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Adherence to colorectal cancer screening measured as the proportion of time covered

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Abstract

Background and Aims—Colorectal cancer (CRC) screening can reduce CRC incidence and mortality, but measuring screening adherence over time is challenging. We examined adherence using a novel measure characterizing the proportion of time covered (PTC) by screening tests.

Methods—Eligible patients were age 50 to 60 years and followed at a large, safety-net healthcare system between January 2010 and September 2014. We estimated PTC as the number of days up-to-date with screening divided by number of days from cohort entry until study end, CRC diagnosis, or death. We estimated mean and median PTC and used least significant difference tests to assess differences in adherence by patient characteristics.

Results—Of 18,257 patients, most were non-Hispanic black (40.5%) or Hispanic (34.9%) and female (62.4%). Approximately 40% (n=7,559) were never screened during the study period; the remaining 10,698 patients completed 19,105 screening examinations (14,481 FITs, 4,393

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colonoscopies, 94 sigmoidoscopies, and 137 barium enemas). Overall, mean PTC was 29.1% (95% CI, 28.6% – 29.5%). Among those who completed at least one screening test (n=10,698), mean PTC was 49.0% (95% CI, 48.5% – 49.5%). Most common reasons for non-adherence were lack of repeat FIT and no diagnostic colonoscopy after abnormal FIT. Mean PTC increased with number of primary care visits (0 visits: 21%, 1 visit: 29%, 2–3 visits: 35%, 4 visits: 37%, all $p<0.05$).

Conclusions—PTC provides a reliable estimate of screening adherence, capturing breakdowns in the CRC screening process amenable to intervention. Repeat FIT and diagnostic colonoscopy are important intervention targets that may increase adherence in underserved populations.

Introduction

Colorectal cancer (CRC) screening is endorsed as an effective preventive service¹ because it facilitates early detection of cancer and removal of adenomatous polyps,² thereby lowering CRC mortality. Although a substantial research effort has focused on improving onetime CRC screening,^{3–6} there is growing recognition that CRC screening is a complex process⁷ involving several steps, including repeat screening for patients with normal test results, diagnostic evaluation and surveillance for those with abnormal results, and treatment of any detected lesions. Failures may occur at each of these steps, reducing effectiveness of screening. Achieving the national goal of 80% screened by 2018^{8,9} requires coordinated efforts to systematically track and report adherence¹⁰ to each step in the screening process.

Measuring adherence to the CRC screening can be challenging because several CRC screening modalities are regarded as equally effective^{1,11} and have different recommended intervals for repeat screening and/or surveillance.^{12–14} Patient or physician preferences for a particular modality may also influence screening decisions, creating additional challenges for measuring adherence while accommodating for “competing” examinations.¹⁵ Variation in the way healthcare systems measure adherence can mask breakdowns in the screening process¹⁶ and overestimate adherence. For example, quality and performance measures, such as HEDIS¹⁷ or ACO Quality Measures,¹⁸ report completion of any screening test over the recommended interval, ignoring adherence to downstream steps in the screening process (eg, follow-up of abnormal results) or repeat screening.¹⁹ Alternative approaches, such as “proportion of time covered,”^{20–22} may be better suited to accommodate these challenges and measure adherence across the entire screening process. Although proportion of time covered is frequently used in medication adherence research as a valid surrogate of adherence,²³ and emerging evidence support its use for measuring hepatocellular carcinoma surveillance²⁴, there are no data to show if and how this approach may be used to measure CRC screening adherence. Compared with traditional adherence measures, time covered approaches provide a better measure of adherence by: (1) accounting for quality, timing, and results of screening examinations; (2) not penalizing patients for examinations performed just outside the recommended interval; and (3) including all available follow-up time.²⁴

The purpose of this study was to develop and employ a novel measure of adherence to CRC screening using a proportion of time covered approach. We examined this approach over a

four-year period in a large population of screen-eligible patients receiving care at a safety-net healthcare system.

