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SYSTEMATIC REVIEWS AND META-ANALYSES

Siddharth Singh, Section Editor

Endoscopy Unit Level Interventions to Improve Adenoma Detection Rate: A Systematic Review and Meta-Analysis

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This article has an accompanying continuing medical education activity, also eligible for MOC credit, on page e53. Upon completion of the CME activity, successful learners will be able to identify and explain the rationale behind interventions to improve the ADR that can be implemented on an endoscopy unit level.

BACKGROUND & AIMS: **Adenoma detection rate (ADR) is inversely correlated with the risk of interval colon cancer and is a key target for quality improvement in endoscopy units. We conducted a systematic review and meta-analysis to identify and evaluate the effectiveness of interventions that can be implemented at the endoscopy unit level to improve ADRs.**

METHODS: **Following Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines, a systematic search was conducted in MEDLINE, Embase, and Cochrane Central Register of Controlled Trials databases between January 1990 and December 2022 to identify relevant studies. Both randomized controlled trials and observational studies were eligible. Data for the primary outcome of ADR were analyzed and reported on the log-odds scale with 95% CIs using a random-effects meta-analysis model using the empiric Bayes estimator.**

RESULTS: **From 10,778 initial citations, 34 studies were included in the meta-analysis comprising 371,041 procedures and 1501 endoscopists. The provision of report cards (odds ratio [OR], 1.28; 95% CI, 1.13–1.45; $P < .001$) and the presence of an additional observer to identify polyps (OR, 1.25; 95% CI, 1.09–1.43; $P = .002$) were associated with significant increases in ADRs whereas multimodal interventions were borderline significant (OR, 1.18; 95% CI, 1.00–1.40; $P = .05$) and withdrawal time monitoring was not associated significantly with an increase in ADRs (OR, 1.35; 95% CI, 0.93–1.96; $P = .11$).**

CONCLUSIONS: **The provision of report cards and the presence of an additional observer to identify polyps are associated with improved ADRs and should be considered for implementation in endoscopy facilities.**

Keywords: Adenoma Detection Rate; Endoscopists; Report Card; Feedback; Quality Improvement.

Colorectal cancer is a major cause of morbidity and mortality and is the second leading cause of cancer-related deaths in the United States, accounting for more than 50,000 deaths annually.[1] Among the screening tools available, screening colonoscopies have been associated with a reduction in both the incidence of and mortality from colorectal cancer through the detection and resection of precancerous adenomatous polyps.[2–4] However, the effectiveness of screening colonoscopy is highly dependent on the quality of the procedure. Among the many quality indicators studied, the adenoma detection

Abbreviations used in this paper: **AADR, advanced adenoma detection rate; ACG, American College of Gastroenterology; ADR, adenoma detection rate; ASGE, American Society for Gastrointestinal Endoscopy; GRADE, Grading of Recommendations Assessment, Development and Evaluation; PDR, polyp detection rate; NOS, Newcastle–Ottawa scale; OR, odds ratio; PCCRC, postcolonoscopy colorectal cancer; RCT, randomized clinical trial.**

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rate (ADR) has emerged as the most important because of its correlation with the risk of developing postcolonoscopy colorectal cancer (PCCRC). A landmark study involving 45,026 subjects and 186 endoscopists from the National Colorectal Cancer Screening Program in Poland found a 10-fold increased risk of PCCRC when comparing endoscopists with an ADR of less than 20% to those with an ADR of 20% or higher.[5] Furthermore, using data from 314,872 colonoscopies performed by 136 gastroenterologists, Corley et al[6] subsequently reported that each 1% increase in ADR was associated with a 3% decrease in the risk of PCCRC.

The American Society for Gastrointestinal Endoscopy (ASGE), the American College of Gastroenterology (ACG),[7] and the United States Multi-Society Task Force[8] recommend endoscopists achieve an overall ADR of 25% or higher, with the American Gastroenterology Association suggesting an ADR of 30% or higher.[9] Unfortunately, marked variation in detection rates have been reported among endoscopists, estimated to be in the magnitude of 3- to 6-fold.[6,10,11] Given the increased risk of PCCRC associated with low ADR, improving it has become a major focus for quality improvement. To this end, numerous strategies have been studied, which can be broadly categorized as follows: (1) endoscopy unit–level interventions, which generally are interventions that can be applied broadly to a roster of endoscopists and often is implemented on a systems level; (2) procedure-targeted interventions, which generally involve more significant changes in endoscopy technique and more commonly is implemented on an individual endoscopist level; and (3) technology-based interventions, which involves novel devices and equipment to improve visualization. Of these categories, endoscopy unit–level interventions are perhaps the easiest to implement widely because they generally require fewer changes in the technical aspect of how a colonoscopy is performed. Thus, the objective of this study was to conduct a systematic review and meta-analysis to identify endoscopy unit–level interventions aimed at improving ADRs and their effectiveness.

What You Need to Know

Background

Many potential interventions to improve the adenoma detection rate (ADR) are available in the literature, but evidence-based guidance on which to implement in the endoscopy unit are lacking.

Findings

In this systematic review and meta-analysis, we found that issuing report cards and having an additional observer detect polyps both significantly increased the ADR.

Implications for patient care

Endoscopy units should consider using these interventions to improve the ADR of their endoscopists.

Methods

Overview and Eligibility Criteria

The objective of this systematic review and meta-analysis was to identify studies that evaluated the effectiveness of any intervention aimed at improving ADRs that could be implemented at an endoscopy unit level. Both randomized controlled trials and observational studies were included. We excluded studies that evaluated interventions aimed at improving procedural factors and technological factors because these already have been studied in prior meta-analyses.[12,13] Case reports, case series, interventions that focused on trainees, or studies that focused on a specific patient subgroup, such as inflammatory bowel disease, were excluded. The systematic review was conducted and reported according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement recommendations.[14] The study was registered on PROSPERO (CRD42018090483).

