

Impact of a Clinical Decision Support System on Guideline Adherence of Surveillance Recommendations for Colonoscopy After Polypectomy

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Abstract

Background: Surveillance colonoscopy is required in patients with polyps due to an elevated colorectal cancer (CRC) risk; however, studies suggest substantial overuse and underuse of surveillance colonoscopy. The goal of this study was to characterize guideline adherence of surveillance recommendations after implementation of an electronic medical record (EMR)-based Colonoscopy Pathology Reporting and Clinical Decision Support System (CoRS). **Methods:** We performed a retrospective cohort study of patients who underwent colonoscopy with polypectomy at a safety-net healthcare system before (n=1,822) and after (n=1,320) implementation of CoRS in December 2013. Recommendations were classified as guideline-adherent or nonadherent according to the US Multi-Society Task Force on CRC. We defined surveillance recommendations shorter and longer than guideline recommendations as potential overuse and underuse, respectively. We used multivariable generalized linear mixed models to identify correlates of guideline-adherent recommendations. **Results:** The proportion of guideline-adherent surveillance recommendations was significantly higher post-CoRS than pre-CoRS (84.6% vs 77.4%; $P<.001$), with fewer recommendations for potential overuse and underuse. In the post-CoRS period, CoRS was used for 89.8% of cases and, compared with cases for which it was not used, was associated with a higher proportion of guideline-adherent recommendations (87.0% vs 63.4%; RR, 1.34; 95% CI, 1.23–1.42). In multivariable analysis, surveillance recommendations were also more likely to be guideline-adherent in patients with adenomas but less likely among those with fair bowel preparation and those with family history of CRC. Of 203 nonadherent recommendations, 70.4% were considered potential overuse, 20.2% potential underuse, and 9.4% were not provided surveillance recommendations. **Conclusions:** An EMR-based CoRS was widely used and significantly improved guideline adherence of surveillance recommendations.

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Colorectal cancer (CRC) screening can reduce CRC incidence and mortality.¹ Although CRC screening can be performed using stool-based methods or colonoscopy,

many US providers prefer colonoscopy because it is both diagnostic and therapeutic, permitting simultaneous removal of precancerous lesions.^{2,3}

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Surveillance colonoscopy is required after polypectomy given an elevated risk of recurrent polyps and cancer.^{4,5} The long-term effectiveness of colonoscopy-based screening depends on appropriate surveillance intervals; however, previous studies suggest there is substantial overuse and underuse.^{6–8} Underuse may increase risk of interval cancer and cancer-related mortality,^{9,10} whereas overuse is associated with unnecessary costs and an increased risk of potential harms.^{5,11–14} Appropriate surveillance colonoscopy intervals, a focus of healthcare reform in gastroenterology, is one of the Centers for Medicare and Medicaid Services Physician Quality Reporting System measures.

A prior study at Parkland Health and Hospital System, the sole safety-net healthcare system for Dallas County, demonstrated guideline-adherent surveillance intervals in 77.4% of patients who underwent a polypectomy during colonoscopy.¹⁵ Recommendations representing potential overuse, underuse, and missing surveillance recommendations were observed in 14.4%, 4.7%, and 3.5% of patients, respectively. To address this, we developed and implemented an electronic medical record (EMR)–based Colonoscopy Pathology Reporting and Clinical Decision Support System (CoRS) in December 2013. CoRS is a user-friendly, EMR-based template that captures data from colonoscopy and pathology reports and uses a computerized algorithm to generate tailored, guideline-adherent recommendations for the next surveillance colonoscopy after polypectomy.¹⁶ The CoRS algorithm is based on published guidelines and produces tailored reporting letters (in English and Spanish) for patients and their referring physicians. Provider acceptance and use in clinical practice exceeded 90% during the first 6 months after implementation. However, prior studies have shown that early provider acceptance of new interventions can decrease over time.¹⁶ Further, the impact of CoRS on guideline adherence to surveillance recommendations was unknown.

The goals of our study were to (1) evaluate the impact of CoRS implementation on guideline adherence of surveillance recommendations, (2) identify additional factors associated with guideline-adherent surveillance recommendations among patients who underwent colonoscopy with polypectomy, and (3) identify factors associated with providers' use of CoRS at an academic safety-net health system.