Methods

Patients and procedures

This study was part of the National Cancer Instituted-funded Population-Based Research Optimizing Screening through Personalized Regimens (PROSPR) Consortium. Details of the cohort have been previously reported.^{7, 25}

We conducted the study at Parkland Health & Hospital System, Dallas County's safety-net healthcare system, using data from the PROSPR Parkland-UT Southwestern colorectal cohort. Parkland is a vertically integrated system, including 12 community-based primary care clinics, outpatient specialty clinics, and colonoscopy suites. Parkland uses several public payer programs to care for a large population of vulnerable, underserved patients, most of whom are racial/ethnic minorities and uninsured. These programs include federal and state-based payers (Medicare and Medicaid) and financial assistance programs funded by county tax dollars that cover CRC screening for no or reduced cost. Screening is available to primary care patients age 50 years or older and offered opportunistically (ie, no organized screening outreach program) during in-person clinic visits. Screening modality is based on provider and patient preferences, and most average-risk patients receive FIT.²⁶ Although the electronic health record (HER) system includes a portfolio of visit-based best practice alerts, including CRC screening, these are passive reminders with little impact on screening adherence. Parkland's GI lab offers diagnostic colonoscopy at minimal co-payment for patients with abnormal FIT.

For this study, we identified patients entering the PROSPR cohort between January 1, 2010 and December 31, 2010 (ie, Dallas County residents with a primary care provider visit on or after January 1, 2010). We restricted the cohort to ages 50 to 60 years (at cohort entry) because patients who become Medicare-eligible at age 65 may opt to receive care outside the safety-net system. We also excluded patients with a history of CRC, colectomy, or prior screening with colonoscopy or sigmoidoscopy.

Two investigators manually abstracted endoscopy and pathology reports of all colonoscopies (n=4,393) performed during the study period. We used a structured data collection form that included bowel prep quality, cecal intubation, and polyp number, size, and histology. Bowel prep quality was assessed with the Boston Bowel Preparation Scale²⁷ (scores of 5 or higher indicate poor prep) or described with free text in the endoscopy report by the treating endoscopist at the time of the procedure. For quality assurance purposes, 2 investigators independently reviewed 5% (n=210) of abstracted endoscopy and pathology reports. Discrepancies occurred in less than 15% of the sample (n=25); common discrepancies included colonoscopy indication and missing bowel prep. We then used abstracted data to classify colonoscopies into surveillance recommendation intervals (eg, 5 years, 10 years), according to U.S. Multi-Society Task Force guidelines.^{13, 14}

Statistical analysis

We measured screening adherence as the proportion of time covered by CRC screening (hereafter referred to as “PTC”). We divided number of days patients were covered (ie, up-to-date) with CRC screening by the number of days from cohort entry to (2) end of the study period (September 30, 2014); (2) date patient moved from Dallas County and no longer eligible for services at Parkland; or (3) date of CRC diagnosis or death. For 42 patients (0.2% of total) who exited and re-entered the cohort before the end of the study period (ie, moving in and out of Dallas County), we only considered follow-up time as that observed in the cohort.

We assigned time to screening examinations based on examination type, quality, and findings (Figure 2). For example, we assigned 6 months to FIT with abnormal findings, 3 years to adequate colonoscopy with 3 to 10 tubular adenomas (<1 cm), and 5 years to sigmoidoscopy or barium enema. We used guideline recommendations from the U.S. Multi-Society Task force on Colorectal Cancer and the American Cancer Society^{13, 14} to assign time to colonoscopies. Where there is flexibility in guideline recommendations, we assigned the more conservative interval. For example, we assigned 5 years to colonoscopies with one or two small (<1 cm) adenomas, where Appendix 1 lists time assigned to all screening examinations. If patients had overlapping examinations, we adjusted the end date of the previous examination, rather than sum all time covered by screening (eg, 2 FITs completed 9 months apart would provide 21 months), as recommended for studying cancer screening in observational data.¹⁶

For patients who received FIT in the year before cohort entry (n=2,320, 12.7%) we assigned additional time by subtracting the cohort entry date from FIT due date (ie, 1 year after index FIT) or next screening examination, whichever came first. For example, a patient with a prior FIT on June 1, 2009 and entering the cohort on January 1, 2010 received 5 months.