Search Strategy

Systematic searches were conducted in Ovid MEDLINE, Embase, and the Cochrane Central Register of Controlled Trials databases from January 1990 through December 2022, restricted to adults (age, >18 y) and published in the English language. The search queries were developed using combinations of exploded and nonexploded subject headings and free-text terms such as, but not limited to, the following: "colonoscopy," "colon polyp," "colon adenoma," "adenoma detection rate," "ADR," "total quality management," "health care quality," "quality improvement," "performance improvement," "quality indicator," "endoscopist-related characteristics," or "endoscopist-related factors," using variant spellings and word endings. The search strategies were modified for each database to include database-specific index terms (Supplement 1). Bibliographies of included studies and relevant guidelines from the American Gastroenterology Association, ACG, ASGE, Canadian Association of Gastroenterology, and European Society of Gastrointestinal Endoscopy from the preceding 5 years were screened. Finally, abstracts from scientific meetings for the past 5 years for Digestive Disease Week, ACG Annual Scientific Meeting, and United European Gastroenterology Week were reviewed.

Study Screening and Data Extraction

Two reviewers (A.A., C.M.) independently screened the titles and abstracts from the search results to determine which study met eligibility criteria followed by independent assessment of the full text and data extraction using a

bespoke form after calibration between the 2 reviewers. The form was pilot tested on a sample of studies a priori. Discrepancies between the 2 reviewers were resolved by consensus, and, failing that, were resolved by a third senior reviewer (M.S.) who made the final determination. Data extraction from observational studies typically involved abstracting study outcomes before and after an intervention whereas data extraction from randomized clinical trials (RCTs) involved abstracting study outcomes after randomization.

Risk of Bias and Quality Assessment

The Newcastle–Ottawa scale (NOS) was used to assess the risk of bias in observational studies (Supplement 2).[15] Each study could be awarded a maximum of 1 star for each numbered item within the Selection and Outcome domains and 2 stars for the Comparability domain, for a maximum of 9 stars. Studies with a NOS score of 3 or fewer stars were classified as high risk of bias. For RCTs, the Cochrane Collaboration's tool for assessing the risk of bias was used (Supplement 3).[16] The tool consists of 7 domains (sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessors, incomplete outcome data, selective outcome reporting, and other sources of bias) and classification of the overall risk of bias. All domains had to be rated as having a low risk of bias for the overall risk of bias to be classified as low. In cases of unclear risk of bias or mixed assessments of low and unclear risk of bias, the overall judgment was classified as having an unclear risk of bias. If any of the domains were classified as high risk, then the trial was considered to be at high risk of bias. Finally, the quality of evidence overall for each intervention in improving the ADR was assessed using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) scale.[17]

Outcomes

The primary outcome of interest was the ADR, defined as the proportion of colonoscopies in which at least 1 adenoma was found. Secondary outcomes of interest were polyp detection rate (PDR) and advanced adenoma detection rate (AADR). PDR was defined as the proportion of colonoscopies in which at least 1 polyp was found while AADR was defined as the proportion of colonoscopies in which at least 1 advanced adenoma was found (size $\geq$10 mm; any villous component; or high-grade dysplasia). For studies that reported the outcome of interest at multiple time points after an intervention, we included only the first outcome assessment period for the meta-analysis.

Statistical Analyses

Binary end point data were collected for detection of adenomas, advanced adenomas, and polyps. These data were analyzed on the log-odds scale using a random-effects meta-analysis model using the empiric Bayes (also called Paule–Mandel) estimator. Statistical effect-size heterogeneity was assessed using the chi-squared test and quantified the relative proportion of variation using the I2 statistic. Univariable random-effects meta-regression was performed with study-level characteristics to explore potential effects of confounding. The variables considered were the study design, publication year, indication for endoscopy, funding source, geographic location, practice setting (academic or nonacademic or both), mean patient age, and proportion of female patients. Publication bias was explored using graphical methods (funnel plot) as well as using the Peters' regression-based test (with more than 3 studies) or else Begg's nonparametric test. The nonparametric approach was preferred when there were fewer studies because we believed the regression tests would be more likely to be anticonservative. The trim-and-fill nonparametric approach to assessing publication bias also was used to try to detect potentially missing studies from the literature and assess how sensitive the pooled estimate was to these hypothetical studies. However, formal tests of publication bias were viewed with an appropriate amount of caution when there were few studies available. Statistical analysis was performed using Stata (version 17; StataCorp LLC).

Results

Study Selection

A total of 10,780 citations were identified in the initial search, of which 263 were eligible for full text review and 40 studies were identified as relevant (Figure 1). Six studies had unique interventions that could not be combined, leaving 34 studies for the meta-analysis. Of the excluded studies, 1 study[18] involved a combination of withdrawal time monitoring and a journal club meeting to review an article on inspection technique, 1 study[19] involved withdrawal time monitoring combined with a bowel preparation intervention, 1 study[20] involved the combination of withdrawal time monitoring and feedback, 1 study involved posting a timer on the screen as an add-on to withdrawal time monitoring by a nurse,[21] 1 study[22] evaluated the impact of video monitoring on ADR, and 1 study used a specialized report card that was based on recording procedure videos from each endoscopist followed by tailored feedback and instructional videos based on specific needs.[23]

Study Characteristics and Quality

A summary of the studies included in the meta-analysis is presented in Table 1.[20,24–58] Overall, endoscopy unit–level interventions were divided into the following categories: (1) report card interventions, (2) multimodal interventions, (3) presence of additional observers, and (4) withdrawal time monitoring

