ORIGINAL RESEARCH

Overuse of Colonoscopy for Colorectal Cancer Screening and Surveillance

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BACKGROUND: Ongoing efforts to increase colorectal cancer (CRC) screening rates have raised concerns that these exams may be overused, thereby subjecting patients to unnecessary risks and wasting healthcare resources.

OBJECTIVE: Our aim was to measure overuse of screening and surveillance colonoscopies among average-risk adults, and to identify correlates of overuse.

DESIGN, SETTING, AND PARTICIPANTS: Our approach was a retrospective cohort study using electronic health record data for patients 50–65 years old with no personal history of CRC or colorectal adenomas with an incident CRC screening colonoscopy from 2001 to 2010 within a multispecialty physician group practice.

MAIN OUTCOME MEASURES: We measured time to next screening or surveillance colonoscopy and predictors of overuse (exam performed more than one year earlier than guideline recommended intervals) of colonoscopies.

KEY RESULTS: We identified 1,429 adults who had an incident colonoscopy between 2001 and 2010, and they underwent an additional 871 screening or surveillance colonoscopies during a median follow-up of 6 years. Most follow-up screening colonoscopies (88 %) and many surveillance colonoscopies (49 %) repeated during the study represented overuse. Time to next colonoscopy after incident screening varied by exam findings (no polyp: median 6.9 years, interquartile range [IQR]: 5.1–10.0; hyperplastic polyp: 5.7 years, IQR: 4.9–9.7; low-risk adenoma: 5.1 years, IQR: 3.3–6.3; high-risk adenoma: 2.9 years, IQR: 2.0–3.4, $p < 0.001$). In logistic regression models of colonoscopy overuse, an endoscopist recommendation for early follow-up was strongly associated with overuse of screening colonoscopy (OR 6.27, 95 % CI: 3.15–12.50) and surveillance colonoscopy (OR 13.47, 95 % CI 6.61–27.46). In a multilevel logistic regression model, variation in the overuse of screening colonoscopy was significantly associated with the endoscopist performing the previous exam.

CONCLUSIONS: Overuse of screening and surveillance exams are common and should be monitored by healthcare systems. Variations in endoscopist recommendations represent targets for interventions to reduce overuse.

KEY WORDS: colorectal cancer screening; colonoscopy; overuse; efficiency. *J Gen Intern Med* 30(3):277–83

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BACKGROUND

Colorectal cancer (CRC) screening is widely recommended based on its proven effectiveness at reducing CRC mortality.¹ Current national guidelines strongly recommend screening adults aged 50 and older, and performing surveillance colonoscopy for adults found to have adenomatous polyps.^{2–7} Efforts to promote CRC screening have been successful, with the national CRC screening rate increasing from 54 % in 2002 to 65 % in 2010.⁸

As rates of CRC screening increase, there is growing concern about inefficient use of endoscopy, including potential overuse of colonoscopy.^{10–20} Overuse of CRC screening exams has become a focus of national efforts, including the *Choosing Wisely* campaign²¹ of the American Board of Internal Medicine Foundation and the American Gastroenterological Association, which are jointly encouraging physicians to reduce delivery of CRC screening exams of uncertain value—particularly repeat colonoscopy within 10 years after a high-quality negative exam or within 5 years after detection of one to two small adenomas.

Despite growing national attention, the assessment of overuse of colonoscopies has been limited as it requires clinical details not available in claims data. The careful measurement of colonoscopy overuse represents an essential first step in the development of interventions to reduce these practices. The objective of our study was to use detailed electronic health record (EHR) data to identify colonoscopy exams that may represent overuse among average-risk adults, and to identify factors associated with overuse.