We used descriptive statistics (eg, proportions, means, medians) to describe characteristics of the study population. Patient characteristics included age at cohort entry, comorbidity (measured by Charlson index²⁸), sex, race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, other), and number of primary care visits before cohort entry (0, 1, 2–3, 4+). We report mean and median PTC, in the total study population (n=18,257) and among screeners only (n=10,698). Screeners included patients who completed at least one screening examination during the study period.

In secondary analysis, we estimated mean PTC within select patient subgroups. We used least significant difference tests to assess differences in mean adherence time, with Tukey’s method to correct for multiple comparisons.²⁹

Analyses were conducted using SAS version 9.3 (SAS Institute, Cary, NC). All statistical tests were 2-sided. The study was approved by the Institutional Review Board at UT Southwestern Medical Center (No. 082011-040).

Results

Patient characteristics

Baseline characteristics of the study population (n=18,257) are shown in Table 1. Most patients were non-Hispanic black (40.5%) or Hispanic (34.9%), female (62.4%), and had no comorbid conditions (53.8%). Mean age was 54.9 years. Some patients (12.7%) received FIT in the year before cohort entry. Two-thirds attended at least one primary care visit before cohort entry (67.6%). Patients contributed mean 4.3 years of follow-up.

Screening examinations

Over 40% of patients (n=7,559) were never screened during the study period; remaining 10,698 patients completed a total of 19,105 screening examinations, including 14,481 FITs, 4,393 colonoscopies, 94 sigmoidoscopies, and 137 barium enemas (Table 1). Of the colonoscopies performed (n=4,393), most (59.4%) had normal findings; nearly 20% (n=836) had 1–2 small (<1 cm) tubular adenomas (Supplementary Table 1). Approximately 10% (n=454) of colonoscopies were classified as inadequate due to poor bowel prep or inability to reach the cecum. There were 795 abnormal FITs (5.5% of all FITs), of which 327 (42.3%) were followed by diagnostic colonoscopy within 6 months.

Proportion of Time Covered

Among all patients, mean PTC was 29.1% (95% CI, 28.6% – 29.5%; Table 2). Common screening patterns were no screening or only one FIT during the study period (Figure 3A, Table 3). There were no appreciable changes in the direction or magnitude of results in sensitivity analyses: (1) excluding patients diagnosed with CRC during the study period (n=75); (2) summing follow-up time using the last exit date among those exiting and re-entering the cohort (n=42); or (3) ignoring time from prior FIT (n=2,320) (Supplementary Table 2).

Among screeners (n=10,698, 58.6% of total), mean PTC was 49.0% (95% CI, 48.5% – 49.5%, Table 2). Common screening patterns were only one or two FITs during the study period (Figure 3B, Table 3). Average time to first screening was 11.3 months from cohort entry, and 17.9 months from first to second screening examination (n=5,439 received two or more screening examinations). Most frequent reasons for non-adherence included lack of repeat FIT (58.5%), no diagnostic colonoscopy after abnormal results (4.4%), and incomplete colonoscopy with no additional testing (4.1%, Supplementary Table 3).

PTC differed by sex, race/ethnicity, number of primary care visits before cohort entry, and comorbidity (Table 4). Notably, PTC increased with the number of primary care visits before cohort entry (0 visits: 21%, 1 visit: 29%, 2–3 visits: 35%, 4 visits: 37%, all differences in means $p<0.05$). We observed a similar pattern among screeners only (n=10,698), although differences were smaller in magnitude.