Methods

Study Setting and Population

We performed a retrospective cohort study of patients at Parkland Health and Hospital System (Parkland) who underwent colonoscopy with polypectomy. Parkland has a 4-room endoscopy unit, which performs 1,500 to 2,000 colonoscopies per year. Colonoscopies are completed by UT Southwestern Medical Center gastroenterology faculty with or without gastroenterology fellows, UT Southwestern Medical Center colorectal surgery faculty, or Parkland-employed gastroenterology faculty. For any patients with polypectomy, the endoscopist makes surveillance recommendations after polyp pathology is available. Any surveillance recommendations made by the fellows are reviewed and approved by the faculty, and therefore reflect the recommendations of the board-certified academic faculty. A county-funded, insurance-subsidy program facilitates access to medical care, including CRC screening and surveillance, for uninsured and underinsured individuals seen at Parkland.

We included 2 cohorts of patients who underwent colonoscopy, performed for any indication, with polypectomy: (1) a previously characterized cohort of consecutive patients who underwent polypectomy between June 1, 2011, and November 30, 2013, before CoRS implementation,¹⁵ and (2) consecutive patients who underwent polypectomy between October 1, 2014, and September 30, 2015, after CoRS implementation. Because CoRS underwent beta testing and refinement between December 2013 and September 2014, cases during this period were not included in either cohort. Both cohorts excluded patients with a personal history of CRC, inflammatory bowel disease (IBD), hereditary polypoid syndromes, prior colectomy, a Boston Bowel preparation score <5 or an endoscopic report of poor preparation quality (inadequate visualization of polyps <5 mm¹⁷), incomplete colonoscopy (defined as failure to intubate the cecum), and polyp retrieval failure. The study was approved by UT Southwestern Medical Center Institutional Review Board.

Colonoscopy Pathology Reporting System

As previously described,¹⁶ CoRS is a novel EPIC-based NoteWriter (PatientKeeper, Inc.) form that uses cascading questions in pull-down menus that prompt the endoscopist to report (1) cecal intubation, (2) quality of bowel preparation, (3) family his-

tory of colon cancer or polyps, (4) number of polyps, and (5) “worst finding” on pathology. For example, in a patient with a large tubular adenoma and a hyperplastic polyp, the worst finding would be “1 cm or larger adenoma.” For patients in whom adenomas are detected, endoscopists specify the presence of villous/tubulovillous histology, high-grade dysplasia, or piecemeal resection. The CoRS algorithm uses these data to generate surveillance recommendations adherent with US Multi-Society Task Force on CRC (MSTF) screening guidelines.⁴ Although CoRS generates an initial recommendation, users can override surveillance recommendations if desired, including the option to stop surveillance because of patient age and/or comorbidity. Similarly, users can override the surveillance recommendation with a shorter or longer interval as desired. CoRS was designed to be easy to use and can be completed quickly by endoscopists with minimal workflow disruption.¹⁶

Data Collection

Two investigators (M.M, E.Y.) abstracted patient demographics, clinical history (including personal or family history of colon polyps and/or CRC), and pathology data (including polyp type, villous histology, and presence of high-grade dysplasia) using standardized forms. A third investigator (A.G.S) was available to resolve any discrepancies. Endoscopic data were captured from Provation, our healthcare system’s electronic colonoscopy reporting system, including physician who performed the colonoscopy (and was thereby responsible for surveillance recommendations), indication (screening, surveillance, or diagnostic), bowel preparation quality (as determined by endoscopist), intubation of cecum, total number of polyps removed, size of largest polyp, and completeness of polyp removal.

We abstracted surveillance recommendations from colonoscopy results letters that had been sent to patients and providers, and recorded whether surveillance recommendations were made using CoRS. If a pathology-based recommendation was not available, we recorded surveillance recommendations in the initial colonoscopy report. Recommendations were compared with the MSTF guidelines and classified as guideline-adherent or nonadherent.⁴ Cases in which a results letter was not available and a recommendation was not present in the colonoscopy report were classified as guideline nonadherent (in

a “no recommendation” category). Nonadherent guideline recommendations were categorized as potential underuse (surveillance interval longer than guideline recommendations) or potential overuse (shorter interval than guideline recommendations).