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METHODS

Study Setting and Participants

We studied primary care patients at Harvard Vanguard Medical Associates (HVMA), a multispecialty group practice with 17 ambulatory sites in Massachusetts using a common EHR since 1997 (Epic Systems, Verona, Wisconsin). In 2012, nearly all HVMA sites achieved CRC screening rates above the state average of 78 %, and half had screened over 90 % of eligible patients.⁹ HVMA gastroenterologists perform procedures either at an ambulatory endoscopy center operated by HVMA or within an affiliated hospital-based endoscopy center.

We studied incident colonoscopies in a retrospective cohort of adult patients who were 50 to 65 years old in 2001 and underwent an initial colonoscopy for CRC screening between 2001 and 2010. We followed patients from their incident screening colonoscopy for up to 10 years (through 31 December 2010) to identify all subsequent screening and surveillance colonoscopies performed during this period. This study was approved by the Harvard Medical School Institutional Review Board and the Harvard Pilgrim Healthcare Human Studies Committee with waiver of informed consent.

Data Sources

Colonoscopy screening and surveillance exams were identified using an EHR algorithm based on diagnostic and procedure codes, and outpatient and hospital encounters. This algorithm is 88 % sensitive and 96 % specific for identifying CRC screening exams compared to manual review by physicians.²²

We performed manual reviews of medical records to collect polyp pathology results and endoscopy exam detail. Manual reviews were performed by a single trained research assistant (SMK) using a standardized chart review instrument. We further employed a review of the process by a physician researcher (TDS) who reviewed 5 % of the charts.

We defined incident endoscopies as those among patients with no prior endoscopy exams and no personal history of CRC or polyps noted in chart review. Quality of bowel preparation was dichotomized into: (1) exams where any problem was noted, such as adherent stool, 'Fair', or 'Poor' quality; and (2) exams where preparation was 'Excellent', 'Good', or 'Adequate', or no problem was noted. Exams where the indication was due to symptoms were considered diagnostic and were excluded from our analyses. We classified family history as positive if family history of polyps or CRC was noted as a reason for exam. We used pathologic findings to calculate adenoma detection rates (ADR), a quality metric for endoscopy. Higher detection rates are associated with lower risk of death from CRC.²³ Specialty societies propose 15 % ADR among women and 25 % among men as quality thresholds for adenoma detection.²⁴

Definition of Outcomes

We identified incident screening colonoscopies occurring between 2001 and 2010. Subsequent colonoscopies were categorized as screening or surveillance based on whether they were performed after a finding of adenoma. We evaluated all of the screening and surveillance colonoscopies that occurred after the incident exam to determine whether they represented overuse tests according to the 2002 and 2008 U.S. Preventive Services Taskforce screening guidelines and the 2003 and 2006 U.S. Multi-Society Task Force on Colorectal Cancer surveillance guidelines.²⁻⁷ Guidelines have not changed significantly since 2002 in recommending a screening colonoscopy every 10 years. Surveillance guidelines recommend a 5-year interval for low-risk adenomas and a 3-year interval for high-risk adenomas.^{3, 4} Low-risk adenomas include one to two small (< 1 cm) tubular adenomas. High-risk adenomas include three to ten adenomas, large (≥ 1 cm) adenomas, villous histology or high-grade dysplasia. We considered patients found to have CRC or more than ten adenomas to be very high risk and excluded these patients from subsequent analyses.

We defined overuse as exams that were not provided within the national guidelines. In this way, we considered overuse of colonoscopies as those that occurred more than one year earlier than the guideline recommended follow-up interval (Table 1).²⁵ We manually reviewed the medical records for any exams repeated within 30 days ($N=30$), and found they were all done as a continuation of the initial exam, such as to ensure adequate polyp removal. We excluded the first of these repeat exams from our analyses.

Statistical Analysis

To quantify how early or late exams were being performed, we used Kaplan-Meier methods to calculate the median time from each colonoscopy to the next for incident screening exams according to exam findings. Patients with no subsequent exam were censored at the time of clinical inactivity or at the end of the study. If patients' subsequent exams were diagnostic, patients were censored at the time of the diagnostic exam. We defined clinical inactivity as the time at which patients had no further office visits or procedures within the medical group for at least two years.