Discussion

Our study suggests a “proportion of time covered” approach provides an informative estimate of screening adherence, identifying frequent coverage gaps and screening failures at

clinically relevant time points. This novel measure reveals that, even among patients engaged in primary care with no or very low costs of screening, adherence is low. Reasons for non-adherence include (1) more than 40% of eligible patients never initiated screening; (2) few patients who initiated screening with FIT completed repeat FIT, on-schedule; and 3) many patients with abnormal FIT results did not complete diagnostic colonoscopy. There were also a number of patients who were ineffectively screened, by either poor bowel prep or inability to reach the cecum. Adherence measures ignoring these outcomes may mask breakdowns in the CRC screening process amenable to intervention. Results highlight the importance of developing more robust measures of screening adherence and support continued efforts to improve CRC screening in underserved populations.

Nearly half of the more than 18,000 patients in our study did not initiate screening, suggesting initial uptake of CRC screening continues to be a rate-limiting step in adherence to the screening process for safety-net populations.³⁰ Although Parkland has implemented visit-based reminders for CRC screening in the EHR, and providers receive audit and feedback of screening performance, a substantial proportion of age-eligible patients were never screened. This finding underscores the need for additional system-level strategies to engage patients in the CRC screening process, particularly those who may be newly eligible or overdue. In a pragmatic, randomized clinical trial, we demonstrated mailed invitations to complete colonoscopy or FIT are effective in increasing the proportion of patients completing the screening process compared to opportunistic screening,^{26, 31} which remains standard of care in most health systems. Other studies have similarly found that screening uptake increases when testing is made convenient and accessible, regardless of patient factors or preferences.^{32–36} Investing in screening outreach outside of usual healthcare visits (vs opportunistic discussion in clinic) may be a cost-effective strategy to promote screening in large healthcare systems with diverse patient populations.

Among those screened at least once during the study period, PTC was less than 50%, largely due to drop offs in screening after completing one or two FITs. Although there may be fewer barriers to one-time FIT completion than one-time colonoscopy, effectiveness of FIT is reduced when patients do not receive annual or biennial screening or diagnostic evaluation of abnormal results.^{37–39} Proportion of patients completing 1, 2, and 3 screening examinations decreased exponentially over the study period: 59% to 30% to only 12%. Because most studies report one-time use rather than repeat screening outcomes, we know little about interventions designed to promote regular FIT screening. Prevalence of repeat screening in community settings ranges from 14% to 54% among persons who have previously completed FIT or FOBT on schedule.^{19, 40, 41} Connection to primary care, comorbidity, and self-efficacy appear to be important determinants of repeat screening.^{32, 40–42} As healthcare systems adopt a “FIT First” approach to CRC screening,⁴³ data concerning adherence to repeated rounds of screening and diagnostic evaluation over longer time periods will become increasingly relevant.

We observed a dose response relationship with number of primary care visits and coverage time, whereby PTC increased with more primary care visits before cohort entry. Primary care visits and physician recommendation are strongly associated with colonoscopy screening in both primary care settings^{3, 44} and population-based surveys.^{45–49} Another

possibility is that symptomatic patients (eg, with hematochezia) are more likely to attend primary care visits and have endoscopy procedures ordered. In other settings with predominantly FIT (vs colonoscopy) screening, patients with greater number of primary care visits have markedly higher odds of completing both initial screening and diagnostic colonoscopy after abnormal results.⁵⁰ Our study extends the findings of previous research by demonstrating that, not only is primary care “connectedness” important for screening adherence, but the magnitude of its effect may increase as patients become more engaged in primary care. Referencing or leveraging existing primary care relationships may improve screening adherence.

