Stechuchak KM, Fisher DA, Olsen MK, McDuffie JR, Ostbye T, et al. Longitudinal adherence to fecal occult blood testing impacts colorectal cancer screening quality. Am J Gastroenterol 2011;106:1125–34.
52. Pornet C, Denis B, Perrin P, Gendre I, Launoy G. Predictors of adherence to repeat fecal occult blood test in a population-based colorectal cancer screening program. Br J Cancer 2014;111:2152–5.
53. Akram A, Juang D, Bustamante R, Liu L, Earles A, Ho SB, et al. Replacing the guaiac fecal occult blood test with the fecal immunochemical test increases proportion of individuals screened in a large healthcare setting. Clin Gastroenterol Hepatol 2017;15:1265–70.
54. Vart G, Banzi R, Minozzi S. Comparing participation rates between immunochemical and guaiac faecal occult blood tests: a systematic review and meta-analysis. Prev Med 2012;55:87–92.
55. Hoffman RM, Steel S, Yee EF, Massie L, Schrader RM, Murata GH. Colorectal cancer screening adherence is higher with fecal immunochemical tests than guaiac-based fecal occult blood tests: a randomized, controlled trial. Prev Med 2010;50:297–9.
56. Murphy CC, Ahn C, Pruitt SL, Hughes AE, Halm EA, Gupta S, et al. Screening initiation with FIT or colonoscopy: post-hoc analysis of a pragmatic, randomized trial. Prev Med 2018;118:332–5.
57. Klabunde CN, Cronin KA, Breen N, Waldron WR, Ambs AH, Nadel MR. Trends in colorectal cancer test use among vulnerable populations in the United States. Cancer Epidemiol Biomarkers Prev 2011;20:1611–21.
58. McQueen A, Vernon SW, Meissner HI, Klabunde CN, Rakowski W. Are there gender differences in colorectal cancer test use prevalence and correlates? Cancer Epidemiol Biomarkers Prev 2006;15:782–91.
59. McQueen A, Vernon SW, Myers RE, Watts BG, Lee ES, Tilley BC. Correlates and predictors of colorectal cancer screening among male automotive workers. Cancer Epidemiol Biomarkers Prev 2007;16:500–9.
60. Murphy CC, Vernon SW, Haddock NM, Anderson ML, Chubak J, Green BB. Longitudinal predictors of colorectal cancer screening among participants in a randomized controlled trial. Prev Med 2014;66:123–30.
61. Myers RE, Bittner-Fagan H, Daskalakis C, Sifri R, Vernon SW, Cocroft J, et al. A randomized controlled trial of a tailored navigation and a standard

intervention in colorectal cancer screening. Cancer Epidemiol Biomarkers Prev 2013;22:109–17.
62. Inadomi JM, Vijan S, Janz NK, Fagerlin A, Thomas JP, Lin YV, et al. Adherence to colorectal cancer screening: a randomized clinical trial of competing strategies. Arch Intern Med 2012;172:575–82.
63. Green BB, Wang CY, Anderson ML, Chubak J, Meenan RT, Vernon SW, et al. An automated intervention with stepped increases in support to increase uptake of colorectal cancer screening: a randomized trial. Ann Intern Med 2013;158:301–11.
64. Coronado GD, Petrik AF, Vollmer WM, Taplin SH, Keast EM, Fields S, et al. Effectiveness of a mailed colorectal cancer screening outreach program in community health clinics: the STOP CRC cluster randomized clinical trial. JAMA Intern Med 2018;178:1174–81.
65. Armstrong K, Kim JJ, Halm EA, Ballard RM, Schnall MD. Using lessons from breast, cervical, and colorectal cancer screening to inform the development of lung cancer screening programs. Cancer 2016;122:1338–42.
66. Vernon SW, McQueen A, Tiro JA, del Junco DJ. Interventions to promote repeat breast cancer screening with mammography: a systematic review and meta-analysis. J Natl Cancer Inst 2010;102:1023–39.
67. Allison JE, Fraser CG, Halloran SP, Young GP. Population screening for colorectal cancer means getting FIT: the past, present, and future of colorectal cancer screening using the fecal immunochemical test for hemoglobin (FIT). Gut Liver 2014;8:117–30.
68. Allison JE, Fraser CG, Halloran SP, Young GP. Comparing fecal immunochemical tests: improved standardization is needed. Gastroenterology 2012; 142:422–4.
69. Fraser CG, Allison JE, Young GP, Halloran SP, Seaman HE. Improving the reporting of evaluations of faecal immunochemical tests for haemoglobin: the FITTER standard and checklist. Eur J Cancer Prev 2015; 24:24–6.
70. Green BB, Anderson ML, Cook AJ, Chubak J, Fuller S, Meenan RT, et al. A centralized mailed program with stepped increases of support increases time in compliance with colorectal cancer screening guidelines over 5 years: a randomized trial. Cancer 2017;123:4472–80.
71. Liang PS, Wheat CL, Abhat A, Brenner AT, Fagerlin A, Hayward RA, et al. Adherence to competing strategies for colorectal cancer screening over 3 years. Am J Gastroenterol 2016;111:105–14.
72. Lo SH, Waller J, Vrinten C, Wardle J, von Wagner C. Self-reported and objectively recorded colorectal cancer screening participation in England. J Med Screen 2016;23:17–23.
73. Lo SH, Halloran S, Snowball J, Seaman H, Wardle J, von Wagner C. Predictors of repeat participation in the NHS bowel cancer screening programme. Br J Cancer 2015;112:199–206.
74. Denters MJ, Deutekom M, Bossuyt PM, van Rijn AF, Fockens P, Dekker E. Involvement of previous non-participants cannot fully compensate for lower participation in a second round of FIT-screening. Cancer Epidemiol 2013;37: 330–5.
75. Grobbee EJ, Schreuders EH, Hansen BE, Bruno MJ, Lansdorp-Vogelaar I, Spaander MCW, et al. Association between concentrations of hemoglobin determined by fecal immunochemical tests and long-term development of advanced colorectal neoplasia. Gastroenterology 2017;153: 1251–9.