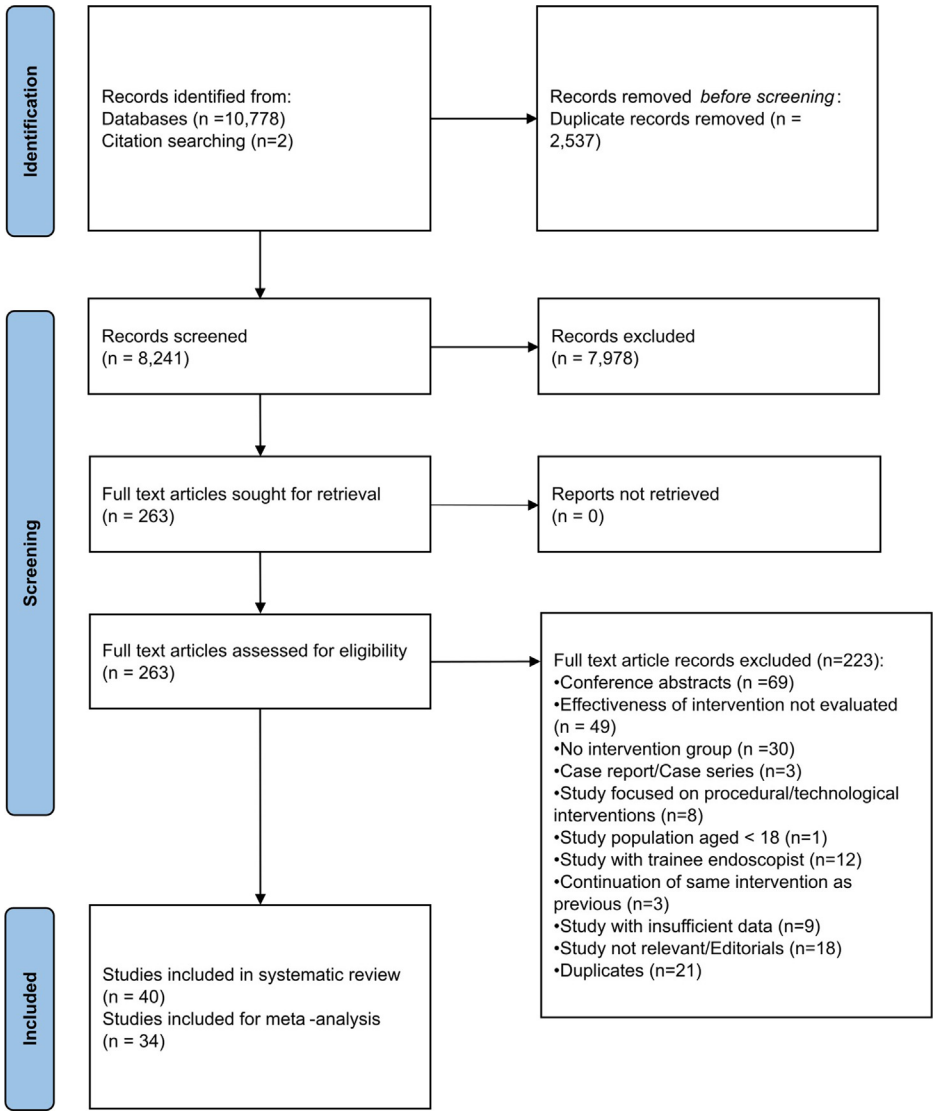

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses flowsheet of studies identified in systematic review and meta-analysis.

interventions. A total of 26 studies were observational and all studies were interrupted time-series in which a study outcome was compared before and after an intervention. There were 8 RCTs identified, of which 6 evaluated the efficacy of an intervention by comparing the ADRs between those who were and were not randomized to the intervention,[25,28,51,54,55,58] whereas 2 studies compared 2 different interventions to determine their relative efficacies.[30,36]

Study quality assessed using the NOS and the Cochrane risk of bias tool is summarized in Supplement 4. Study quality for observational studies was relatively high, with only 3 studies found to be at high risk for bias. The most common source of bias was the potential for lack of comparability between study arms in studies that compared ADR before and after an intervention. However, given the short time interval between the 2 observation periods, it was unlikely non-study intervention-related differences, such as improvements in colonoscope technology, major changes in the endoscopist roster, or substantial changes in the patient population served by the endoscopy unit, had much impact and overall we believed the threat to validity in reality was low overall. For the 8 randomized control trials, all were classified as being at high risk of bias. This was because none of the trials could be blinded owing to the nature of the intervention being a quality-improvement initiative, which requires active participation and behavior change on the part of the physician. Nonetheless, 7 of 8 trials had blinded outcome assessors and with the omission of the blinding domain, which is impossible to implement in this scenario, the risk of bias otherwise was low in the remaining domains. Finally, when assessing the quality of the evidence overall for each intervention using the GRADE framework,[17] all were scored as low because most studies were observational in nature.

Intervention: Report Card

Adenoma detection rate. A total of 15 studies, comprising 1243 endoscopists and 293,741

Table 1. Summary of Characteristics of Studies Included in the Meta-Analysis

Study, year	Intervention	Study type[a]	Continent	Endoscopists, N, specialty, practice type	Colonoscopies, N, preintervention/ postintervention	Patient mean age, *y*	Patient sex, % female	Colonoscopy indication	Description of intervention	Postintervention observation period, *mo*	Preintervention ADR	Postintervention ADR
Abdul-Baki et al,[26] 2015	Report card	3	North America	9, GI, nonacademic	2627/14,899	59.4	53.1	Screening, surveillance, FOBT/FIT, and symptomatic	Public reporting initiative of global colonoscopy quality indicators including ADR, with data reported preintervention and postintervention	34	25.1	36.4
Asgeirsson et al,[27] 2011	Withdrawal time monitoring	3	North America	18, GI and general surgery, nonacademic	900/750	58.2	51.8	Screening only	Recording of WT via timer following institutional recommendation for minimum 6-minute time with ADR measured preintervention and postintervention	6	7.2	9.6
Aslanian et al,[28] 2013	Presence of additional observers	1	North America	7, not reported, academic	249/243	57.9	48.6	Screening only	Active participation of endoscopy nurse with >1.5 years of experience during colonoscopy withdrawal to find polyps ADR measured between groups with endoscopist and nurse participating vs group with endoscopist alone	0	40.6	47
Baker et al,[29] 2015	Withdrawal time monitoring	3	North America	Not reported	1342/1316	58.5	53.5	Screening only	Recording of WT following policy for minimum 6-minute time with PDR measured preintervention and postintervention	9	Not reported	Not reported