Statistical Analysis

Our primary outcome was presence of guideline-adherent surveillance recommendations, defined as a dichotomous outcome (guideline-adherent vs nonadherent). We used a generalized linear mixed model to compare guideline adherence pre- versus post-CoRS, incorporating the nested structure of patients within providers. Univariable and multivariable generalized linear mixed model analysis identified correlates of guideline adherence among patients in the post-CoRS cohort, again incorporating the nested structure of patients within providers. Potential correlates included provider specialty (gastroenterology vs other) and year of training; month of the year; patient’s age, sex, race/ethnicity, insurance, American Society of Anesthesiologists (ASA) classification, and family history of colon cancer; colonoscopy indication; total adenomas; presence of high-grade dysplasia; and preparation quality. High-risk adenomas were defined as ≥ 3 adenomas, adenomas measuring ≥ 1 cm, sessile serrated adenoma/polyps, and any polyp containing high-grade dysplasia or villous histology. We also performed exploratory analyses for correlates of potential overuse and underuse, with appropriate use (ie, guideline-adherent) as the reference. Relative risks (RRs) and 95% CIs were computed from odds ratios to assess magnitude of associations in the setting of odds ratios > 2.5 and < 0.5 .¹⁸

Finally, we characterized provider use of CoRS among patients who underwent colonoscopy and polypectomy, including variation in proportion of use during the study period. We examined correlates for provider use of CoRS using multivariable generalized linear mixed model analysis with backward elimination. Statistical significance was defined as $P < .05$ for all multivariable analyses. All data analysis was conducted using SAS 9.4 (SAS Institute Inc.).

Results

Patient Characteristics

The post-CoRS cohort was derived from 1,533 patients who underwent colonoscopy with polypecto-

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my between October 2014 and September 2015. A total of 213 (13.9%) were excluded from our analysis of guideline-adherent recommendations: 43 had CRC, hereditary polyposis syndrome, or IBD; 13 had incidental non-CRC pathology requiring further diagnostic evaluation; 4 had a polyp that could not be retrieved; 107 had incomplete colonoscopy; and 46 had poor bowel preparation. Characteristics of the final post-CoRS cohort (n=1,320) are shown in Table 1. Median age was 58 years (range, 23–91 years), with 249 (18.9%) aged >65 years, and approximately half (56.4%) were women. Patients were racially diverse, with 40.8% Hispanic, 37.1% black, and 17.7% non-Hispanic white. Bowel preparation quality was good or excellent in most cases, although 359 (27.2%) had fair preparation. Polyp histology included 366 (27.7%) with no adenomas, 646 (48.9%) with 1 to 2 adenomas, and 308 (23.3%) with ≥3 adenomas. Some differences were seen in the pre-CoRS (n=1,822) and post-CoRS cohorts regarding patient age, colonoscopy indication, and bowel preparation quality. However, we noted similar colonoscopy findings, including type of polyps, number of adenomas, and proportion with high-grade dysplasia or requiring piecemeal resection (Table 1).

Impact of CoRS on Guideline Adherence

Provision of guideline-adherent surveillance recommendations was significantly more common in the post- versus the pre-CoRS cohort (84.6% vs 77.4%; $P<.001$) (Figure 1). In both cohorts, approximately two-thirds of nonadherent recommendations were categorized as potential overuse, one-fifth were deemed potential underuse, and 10% to 15% cases did not have any surveillance recommendations. In a sensitivity analysis excluding colonoscopies without surveillance recommendations, guideline adherence of surveillance recommendations remained significantly higher in the post-CoRS versus the pre-CoRS cohort (85.9% vs 80.2%; $P<.001$).

Of 1,822 patients in the pre-CoRS cohort, 1,410 (77.4%) were provided guideline-adherent surveillance recommendations; 85 (4.7%) had recommendations consistent with potential underuse, 263 (14.4%) consistent with potential overuse, and 64 (3.5%) had no surveillance recommendation issued. Of 1,320 patients in the post-CoRS cohort, 1,117 (84.6%) were provided guideline-adherent surveil-