Table 1. Definition of Overuse of Screening and Surveillance Colonoscopy

Exam result	Guideline recommended screening interval	OVERUSE screening interval
No adenoma	10 years	< 9 years
1-2 small (< 1 cm) tubular adenoma(s)	5 years	< 4 years
3-10 adenomas, large (≥ 1 cm) adenomas, villous histology, high grade dysplasia	3 years	< 2 years

We conducted an exam-level analysis by calculating the proportion of follow-up screening and surveillance colonoscopies performed after the incident exam that represented overuse. We fit multivariable logistic regression models of follow-up exams to identify predictors of overuse. We examined overuse using models for two different groups: overuse among follow-up screening colonoscopies performed for patients with no history of adenoma (Model 1), and overuse among surveillance colonoscopies performed following adenoma detection (Model 2). We accounted for clustering by endoscopist performing the prior exam using generalized estimating equations. Based on prior studies of endoscopy timing,^{10–12} we controlled for sociodemographic factors of patient age, gender, and insurance status (insured versus uninsured); outpatient visits (≥ 4 visits/year versus < 4 visits/year); calendar year; prior exam characteristics including bowel preparation quality (problem with preparation versus no problem); pathologic findings of the prior exam (no polyp, hyperplastic polyp, 1–2 small adenoma, ≥ 3 adenomas/large adenoma/villous histology/dysplasia); and whether an early screening interval was recommended by the endoscopist after the prior exam (early follow-up versus no early follow-up recommended). We fit our adjusted models both with and without patients with family history of polyp or CRC based on chart review, because only some patients with a positive family history warrant early interval follow-up,² and similar to other settings,²⁶ we did not have sufficient detail in the medical record to differentiate between these patients.

To measure the variation in overuse of screening and surveillance colonoscopies attributable to the endoscopist, we estimated hierarchical models using the fixed-effects included in Models 1 and 2 with random effects at the patient and endoscopist levels. We calculated the fraction of variance explained by the endoscopist using a standard variance for the logistic regression.²⁷ Analyses were performed using SAS version 9.3 (Cary, NC).

RESULTS

Study Subjects

We identified 1,740 patients who had an incident screening colonoscopy in the practice between 2001 and 2010. We excluded patients identified on manual record review as being above average risk or due to missing covariate data (Fig. 1). The remaining 1,429 patients received care from 196 primary care physicians and 23 endoscopists. Most (77 %) patients were white and privately insured (87 %) (Table 2).

There were 39 (3 %) deaths during the study. The median follow-up time was 6.1 years (interquartile range [IQR]: 4.1–8.8) after incident colonoscopy. The 1,429 patients with an incident colonoscopy completed another 978 subsequent colonoscopies during follow-up. Among follow-up endoscopies, the endoscopist listed symptoms as the only indication in 11 % ($n=107$), and these diagnostic exams were excluded, leaving 871 follow-up screening and surveillance exams.

Colonoscopy Findings

The cecum was not reached in 4 % ($n=56$) of incident colonoscopies (Table 2). Endoscopists documented the quality of bowel preparation for 57 % ($n=820$) of incident colonoscopies, including 21 % ($n=298$) indicating a problem with the preparation. The ADR was 33 % among incident screening colonoscopies (Table 3).

Among the incident screening exams in which no polyps ($n=713$) or only hyperplastic polyps ($n=338$) were detected, 41 % ($n=433$) had a subsequent endoscopy during the study. Among incident screening colonoscopies, endoscopists recommended follow-up intervals that were earlier than guideline recommendations in 58 % of exams including 62 % ($n=444$) of the 713 incident colonoscopies in which no polyps were detected, 75 % ($n=254$) of 338 incident colonoscopies with hyperplastic polyps, 39 % ($n=101$) of 257 incident colonoscopies with low-risk adenomas, and 30 % ($n=33$) of 109 screening colonoscopies with high-risk adenomas. A family history of CRC or polyps was noted in 16 % ($n=224$) of the 1,429 incident colonoscopies, and early follow-up was recommended by endoscopists in 71 % ($n=159$) of these exams.