Table 1. Continued

Study, year	Intervention	Study type[a]	Continent	Endoscopists, N, specialty, practice type	Colonoscopies, N, preintervention/ postintervention	Patient mean age, *y*	Patient sex, % female	Colonoscopy indication	Description of intervention	Postintervention observation period, *mo*	Preintervention ADR	Postintervention ADR
Coe et al,[30] 2013	Multimodal	1	North America	15, GI, academic	680/520	Not reported	50.5	Screening, surveillance, FOBT/FIT, and symptomatic	EQUIP I: 2 PowerPoint (Microsoft) presentations (approximately 1 hour each) + monthly ADR feedback + access to educational materials First session: methods and technical aspects, lesion recognition (focus on flat lesions); second session: preintervention and post-test on neoplastic vs non-neoplastic lesions and advanced imaging modalities ADR compared between group that received feedback on individual ADR once vs group that received EQUIP training	7	35.9	46.7
Deng et al,[31] 2016	Report card	2	Asia	12, not reported, academic	1165/1302	55.4	49.1	Screening, surveillance, FOBT/FIT, and symptomatic	Report cards detailing ADR, WT, bowel preparation quality, cecal intubation, details of anesthesia, insertion time, and complications ADR measured preintervention and postintervention	6	16.1	20
Evans et al,[32] 2020	Multimodal	3	North America	17, GI and general surgery, academic	833/850	60.3	54	Screening, surveillance, FOBT/FIT, and symptomatic	Colonoscopy Skills Improvement program, consisting of 1 day hands-on endoscopy sessions, with 2 certified faculty teaching up to 3 endoscopists per session and individualized feedback provided ADR measured preintervention and postintervention	8	31.8	35.3

Table 1. Continued

Study, year	Intervention	Study type[a]	Continent	Endoscopists, N, specialty, practice type	Colonoscopies, N, preintervention/ postintervention	Patient mean age, *y*	Patient sex, % female	Colonoscopy indication	Description of intervention	Postintervention observation period, *mo*	Preintervention ADR	Postintervention ADR
Gurudu et al,[33] 2017	Report card	2	North America	16, GI staff and fellows, academic	555/1057	58.7	48	Screening only	Scorecard containing individual anonymized ADR, PDR, SPDR, and AADR of each endoscopist and for the group ADR measured preintervention and postintervention	6	30.5	37.7
Hoff et al,[34] 2021	Multimodal	3	Europe	Not reported, not reported, setting: National CRC screening program	5390/6879	Not reported	53.4	Not reported	3-day train-the-colonoscopy trainer course held at endoscopy laboratories with patients and focused on improving both the trainer's own skills in colonoscopy and the skills needed to instruct trainees ADR measured preintervention and postintervention	12	Not reported	Not reported
Inra et al,[35] 2017	Report card	2	North America	28, GI, academic and nonacademic	991/996	57.4	52.7	Screening only	2 scorecards with individual endoscopists' ADR, WT, and CIR for males and females separately were distributed ADR measured preintervention and postintervention	3	26.7	24.2

Table 1. Continued

Study, year	Intervention	Study type[a]	Continent	Endoscopists, N, specialty, practice type	Colonoscopies, N, preintervention/ postintervention	Patient mean age, *y*	Patient sex, % female	Colonoscopy indication	Description of intervention	Postintervention observation period, *mo*	Preintervention ADR	Postintervention ADR
Kaminski et al,[36] 2016	Multimodal	1	Europe	Not reported, not reported, setting: National CRC screening program	2977/3381	57	63.9	Screening only	One group receiving Train Colonoscopy Leaders course with 3 phases Phase I: 2-hour environmental assessment visit by endoscopy nurses (10 colonoscopies) and 2-day training by UK trainers (skills improvement, training the trainer, leadership training) Phase II: 2-day hands-on training Phase III: repeat previous nurse assessments (10 colonoscopies); and evaluation of first 30 colonoscopies with feedback Separate group receiving report card feedback on quality indicators including ADR preintervention and postintervention ADR compared between report card group and Train Colonoscopy Leaders course group	8	17.4	25.6
Kahi et al,[37] 2013	Report card	3	North America	6, GI and general surgery, academic	336/592	59.8	67	Screening only	Quarterly report card detailing ADR, bowel preparation quality documentation, cecal intubation, and WT ADR measured preintervention and postintervention	24	44.7	53.9
Keswani et al,[24] 2015	Report card	2	North America	20, GI, academic	2444/6811	Not reported	Not reported	Screening only	Distribution of scorecard detailing individual and institutional ADRs and WT, including the 10th and 90th percentiles ADR measured preintervention and postintervention	0	28	31