Table 1. Patient Characteristics

Variable	Pre-CoRS Cohort (N=1,822)	Post-CoRS Cohort (N=1,320)	P Value
Age			
<50 y	253 (13.9%)	148 (11.2%)	.001
50–54 y	403 (22.1%)	300 (22.7%)	
55–59 y	385 (21.1%)	295 (22.4%)	
60–65 y	417 (22.9%)	328 (24.9%)	
>65 y	364 (20.0%)	249 (18.9%)	
Sex, male (%)	838 (46.0%)	576 (43.6%)	.11
Race/Ethnicity			
Non-Hispanic white	427 (23.4%)	234 (17.7%)	<.001
Black	721 (39.6%)	489 (37.1%)	
Hispanic	582 (31.9%)	539 (40.8%)	
Other	92 (5.0%)	58 (4.4%)	
Provider specialty			
Gastroenterology	1,822 (100%)	1,314 (99.5%)	.004
Surgery	–	6 (0.5%)	
Provider year			
First year fellow	430 (23.6%)	192 (14.6%)	<.001
Second year fellow	573 (31.4%)	406 (30.8%)	
Third year fellow	502 (27.6%)	618 (46.8%)	
Faculty	317 (17.4%)	104 (7.9%)	
Colonoscopy indication			
Screening	511 (28.2%)	482 (36.5%)	<.001
Surveillance	325 (17.9%)	264 (20.0%)	
Diagnostic	986 (53.9%)	574 (43.5%)	
Bowel preparation quality			
Excellent	335 (18.4%)	467 (35.4%)	<.001
Good	1,068 (58.6%)	494 (37.4%)	
Fair	419 (23.0%)	359 (27.2%)	
Polyp type			
Hyperplastic	487 (26.8%)	366 (27.7%)	.27
Tubular adenoma	1,276 (70.3%)	908 (68.8%)	
Sessile serrated adenoma/polyp	52 (2.9%)	46 (3.5%)	
Number of adenomas			
None	493 (27.0%)	366 (27.7%)	.14
1–2	963 (52.9%)	646 (48.9%)	
≥3	366 (20.1%)	308 (23.3%)	
Largest polyp size			
<10 mm	1,500 (82.3%)	1,167 (88.8%)	<.001
≥10 mm	322 (17.7%)	147 (11.1%) ^a	
Piecemeal resection	72 (4.0%)	36 (2.7%)	.21
High-grade dysplasia	18 (1.0%)	14 (1.1%)	.93

Abbreviation: CoRS, Colonoscopy Pathology Reporting and Clinical Decision Support System.

^a6 patients have missing polyp size.

lance recommendations, 41 (3.1%) had recommendations consistent with potential underuse, 143 (10.8%) consistent with potential overuse, and 19 (1.4%) had no surveillance recommendation issued.

Guideline Adherence of Surveillance Recommendations

Of the 1,320 patients who underwent polypectomy in the post-CoRS cohort, CoRS was used in 1,186 (89.8%). In multivariable adjusted analyses, use of CoRS was associated with increased likelihood of guideline-adherent recommendations: 87.0% among CoRS users compared with 63.4% among those who did not use CoRS (RR, 1.34; 95% CI, 1.24–1.42).

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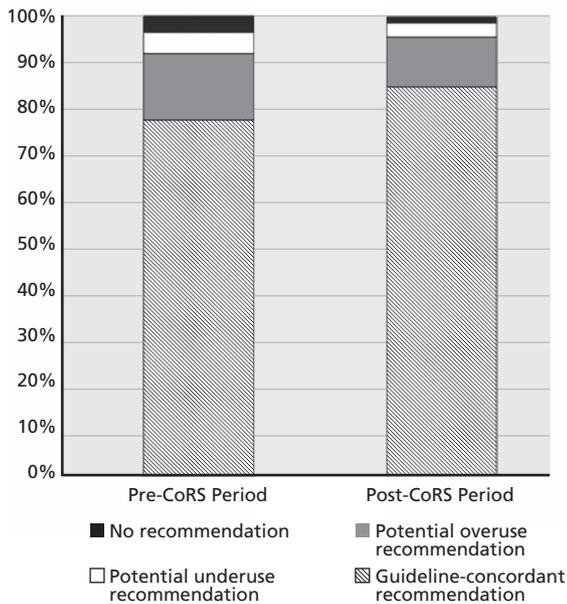


Figure 1. Guideline adherence to surveillance recommendations for pre-CoRS and post-CoRS cohorts.

Abbreviation: CoRS, Colonoscopy Pathology Reporting and Clinical Decision Support System.