Our results also highlight the importance of developing robust screening adherence measures oriented to clinically relevant time points in the screening process. Adherence measures should demonstrate how well (or poorly) healthcare systems serve patient subgroups, including those newly enrolled or screen-eligible, experiencing screening coverage gaps, and continuously engaged in primary care. For example, we noted screening initiation, on average, did not occur until almost an entire year after the qualifying primary care visit. Other aspects of our analyses show 25% and 50% PTC were common screening patterns, suggesting interventions targeted at repeat FIT or diagnostic colonoscopy after abnormal findings may minimize coverage gaps among patients intermittently screened. Our use of detailed information abstracted from pathology and endoscopy reports to calculate adherence highlights the importance of developing systematic approaches to obtaining colonoscopy indication and findings from administrative data.

Findings are subject to the limitations of our adherence measure. For example, we assigned 12 months’ time to FIT with normal findings, but our estimate of adherence may change when considering longer intervals between repeat screenings, such as 24 months endorsed by European screening programs.⁵¹ We also could not distinguish “severity” of gaps in screening coverage. For example, failure to complete repeat FIT may not be as clinically concerning as failure to complete diagnostic colonoscopy after abnormal FIT or colonoscopy for polyp surveillance. Although the 4-year follow-up period was longer than most studies of CRC screening adherence, we lacked sufficient data to determine whether patients with normal findings or low-risk adenomas at colonoscopy underwent appropriate surveillance 5 to 10 years later. Adherence may decline over longer periods of observation, with more opportunity for patients to miss diagnostic follow-up or repeat screening. Finally, nonadherence to screening includes both under- and over-use, and we did not estimate screening over-use in our study population. As colonoscopy becomes more widely available,⁵² there are growing concerns of overuse and associated risks of adverse events,⁵³ increased healthcare costs, and reduced endoscopic capacity in under-screened populations.^{54–56} Given the large proportion of patients who never initiated screening in our study population, we expected few instances of screening overuse, and, indeed, fewer than 2% of patients completed more than four screening examinations.

In summary, using “proportion of time covered” adds to our understanding of existing analytic approaches to measure screening adherence and identifies coverage gaps at clinically relevant time points in the CRC screening process. Our results suggest screening

initiation and repeat FIT are important intervention targets that may increase screening adherence in underserved populations.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Dr. Murphy had full access to all the data in the study and takes responsibility for the data and the accuracy of the data analysis.

The authors have no conflicts of interest to disclose.

Abbreviations

CI	confidence interval
CRC	colorectal cancer
FIT	fecal immunochemical test
FOBT	fecal occult blood test
HEDIS	Healthcare Effectiveness Data and Information Set
PROSPR	Population-Based Research Optimizing Screening through Personalized Regimens
PTC	proportion of time covered

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Figure 1.
Study flow diagram (n=18,257)

Figure 2.
Estimating proportion of time covered for different combinations of screening examinations

Figure 3. Distribution of PTC, in the total study population (A; n=18,257) and screeners only (B; n=10,698)

Table 1

Baseline characteristics of 18,257 patients eligible for colorectal cancer screening, age 50–60 years, Parkland Health & Hospital System

	n	(%)
Age at cohort entry, mean (SD)	54.9	(3.12)
50–54	9,632	(52.8)
55–60	8,625	(47.2)
Sex		
Male	6,867	(37.6)
Female	11,390	(62.4)
Race/ethnicity		
Non-Hispanic white	3,307	(18.1)
Non-Hispanic black	7,394	(40.5)
Hispanic	6,362	(34.9)
Other	1,194	(6.5)
Insurance		
Medicaid	2,093	(11.5)
Medicare	1,844	(10.1)
County assistance	13,315	(72.9)
Commercial or other	1,005	(5.5)
Primary care visits in year before cohort entry, mean (SD)	1.6	(1.86)
0	5,909	(32.4)
1	4,799	(26.3)
2–3	5,289	(29.0)
4+	2,260	(12.4)
FIT in year before cohort entry		
No	15,937	(87.3)
Yes	2,320	(12.7)
Comorbidity score		
0	9,826	(53.8)
1	5,069	(27.8)
2+	3,362	(18.4)
Follow-up time (in years), mean (SD)	4.3	(0.56)
Any screening	10,698	(58.6)
FIT	8,726	(47.8)
Colonoscopy	4,038	(22.1)
Sigmoidoscopy	76	(0.4)
Number of screening examinations during study period		
1	10,698	(58.6)
2	5,439	(29.8)
3	2,258	(12.4)
4 +	607	(3.3)