Table 1. Continued

Study, year	Intervention	Study type[a]	Continent	Endoscopists, N, specialty, practice type	Colonoscopies, N, preintervention/ postintervention	Patient mean age, *y*	Patient sex, % female	Colonoscopy indication	Description of intervention	Postintervention observation period, *mo*	Preintervention ADR	Postintervention ADR
Lee et al,[25] 2011	Presence of additional observers	1	Asia	20, GI staff and trainees, academic	384/407	58.4	47	Screening only	Active participation of endoscopy nurses at detecting polyps during withdrawal ADR compared in group with endoscopist and nurse participating vs endoscopist alone	0	43.2	48.2
Lim et al,[59] 2022	Report card	3	Europe	48, GI and general surgery, nurse, trainees, academic and nonacademic	2226/2050	Not reported	Not reported	Screening, surveillance, FOBT/FIT, and symptomatic	Individualized feedback letter to endoscopists with their own key performance indicators including ADR and PDR compared with anonymized data of other endoscopists within department every 6 months	6	12.7	12.2
Manes et al,[39] 2019	Withdrawal time monitoring	2	Europe	6, not reported, nonacademic	330/330	60.1	45.6	Screening, surveillance, FOBT/FIT, and symptomatic	Endoscopists were informed that their WT was being monitored by an endoscopy nurse with ADR measured before being informed and after	3	27.3	33.6
Murchie et al,[40] 2018	Report card	2	North America	14, GI and general surgery, academic	1047/1156	Not reported	53	Screening only	Endoscopists sent monthly report cards with individual PDR, group PDR, and suggested benchmarks ADR measured preintervention and postintervention	6	29.2	29.6
Parihar et al,[42] 2018	Withdrawal time monitoring	2	Europe	3, GI, academic	260/1079	56.6	55	Screening, surveillance, FOBT/FIT, and symptomatic	Recording of mandatory timed WT of 6 minutes by endoscopy nurses along with WT displayed on screen, with ADR measured preintervention and postintervention	24	10.4	17.8

Table 1. Continued

Study, year	Intervention	Study type[a]	Continent	Endoscopists, N, specialty, practice type	Colonoscopies, N, preintervention/ postintervention	Patient mean age, *y*	Patient sex, % female	Colonoscopy indication	Description of intervention	Postintervention observation period, *mo*	Preintervention ADR	Postintervention ADR
Pedersen et al,[43] 2020	Multimodal	2	Europe	20, GI staff and trainees, academic	894/1488	64.2	Not reported	Screening, surveillance, FOBT/FIT, and symptomatic	(1) Two colonoscopy skills upgrading courses (scope handling, patient positioning and techniques to improve visualization), 2 polypectomy courses and, 1 train-the-trainer course; (2) Biannual report card feedback with individual and group PDR and CIR PDR measured preintervention and postintervention	3	Not reported	Not reported
Rajasekhar et al,[44] 2015	Multimodal	2	Europe	118, GI and general surgery, nurse, trainees, academic and nonacademic	4351/13,157	Not reported	54.8	Diagnostic only	(1) Training of lead colonoscopist and endoscopy nurse at each center on evidence bundle of WT $\geq$6 minutes, use of hyoscine butylbromide, use of supine patient position for transverse colon examination, and performance of rectal retroflexion; (2) local leads provided 45-minute session on bundle including video presentation local training; (3) monthly email reminders and feedback every 6 months ADR measured preintervention and postintervention	9	16	18.1
Rasschaert et al,[60] 2022	Report card	2	Europe	9, GI, academic	682/752	Not reported	Not reported	Screening, surveillance, FOBT/FIT, and symptomatic	Provided individualized feedback on personal and group ADR, PDR, bowel preparation adequacy, CIR, and percentage of polyps confirmed to be adenomas	5	22.9	27.5

Table 1. Continued

Study, year	Intervention	Study type[a]	Continent	Endoscopists, N, specialty, practice type	Colonoscopies, N, preintervention/ postintervention	Patient mean age, *y*	Patient sex, % female	Colonoscopy indication	Description of intervention	Postintervention observation period, *mo*	Preintervention ADR	Postintervention ADR
Razzak et al,[45] 2016	Withdrawal time monitoring	2	North America	6, GI, academic	540/528	61.2	4.7	Screening, surveillance, FOBT/FIT, and symptomatic	Email sent out to endoscopists about monitoring of WT by endoscopy nurse with WT placed on templated report ADR measured preintervention and postintervention	3	21.4	36
Seo et al,[47] 2020	Report card	2	Europe	15, GI, academic	1278/1811	59.1	40.3	Screening, surveillance, FOBT/FIT, and symptomatic	Report card with individual and group ADR sent out via email every 3 months ADR measured preintervention and postintervention	6	39.7	44.1
Sey et al,[48] 2017	Report card	2	North America	17, GI and general surgery, academic	1133/1985	58.6	59.8	Screening only	Two scorecards containing individual CIR, ADR, PDR, AADR, CRCd, perforation rate, and bowel preparation quality compared with institutional mean distributed to endoscopists annually ADR measured preintervention and postintervention	12	34.5	41.2
Taber and Romagnuolo,[49] 2010	Withdrawal time monitoring	3	North America	Not reported, not reported, academic	1405/1387	55.1	60.2	Screening, surveillance, FOBT/FIT, and symptomatic	Recording of WT by automatic calculation through endoscopic software using cecal arrival time stamp and displayed to endoscopist with PDR measured preintervention and postintervention	5	Not reported	Not reported

Table 1. Continued

Study, year	Intervention	Study type[a]	Continent	Endoscopists, N, specialty, practice type	Colonoscopies, N, preintervention/ postintervention	Patient mean age, *y*	Patient sex, % female	Colonoscopy indication	Description of intervention	Postintervention observation period, *mo*	Preintervention ADR	Postintervention ADR
Testoni et al,[61] 2023	Multimodal	2	Europe	21, not reported, academic and nonacademic	2314/1190	Not reported	48	Screening, surveillance, FOBT/FIT, and symptomatic	Online training module in which experts presented and discussed European and American Society of Gastrointestinal Endoscopy colonoscopy indicators and techniques to complete colonoscopy and reach cecum	20	40.1	36.9
Tinmouth et al,[51] 2021	Report card	1	North America	833, GI and general surgery and internal medicine, academic and nonacademic	72,745/170,940	Not reported	51.4	Screening, surveillance, FOBT/FIT, and symptomatic	Double-sided confidential report card with 9 performance indicators (colonoscopy volume, CIR, polypectomy rate and bleeding, perforations, CRC, PCCRC, poor bowel preparation, and percentage of normal colonoscopies) emailed to endoscopists with individual scores compared with provincial average ADR measured between group receiving report card and group not receiving report card	12	29.2	30.2
Uche-Anya et al,[52] 2020	Report card	2	North America	194, GI and general surgery, academic and nonacademic	2106/4209	60.1	56.1	Screening only	Quarterly report cards distributed via email detailing individual and site ADR, CIR, WT, bowel preparation, and follow-up recommendations ADR measured preintervention and postintervention	20	15.6	26.2