Surveillance recommendations were also more likely to be guideline-adherent in patients with adenomas (RR, 1.15; 95% CI, 1.09–1.20 for 1–2 adenomas, and RR, 1.22; 95% CI, 1.16–1.25 for ≥ 3 adenomas) but less likely to be guideline-adherent among patients with fair bowel preparation (RR, 0.80; 95% CI, 0.69–0.89) and those with a family history of colon cancer (RR, 0.86; 95% CI, 0.77–0.97) (Table 2). Recommendations were guideline-adherent in 75.7% of patients without adenomas, 86.8% of those with 1 to 2 small adenomas (< 10 mm), 82.0% of those with 1 to 2 large adenomas (≥ 10 mm), and 91.6% of patients with ≥ 3 adenomas. Other factors, including patient age ($P=.24$), patient insurance ($P=.88$), and provider year of training ($P=.18$) were not associated with guideline adherence.

In the subset of patients with any adenoma ($n=954$), use of CoRS (RR, 1.33; 95% CI, 1.12–1.39) and fair bowel preparation quality (RR, 0.85; 95% CI, 0.74–0.93) were the only factors significantly associated with guideline adherence. An association between CoRS use and guideline adherence was observed in those with high- and low-risk adenomas (RR, 1.20; 95% CI, 1.04–1.27, and RR, 1.55; 95% CI, 1.38–1.65, respectively).

Potential Overuse and Underuse of Recommended Surveillance Intervals

Among the 203 patients who received nonadherent surveillance recommendations in the post-CoRS cohort, 143 recommendations (70.4%) were categorized as potential overuse, 41 (20.2%) were deemed potential underuse, and 19 patients (9.4%) did not receive any surveillance recommendations. Among potential overuse recommendations ($n=143$), 72 (50.4%) were 1 to 2 years shorter, 47 (32.9%) were 3 to 5 years shorter, and 24 (16.8%) were > 5 years shorter than guideline recommendations. Among potential underuse recommendations, 22 (53.7%) were 1 to 2 years longer, 15 (36.6%) were 3 to 5 years longer, and 4 (9.8%) were > 5 years longer than guideline recommendations.

In exploratory secondary analyses, potential overuse of surveillance was less likely among patients in whom CoRS was used (RR, 0.55; 95% CI, 0.33–0.88) and those with adenomas (RR, 0.55; 95% CI, 0.38–0.79 for 1–2 adenomas, and RR, 0.12; 95% CI, 0.06–0.25 for ≥ 3 adenomas), but more likely among patients with fair bowel preparation quality (RR, 3.77; 95% CI, 2.65–5.12) and those with a family history of CRC (RR, 1.74; 95% CI, 1.08–2.68). The only factor associated with potential underuse of surveillance colonoscopy was presence of 1 to 2 adenomas (RR, 0.31; 95% CI, 0.13–0.72).

Factors Associated With CoRS Use

Correlates of CoRS use in univariate and multivariable analysis are reported in Table 3. CoRS was less likely to be used for colonoscopies performed by surgeons compared with gastroenterologists (RR, 0.003; 95% CI, < 0.001 –0.98), colonoscopies completed for diagnostic rather than screening indications (RR, 0.94; 95% CI, 0.87–0.99), and procedures with fair versus excellent bowel preparation (RR, 0.92; 95% CI, 0.83–0.99). CoRS was more likely to be used for colonoscopies in which an adenoma was detected (RR; 1.14; 95% CI, 1.10–1.16 for 1–2 adenomas, and RR, 1.14; 95% CI, 1.09–1.17 for ≥ 3 adenomas) and procedures performed after the first quarter of the academic year when new gastroenterology fellows begin their program (RR, 1.18–1.21 for second through fourth quarters of academic year).

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Table 2. Correlates of Guideline Adherent Surveillance Recommendations in the Post-CoRS Cohort

Variable	Unadjusted Analysis RR (95% CI)	Adjusted Analysis RR (95% CI)	Proportion With Guideline-Adherent Recommendations	P Value
Use of CoRS	1.38 (1.30–1.44)	1.34 (1.24–1.42)	87.0% vs 63.4%	<.001
Family history of CRC	0.93 (0.83–1.00)	0.86 (0.77–0.97)	79.2% vs 85.3%	.008
Bowel preparation quality				
Excellent	Ref	Ref	86.5%	<.001
Good	1.04 (0.99–1.08)	1.05 (0.99–1.08)	91.1%	
Fair	0.81 (0.72–0.90)	0.80 (0.69–0.89)	73.3%	
Number of adenomas				
None	Ref	Ref	75.7%	<.001
1–2	1.15 (1.09–1.20)	1.15 (1.09–1.19)	86.4%	
≥3	1.21 (1.16–1.25)	1.22 (1.16–1.25)	91.6%	

Abbreviations: CoRS, Colonoscopy Pathology Reporting and Clinical Decision Support System; CRC, colorectal cancer; RR, relative risk.