The median time to follow-up after a colonoscopy differed by exam findings for incident colonoscopies. Follow-up ranged from 2.9 years following detection of high-risk adenomas to 6.9 years following detection of no polyps (log-rank $p<0.001$, Table 3). A total of 801 patients were censored, 270 due to clinical inactivity, 107 at time of a diagnostic endoscopy exam and 424 at the end of the study period.

Following detection of low-risk adenomas at the initial exam, 26.1 % of exams were not followed by a surveillance exam within one year after the recommended surveillance interval. Among initial exams in which high-risk adenomas were detected, 24.0 % were not followed up within one year after the recommended surveillance interval.

Among 433 follow-up screening colonoscopies performed after the incident colonoscopy detected no adenomas, 88.2 % ($n=382$) represented overuse. Among the 438 surveillance colonoscopies, 49.1 % ($n=215$) represented overuse exams.

Overuse of Follow-up Screening Colonoscopy

In Model 1, after adjusting for patient and exam characteristics, overuse of screening colonoscopy was associated with early interval follow-up recommended by the endoscopist (adjusted odds ratio [OR] 6.27, 95 % confidence interval [CI] 3.15–12.50)(Table 4).

In the hierarchical logistic regression model, a significant proportion of the variation in overuse of screening colonoscopies was associated with the endoscopist. The endoscopist-level variance was 0.72 (standard error 0.56) and accounted

Figure 1.. Study population. CRC=colorectal cancer.

for 18 % of unexplained variation in overuse after accounting for patient characteristics, exam findings and exam characteristics.

Overuse of Follow-Up Surveillance Colonoscopy

In Model 2, overuse of surveillance colonoscopy was positively associated with detection of a low-risk adenoma on the prior exam (compared to high-risk adenoma, OR 7.78, 95 % CI 4.11–14.70), problems with the bowel preparation (OR 1.42, 95 % CI 1.12–1.80), and endoscopist recommendations (OR 13.47, 95 % CI 6.61–27.46).

In hierarchical models of surveillance colonoscopy overuse, the endoscopist-level variance was 0.19 (standard error 0.16) and accounted for 5 % of unexplained variation in overuse after accounting for patient characteristics, exam findings and exam characteristics.

In sensitivity analyses, the significance of exam characteristics and endoscopist recommendations in predicting overuse of screening and surveillance exams were

unchanged when we excluded patients with a positive family history (results not shown).

Table 2. Characteristics of Patients with Incident Colonoscopy from 2001 to 2010, N=1,429

	N	%
Patient characteristics		
Age (median [IQR])	53	51–57
Female	743	52.0
Race		
White	1,007	77.0
Black	153	11.7
Other	123	8.6
Race missing or declined	146	10.2
Insurance status		
Commercial insurance	1,240	86.8
Medicare	17	1.2
Medicaid	25	1.8
Uninsured	147	10.3
Number of visits per year (median [IQR])	4.0	2.5–6.3
Exam characteristics		
Cecum reached	1,373	96.1
Bowel preparation quality		
Problem with bowel preparation	298	20.9
Adequate bowel preparation	522	36.5
Not documented	609	42.6
Endoscopist recommendation		
Earlier than guideline follow-up	832	58.2

Table 3. Colorectal Cancer Screening and Surveillance Endoscopy Exam Findings and Median Time to Next Colonoscopy

SCREENING	N (%)	Median Time (years)	IQR
INCIDENT SCREENING COLONOSCOPY ^a	Total=1,429		
No polyps	713 (50)	6.9	5.1-10.0
Hyperplastic polyp(s) only	338 (24)	5.7	4.9-9.7
1-2 small tubular adenoma(s)	257 (18)	5.1	3.3-6.3
3-10 adenomas, large adenoma, villous histology or high-grade dysplasia	109 (8)	2.9	2.0-3.4
Malignancy or > 10 adenomas ^b	12 (1)	—	—