Table 1. Continued

Study, year	Intervention	Study type[a]	Continent	Endoscopists, N, specialty, practice type	Colonoscopies, N, preintervention/ postintervention	Patient mean age, *y*	Patient sex, % female	Colonoscopy indication	Description of intervention	Postintervention observation period, *mo*	Preintervention ADR	Postintervention ADR
Vavricka et al,[53] 2016	Withdrawal time monitoring	2	Europe	7, GI, academic	355/203	Not reported	48.2	Screening only	Monitoring of WT by endoscopy nurses with timer with endoscopists aware of being monitored ADR measured preintervention and postintervention	4.5	21.4	36
Wallace et al,[54] 2017	Multimodal	1	North America	Not reported	3092/8673	Not reported	52.5	Screening only	1-hour lecture focusing on improving adenoma detection (EQUIP I/II intervention) followed by 1- to 2-hour review session, identification of low performers, and discussion of obstacles to high-quality colonoscopy In addition, telephone calls offered to discuss implementation progress and optional 1-on-1 proctoring offered EQUIP posters posted in endoscopy units ADR compared between sites receiving EQUIP vs sites not receiving EQUIP	0	31	42
Wang et al,[55] 2018	Presence of additional observers	1	Asia	Not reported, not reported, academic	291/296	53.3	53	Screening only	Endoscopy nurse with >3 years of endoscopy experience assisted in polyp detection during withdrawal ADR compared between group with endoscopist and nurse participating vs group with endoscopist alone	0	23	30.4

Table 1. Continued

Study, year	Intervention	Study type[a]	Continent	Endoscopists, N, specialty, practice type	Colonoscopies, N, preintervention/ postintervention	Patient mean age, *y*	Patient sex, % female	Colonoscopy indication	Description of intervention	Postintervention observation period, *mo*	Preintervention ADR	Postintervention ADR
Wazir et al,[56] 2018	Presence of additional observers	2	North America	Not reported, not reported, academic	765/916	Not reported	58	Surveillance only	Endoscopy technicians with >3 years of endoscopy experience assisted in polyp detection during withdrawal ADR measured preintervention without technician assistance and postintervention	0	37.6	41.8
Yamakawa et al,[57] 2021	Report card	3	Asia	11, not reported, nonacademic	803/803	53.6	52.9	Screening, surveillance, FOBT/FIT, and symptomatic	Endoscopists were presented their ADR, MAP, and SPDR in a ranked bar chart format at meeting followed by director individually meeting and informing endoscopist of their scores ADR measured preintervention and postintervention	5	40.8	50.8
Yao et al,[58] 2021	Report card	1	Asia	11, not reported, academic	367/231	47.9	56.6	Screening, surveillance, FOBT/FIT, and symptomatic	Computer-generated weekly report card including ADR, PDR, withdrawal time, and cecal intubation ADR compared between group that received intervention vs group that did not	2	10.8	20.3

AADR, advanced adenoma detection rate; ADR, adenoma detection rate; CIR, cecal intubation rate; CRCd, colorectal cancer detection; EQUIP, Endoscopic Quality Improvement Program; FOBT/FIT, fecal occult blood test/ fecal immunochemical test; GI, gastrointestinal; MAP, mean adenoma per procedure; PCCRC, postcolonoscopy colorectal cancer; PDR, polyp detection rate; SPDR, sessile polyp detection rate; WT, withdrawal time.
[a]1, randomized control trial; 2, prospective cohort; 3, retrospective cohort.

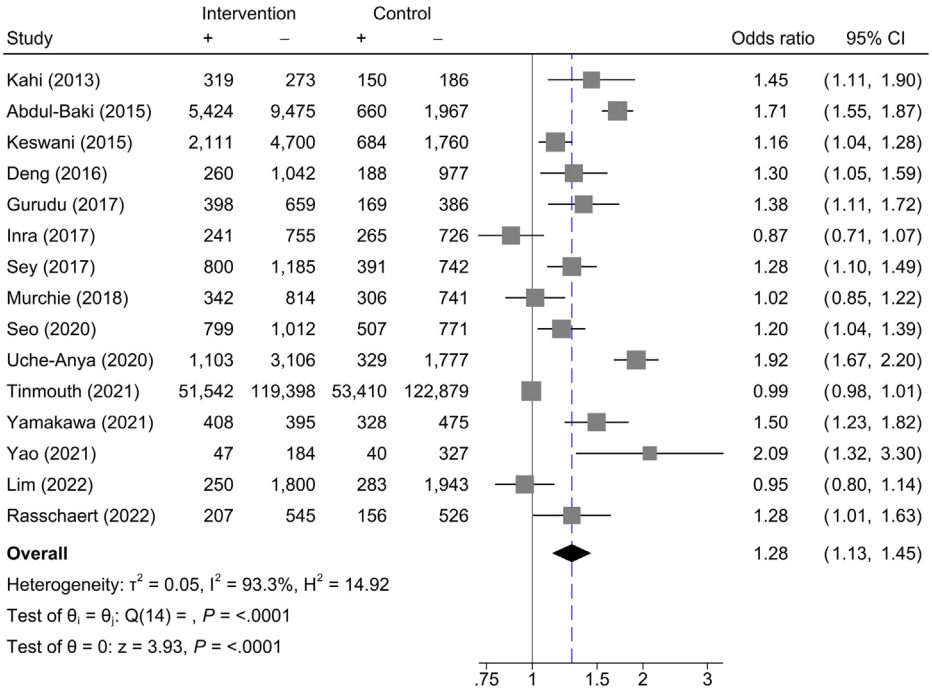

Figure 2. Forest plot comparing the impact of report card intervention on adenoma detection rate. +, presence of outcome; -, absence of outcome.