Discussion

Our study is one of the first to evaluate the impact of an EMR-based clinical decision support (CDS) tool on guideline adherence for postpolypectomy surveillance recommendations. CoRS had sustained provider uptake and was used in nearly 90% of all colonoscopies with polypectomy >1 year after its implementation. CoRS implementation significantly improved guidelines adherence of surveillance recommendations. However, 15% of surveillance recommendations after CoRS implementation were not adherent with guidelines, and most nonadherent recommendations represented potential overuse.

Our findings show that a colonoscopy reporting system can increase the delivery of guideline-adherent surveillance recommendations. This delivery was significantly higher than observed in our pre-CoRS cohort, improving from 77% of cases before CoRS to 86% after implementation. In the post-CoRS cohort, recommendations were guideline-adherent in nearly 90% of patients for whom CoRS was used compared with only two-thirds of patients for whom it was not used. Although there were no significant changes in endoscopy faculty or other interventions implemented during this period, this increase in guideline adherence could be related to other factors given the study's pre/post design. For example, it is possible there were temporal trends in provider knowledge or awareness of surveillance guidelines given changes in gastroenterology fellows over the study period. Although the efficacy of CoRS would be best evaluated using a randomized controlled trial or step-wedge design, our study has the benefit of characterizing its effectiveness at improving surveillance recommendations when implemented as part of routine clinical care.

Among non-guideline-adherent recommendations in our study, nearly three-fourths were related to potential overuse, which decreases colonoscopy value by increasing costs and risks of screening harms with relatively small increases in screening benefits. Independent of CoRS use, fair bowel preparation quality was strongly associated with nonadherent recommendations, which may be driven by fear of missed lesions in patients with suboptimal preparation quality.^{19–21} These data highlight issues that must be addressed to improve colonoscopy value. First, interventions are needed to improve preparation quality and reduce the need for short-interval examinations.^{22,23} Colonoscopies with suboptimal bowel preparation not only have lower likelihood of benefits, given the possibility of missed lesions,²⁴ but also are associated with increased risk of harm from procedural-related complications, such as perforation. Second, there is a need for increased direction on how fair bowel preparation quality should impact surveillance recommendations. Although it is clear that examinations with poor preparation should be repeated within a short interval—typically <1 year—ideal surveillance intervals for patients with fair bowel preparation are less clear, particularly if limited to a single segment of the colon. Guidelines state that a 5-year interval can be considered for patients with fair preparation quality in whom small adenomas are detected but provide less direction for other patients with fair preparation quality, such as those with only hyperplastic polyps.⁴ The Boston Bowel Preparation Scale provides a more objective assessment of preparation quality, but there is still a potential “grey zone” (scores of 5–6) with limited guidance about whether and how surveillance intervals should be adjusted.²⁵ In our study, shorter-than-recommended intervals in patients with fair prepa-

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Table 3. Correlates of CoRS Use in the Post-CoRS Cohort

Variable	Unadjusted Analysis RR (95% CI)	Adjusted Analysis RR (95% CI)	P Value
Provider specialty			
Gastroenterology	Ref	Ref	.044
Surgery	0.04 (0.001–0.58)	0.003 (<0.001–0.98)	
Quarter of year			
July–September (Q1)	Ref	Ref	<.001
October–December (Q2)	1.19 (1.12–1.22)	1.21 (1.14–1.24)	
January–March (Q3)	1.15 (1.07–1.20)	1.18 (1.09–1.22)	
April–June (Q4)	1.16 (1.09–1.21)	1.19 (1.12–1.23)	
Bowel preparation quality			
Excellent	Ref	Ref	.041
Good	0.99 (0.95–1.03)	0.98 (0.92–1.02)	
Fair	0.96 (0.90–1.00)	0.92 (0.83–0.99)	
Colonoscopy indication			
Screening	Ref	Ref	.048
Surveillance	1.01 (0.97–1.00)	1.00 (0.94–1.04)	
Diagnostic	0.95 (0.91–0.99)	0.94 (0.87–0.99)	
Insurance status			
Medical subsidy plan	Ref	Ref	.040
Medicare	1.04 (0.99–1.07)	1.01 (0.97–1.07)	
Medicaid	1.06 (1.01–1.09)	1.08 (1.03–1.11)	
Commercial	1.01 (0.90–1.00)	1.00 (0.87–1.07)	
Number of adenomas			
None	Ref	Ref	<.001
1–2	1.11 (1.07–1.14)	1.14 (1.10–1.16)	
≥3	1.12 (1.07–1.15)	1.14 (1.09–1.17)	