Table 2

Mean and median PTC, in the total study population (n=18,257) and screeners only (10,698)

Total study population (n=18,257)		Screeners ^I only (n=10,698)	
Mean (95% CI)	Median (95% CI)	Mean (95% CI)	Median (95% CI)
29.1 (28.6 – 29.5)	22.0 (21.8 – 22.1)	49.0 (48.5 – 49.5)	44.9 (44.3 – 45.4)

NOTE: We estimated proportion of time covered (PTC) as the number of days patients were up-to-date with CRC screening divided by the number of days in the cohort

^IScreeners defined as patients receiving any screening examination (FIT, colonoscopy, sigmoidoscopy, or barium enema) after cohort entry; patients who received FIT before cohort entry but did not receive additional screening examinations during study period were not considered screeners.

Abbreviations: PTC, proportion of time covered; CI, confidence interval

Table 3

Common screening patterns in the total study population (n=18,257)

Screening pattern	n	%
No screening	7,559	41.4
FIT	3,446	18.9
FIT + FIT	1,809	9.9
Colonoscopy	1,773	9.7
FIT + FIT + FIT	1,038	5.7
FIT + Colonoscopy	1,003	5.5
FIT + FIT + FIT + FIT	271	1.5
FIT + FIT + Colonoscopy	262	1.4
Colonoscopy + FIT	206	1.1

NOTE: A total of 133 different screening patterns were observed; table includes screening patterns occurring in at least 1% of study population

Table 4
Mean PTC within patient subgroups, in the total study population (n=18,257) and screeners only (n=10,698)¹

	Total study population (n=18,257)			Screeners only (n=10,698) ¹		
	Mean	Diff. in Means ²	95% CI	Mean	Diff. in Means ²	95% CI
Age at cohort entry						
50–54	29.0			48.9		
55–60	29.1	0.1	–0.8 – 1.1	49.1	0.2	–0.8 – 1.2
Sex						
Male	26.1			47.4		
Female	30.8	4.8 [*]	3.8 – 5.7	49.8	2.4 [*]	1.4 – 3.5
Race/ethnicity						
Non-Hispanic white	23.5			47.4		
Non-Hispanic black	26.9	3.4 [*]	1.7 – 5.1	47.5	0.1	–1.9 – 2.1
Hispanic	34.5	10.9 [*]	9.2 – 12.6	50.8	3.4 [*]	1.4 – 5.4
Other	28.7	5.2 [*]	2.5 – 7.9	50.5	3.1	–0.04 – 6.2
Primary care visits in year before cohort entry						
0	20.6			44.1		
1	29.4	8.8 [*]	7.3 – 10.3	48.0	3.9 [*]	2.1 – 5.7
2–3	34.6	14.0 [*]	12.5 – 15.5	51.4	7.2 [*]	5.5 – 8.9
4+	37.2	16.6 [*]	14.6 – 18.5	54.0	9.9 [*]	7.7 – 12.0
Comorbidity score						
0	29.2			49.0		
1	30.0	0.8	–0.4 – 2.1	49.1	0.1	–1.2 – 1.5
2+	27.2	–2.0 [*]	–3.5 to –0.5	48.9	–0.1	–1.8 – 1.6

^{*} indicates comparison significant at the 0.05 level

¹ Screeners defined as patients receiving any screening examination (FIT or FOBT, colonoscopy, sigmoidoscopy, or barium enema) after cohort entry; patients who received FIT or FOBT before cohort entry but did not receive additional screening examinations during study period were not considered screeners.

² Difference from referent group, shaded in gray

Abbreviations: PTC; proportion of time covered; Diff; difference; CI, confidence interval

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