IQR interquartile range

^a Time to next exam after incident screening colonoscopy differed by findings (Log-rank $p < 0.001$)

^b Time to next exam not calculated after malignancy or very-high-risk adenoma, because there is no guideline defined interval to next exam

DISCUSSION

We identified substantial inefficiency in the use of colonoscopy for CRC screening among an average-risk population, with many patients undergoing repeat exams at intervals much earlier than guideline recommendations currently support. This overuse appeared most pronounced following normal screening exams, where the median time to next exam was as short as 5.9 years in the setting of hyperplastic polyps. Endoscopists commonly recommended shorter screening and surveillance intervals than established guidelines support, and these

recommendations were strongly correlated with subsequent colonoscopy overuse.

Our findings are consistent with the prior studies of overuse of colonoscopy using claims data, while also adding critical insights to address overuse. Similar to our finding of a median 6.9 years to next screening colonoscopy, analyses of Medicare data demonstrated that nearly one-half of patients undergo colonoscopy less than 7 years after a negative screening colonoscopy.¹³ Other studies using Medicare data identified underuse of surveillance colonoscopy following adenoma detection.¹¹ This is consistent with our finding that one-quarter of exams in which adenomas were detected were not followed up by the guideline-recommended interval. Our analyses substantially expand on prior studies by assessing risk factors for early interval screening like bowel preparation quality and by providing information on overuse of colonoscopies for adenoma surveillance. Our findings were less consistent with studies of other local systems, including a Michigan study that examined endoscopists' recommendations after polypectomy and found that nearly all (84-94 %) patients received guideline-consistent recommendations.¹⁰

Our models suggest that endoscopist recommendations for early follow-up are a driver of overuse. This is consistent with prior studies showing endoscopist variation as a driver of potentially inappropriate colonoscopies among older patients.²⁸ Endoscopists are therefore a potential target for interventions to reduce overuse. Many endoscopists do not consistently agree with the follow-up intervals recommended in the guidelines and report preferences for shorter screening and surveillance intervals.^{17, 29-31} This reinforces the need to achieve endoscopists' support in addressing overuse, possibly by examining practice variation and establishing locally

Table 4. Predictors of Overuse of Screening or Surveillance Colonoscopy

	SCREENING COLONOSCOPY		SURVEILLANCE COLONOSCOPY	
	N=433		N=438	
	Odds ratio (95% Confidence interval)			
	Unadjusted % Overuse	Adjusted ^a	Unadjusted % Overuse	Adjusted ^a
Patient characteristics				
Age 60-65	86	Reference	40	Reference
Age 50-59	89	1.56 (0.66-3.72)	51	1.31 (0.69-2.47)
Male	88	Reference	47	Reference
Female	89	1.17 (0.64-2.13)	52	1.28 (0.94-1.74)
Insured	88	Reference	48	Reference
Uninsured	92	1.13 (0.43-2.95)	59	1.54 (0.67-3.51)
<4.0 visits per year	89	Reference	51	Reference
≥4.0 visits per year	87	0.86 (0.50-1.48)	46	1.24 (0.91-1.68)
Prior exam findings				
No bowel preparation problem	88	Reference	48	Reference
Problem with bowel preparation	88	1.01 (0.62-1.64)	52	1.42 (1.12-1.80)
No polyp	88	Reference	—	—
Hyperplastic polyp	88	0.61 (0.30-1.22)	—	—
High-risk adenoma	—	—	18	Reference
Low-risk adenoma	—	—	64	7.78 (4.11-14.70)
Endoscopist recommendation				
No early follow-up	76	Reference	18	Reference
Earlier than guideline follow-up	95	6.27 (3.15-12.50)	76	13.47 (6.61-27.46)

^aAdjusted for variables listed plus calendar year

endorsed standards. Identifying endoscopist characteristics associated with early follow-up preferences is important. Unfortunately, we did not have access to individual endoscopist characteristics to include this in the current study.