procedures, evaluated the effect of report cards on ADR (Figure 2, Table 2). A total of 13 were cohort studies[24,26,31,33,35,37,40,47,48,52,57,59,60] whereas 2 were randomized controlled trials.[51,58] All cohort studies used an interrupted time-series design that compared ADR before and after an intervention and the median preintervention period, postintervention period, and delay between them, were 6 months (IQR, 3–6 mo), 7 months (IQR, 6–17 mo), and 0 months (IQR, 0–1 mo), respectively. Report cards generally were provided as an endoscopist-specific audit and feedback of colonoscopy performance measures, such as bowel preparation quality, cecal intubation rate, withdrawal time, PDR, and ADR, benchmarked against their peers. Two studies provided PDR without ADR in their report cards.[40,51] All report cards were provided confidentially to the endoscopists with the exception of one,[26] in which the report was available publicly. Six studies limited cases to screening colonoscopy.[24,33,37,40,47,52]

Overall, implementation of a report card intervention was associated with a significant increase in ADR (odds ratio [OR], 1.28; 95% CI, 1.13–1.45; $P < .001$). There was statistically significant heterogeneity among observed studies ($I^2 = 93.5\%$), although the magnitude of between-study heterogeneity was not large ($\tau^2 = 0.047$), with most studies yielding similar effect sizes. Subgroup analysis limited to observational studies with the exclusion of clinical trials produced similar results (OR, 1.28; 95% CI, 1.14–1.45). Among the 13 cohort studies, 4 studies[26,37,40,47] reported small changes in patient variables in the preintervention and postintervention groups, 6 did not report on temporal variations, and 3 reported no differences in patient variables during the entire study period, with a subgroup analysis limited to these 3 studies not showing any significant changes in the effect estimate (OR, 1.39; 95% CI, 1.24–1.57). Similarly, meta-analysis restricted to screening colonoscopies did not produce significantly different results (OR, 1.35; 95% CI, 1.09–1.68).[24,33,37,40,52] Heterogeneity was explored further via meta-regression of potential variables of interest, including study design, publication year, procedural indication, funding source, continent, practice

Table 2. Impact of Interventions on Colonoscopy Quality-Related Outcomes

Quality improvement interventions	Adenoma detection rate (OR, 95% CI)	Polyp detection rate (OR, 95% CI)	Advanced adenoma detection rate (OR, 95% CI)	Quality of Evidence based on GRADE[17]
Report card	1.28 (1.13–1.45)	1.27 (1.11–1.44)	1.28 (0.93–1.77)	Low
Multimodal	1.18 (1.00–1.40)	1.26 (1.04–1.53)	–	Low
Additional observers	1.25 (1.09–1.43)	–	–	Low
Withdrawal time monitoring	1.35 (0.93–1.96)	1.13 (0.89–1.43)	–	Low

GRADE, Grading of Recommendations Assessment, Development and Evaluation; OR, odds ratio.

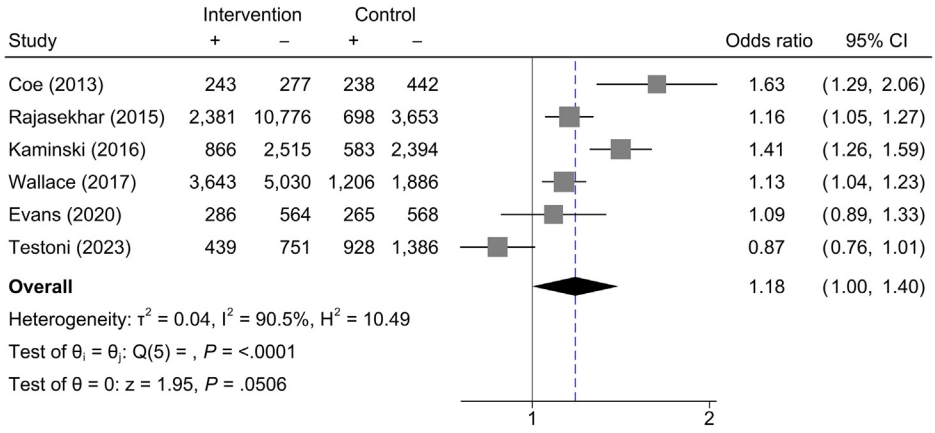

Figure 3. Forest plot comparing the impact of multimodal intervention on adenoma detection rate. +, presence of outcome; -, absence of outcome.

setting, patient age, and patient sex, although none were statistically significant. Based on the forest plot and supported by Peters' regression test of small-study effects, there was no suggestion of publication bias (Supplement 5*A*)

Other outcomes. There were 10 studies comprising 984 endoscopists and 280,005 procedures that evaluated the effect of report cards on PDR. Implementation of the intervention was associated with a significant increase in PDR (OR, 1. 27; 95% CI, 1.11–1.44; $P < .001$). There was statistically significant heterogeneity among observed studies ($I^2 = 68.1\%$), although the magnitude of between-study heterogeneity was not large ($\tau^2 = 0.013$), with most studies yielding similar effect sizes. Based on the forest plot and supported by Peters' regression test of small-study effects, there was no suggestion of publication bias (Supplement 5*B*).

There were 7 studies comprising 91 endoscopists and 30,016 procedures that evaluated the effect of report cards on AADR. Implementation of the intervention was not associated with a significant increase in the AADR (OR, 1.28; 95% CI, 0.93–1.77; $P = .13$). There was statistically significant heterogeneity among observed studies ($I^2 = 80.9\%$). Based on the forest plot and supported by Peters' regression test of small-study effects, there was no suggestion of publication bias (Supplement 5*C*).