Abbreviations: CoRS, Colonoscopy Pathology Reporting and Clinical Decision Support System; RR, relative risk; Q1, first quarter; Q2, second quarter; Q3, third quarter; Q4, fourth quarter.

ration quality were labeled as “potential overuse”; however, because several studies have shown an association between suboptimal bowel preparation and interval cancers, particularly in the proximal colon where polyps can be flat and difficult to detect without optimal visualization,^{26–29} many of these recommendations may have been appropriate.

Although potential overuse of surveillance colonoscopy can be related to additional factors, including lack of knowledge about guidelines or financial incentives,^{30–32} we believe these factors were less relevant in the setting of a safety-net healthcare system with academic faculty. CDS systems such as CoRS address some factors, such as lack of knowledge, but other factors such as financial incentives and fear of interval cancers can persist and drive guideline-non-adherent surveillance recommendations.

Although providers accepted and used CoRS in nearly 90% of cases 1 year after initial implementation, provider uptake was not universal. CoRS was less likely to be used during the first quarter of the academic year and by surgeons (vs gastroenterologists). Increased uptake in later months of the academic year

likely reflects a learning curve after new fellows enter the gastroenterology training program and highlights the need for continual provider education and training with new providers/users.³³ Lower use among nongastroenterologists similarly reflects a deficiency in our initial training, which was targeted to the gastroenterology division. Although UT Southwestern Medical Center gastroenterology fellows and faculty perform most colonoscopies within the health system, other providers who perform colonoscopies, such as surgeons, also require education and training for increased uptake and maximal benefit of CoRS.

There have been other CDS systems to match colonoscopy findings with recommended surveillance intervals. For example, the American Gastroenterological Association developed a CDS based on guidelines that can be embedded into EMRs to facilitate use at point of care.³⁴ Imler et al³⁵ also evaluated an automated system using natural language processing from colonoscopy free-text reports and CDS to facilitate guideline-adherent surveillance recommendations. However, to our knowledge, CoRS is the only reporting system built into the EMR that automatically generates tailored reporting letters, in English and Spanish, for patients and their referring physicians. A limitation of CoRS is that the system is not fully automated and requires some manual input of key colonoscopy and pathology data from providers. However, similar to the system implemented by Leiman et al³⁶ to calculate adenoma detection rates, the process is simply one additional, brief, straightforward step completed after pathology results are available.⁵

Our study has some limitations. First, because it was conducted in a single safety-net health system, results may not be generalized to other settings given variation in drivers of financial gain and endoscopic capacity between institutions. Second, our study’s quasi-experimental study design is prone to temporal trends and confounders that are unrelated to the intervention. Third, gastroenterology fellows made most surveillance recommendations in our study; however, there was direct input by gastroenterology board-certified faculty in all cases. Furthermore, understanding surveillance patterns among fellows is important because they represent the next generation of endoscopists. Fourth, our study was limited by missing data and potential confounders that might have been undocumented drivers of surveillance recommendations. Similarly, there is potential

measurement bias with factors such as bowel preparation quality. Finally, we assessed the intermediate outcome of surveillance recommendations and not when surveillance examinations were performed. The recommendation—necessary but not sufficient for appropriate participation in surveillance—is still informative because providers often depend on endoscopist recommendation for timing of surveillance colonoscopy referrals.³⁷

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Conclusions

Implementation of CoRS, an EPIC-based colonoscopy results reporting and CDS system, was highly successful and used for nearly 90% of all colonoscopies with polypectomy. Its implementation significantly improved guideline adherence of surveillance recommendations. CoRS can be an effective tool for increasing value of CRC screening.