We found that bowel preparation was correlated with surveillance exam overuse. This variable has important limitations. In our sample, there was no standard scale or requirement to routinely document quality of preparation and there are no standard guidelines for follow-up in the case of poor bowel preparation.³² Initiatives to improve bowel preparation quality, potentially via patient education and support, represent another target that could reduce the overuse of surveillance exams. We did not find an association between bowel preparation and screening exam overuse. Perhaps endoscopists have a higher standard for preparation before a surveillance exam due to the higher risk of polyps. The lack of association with screening could also be due to the limitations of the variable. Bowel preparation problems did not appear to compromise adenoma detection in this population. Our observed ADRs are above quality thresholds.²⁴

While our study is strengthened by detailed clinical information, our findings should be considered in the context of some limitations. We relied on documentation from the EHR and were not able to account for patient preferences. Our study period was limited to 10 years and the median follow-up of patients with their first colonoscopy during this time was only 6.1 years.

Early follow-up recommendations may have been prompted by family history. Our cohort of adults who started screening over the age of 50 should include relatively few patients with a family history that would prompt short interval follow-up. However, early screening is not always delivered to patients with a high-risk family history,³³ so we further accounted for family history by repeating our analyses with and without patients noted to have any family history. This did not alter our findings. Future work may improve the accuracy of family history documentation by inviting patients to enter their own family history into their medical record.³⁴ We also collected the indication recorded in the medical record, which helped us distinguish screening from diagnostic exams,³⁵ but sometimes both screening and symptoms were listed as indications.

The newest surveillance guidelines recommend earlier follow-up for serrated polyps.²⁵ Although these guidelines were not in place during our study, serrated pathology may have prompted some early follow-up exams. Finally, we studied a single health system with high CRC screening rates. In this high screening uptake population, our system may have higher rates of overuse than systems with lower screening rates. We also did not have access to results from outside exams, which may represent further overuse. Our exam level analyses emphasized inefficiencies at the system level and did not focus on overuse of colonoscopy for a given patient over time (a patient-level analysis). We were primarily interested in understanding how many CRC screening exams in the system-represented services delivered without guideline-based evidence and what variables predict this type of utilization. Studying the health system in

this way offers important insights for other systems placing increased emphasis on preventive care.

Nationally, underuse of CRC screening continues to be a priority.^{36–38} Our findings should encourage other systems to integrate measures of overuse into programs designed to deliver preventive services. Such efforts could result in substantial reductions in potentially wasted resources. Performing screening colonoscopy on patients with a negative prior colonoscopy at 7 years instead of 10 years represents one excess colonoscopy for a patient enrolled in a screening program from age 50 to 74 years. In our study, using an average price of \$1,242 per colonoscopy,³⁹ this represents an excess \$1.3 million spent on screening the 1,051 patients with an initial negative colonoscopy. The fact that a large proportion of the 14 million screening colonoscopies performed annually in the US⁴⁰ may represent overuse of uncertain value to patients is especially concerning, in light of the 28 million Americans (35 %³⁶ of 80 million adults aged 50–74⁴¹) who are not up to date in CRC screening.

CONCLUSIONS

We found substantial inefficiency in CRC screening and surveillance with overuse of screening colonoscopies and surveillance of low-risk adenoma. Reducing variation in endoscopists' recommendations after endoscopy and improving the quality of bowel preparations for these procedures represent potential targets to improve the efficiency of screening and surveillance programs. Systematic approaches to measure both overuse and underuse of CRC screening and surveillance exams in real time will be needed to support such interventions.

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Conflicts of Interest: The authors declare no conflicts of interest pertaining to this work.

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