Intervention: Multimodal Intervention

Adenoma detection rate. A total of 6 studies comprising 171 endoscopists and 42,018 procedures evaluated the effect of multimodal intervention on ADR (Figure 3). Three were cohort studies using an interrupted time-series design[32,44,61] and 3 were RCTs.[30,36,54] Four studies[30,44,54,61] used didactic lectures that focused on withdrawal technique, optimal visualization, and polyp detection, whereas 2 added a hands-on component, either as a single-day Colonoscopy Skills Improvement[32] or 2-day Train Colonoscopy Leaders[36] course. Studies generally included procedures performed for all indications with the exception of 2 that included only screening colonoscopies.[36,54]

Overall, the pooled OR for the intervention was 1.18 (95% CI, 1.00–1.40; $P = .051$). There was statistically significant heterogeneity among the observed studies ($I^2 = 91.3\%$), but the magnitude of between-study heterogeneity was not large ($\tau^2 = 0.033$), with most studies yielding similar effect sizes. Subgroup analysis limited to RCTs had a higher pooled OR than cohort studies although by the random-effects model, this difference was not statistically significant (OR, 1.35; 95% CI, 1.10–1.66 vs OR, 1.03; 95% CI, 0.87–1.23). Similarly, subgroup analyses comparing didactic only vs didactic with hands-on sessions and studies limited to screening colonoscopies revealed no significant differences in the pooled OR. One study had a co-intervention, consisting of report cards that were issued to the intervention group only and this study reported a significant increase in ADR (OR, 1.13; 95% CI, 1.04–1.23).[54] Based on the forest plot and supported by Peters' regression test of small-study effects, there was no suggestion of publication bias (Supplement 5*D*).

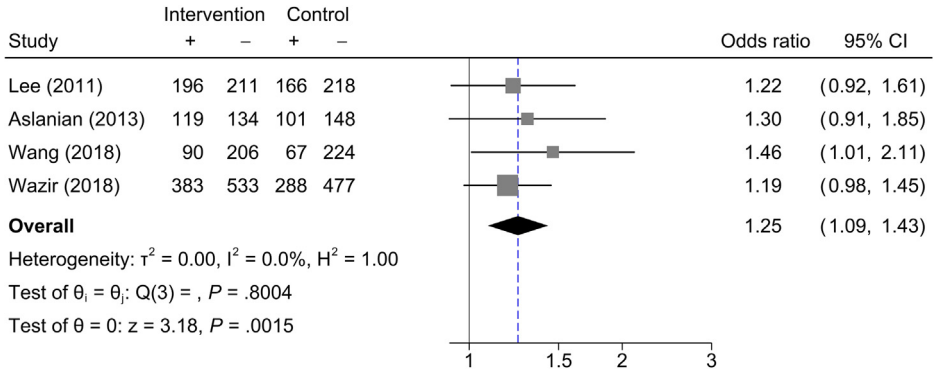

Figure 4. Forest plot comparing the impact of having an additional observer on the adenoma detection rate. +, presence of outcome; -, absence of outcome.

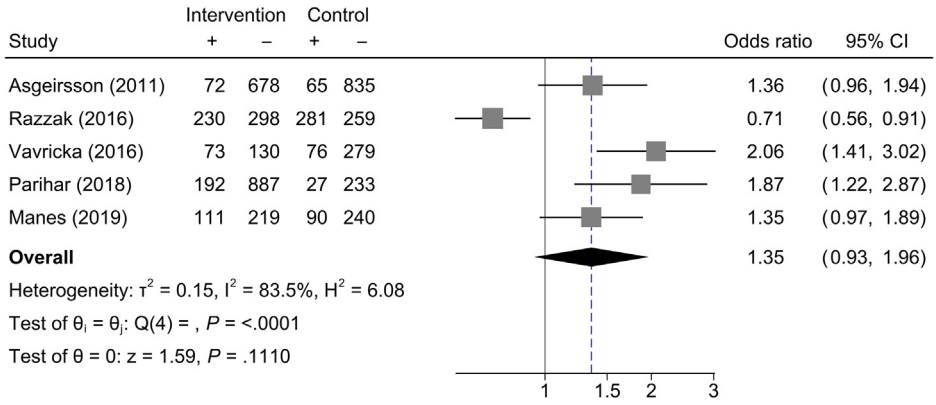

Figure 5. Forest plot comparing the impact of withdrawal time monitoring intervention on adenoma detection rate. +, presence of outcome; -, absence of outcome.

Other outcomes. There were 4 studies comprising 35 endoscopists and 27,616 procedures that evaluated the effect of multimodal intervention on PDR. Implementation of the intervention was associated with a significant increase in the PDR (OR, 1.26; 95% CI, 1.04–1.53; $P <$ .018). There was statistically significant heterogeneity among observed studies ($I^2 = 91.8\%$). However, the magnitude of between-study heterogeneity was not large ($\tau^2 = 0.033$), with most studies yielding similar effect sizes. Based on the forest plot and supported by Peters' regression test of small-study effects, there was no suggestion of publication bias (Supplement 5*E*).

Intervention: Presence of Additional Observer

Adenoma detection rate. A total of 4 studies comprising 27 endoscopists and 3561 procedures evaluated the effect of having an additional observer identify polyps (Figure 4). All were RCTs with the exception of 1 cohort study that used an interrupted time-series design.[56] The intervention used in the RCTs consisted of a nurse who helped detect polyps during the procedure whereas the cohort study used a technician who received special training on polyp detection instead.

Implementation of the intervention was associated with a significant increase in the ADR (OR, 1.25; 95% CI, 1.09–1.43; $P = .0015$). There was no evidence of heterogeneity ($I^2 = 0.0\%$). Subgroup meta-analysis limited to the RCTs produced similar results (OR, 1.25; 95% CI, 1.09–1.43). Based on the forest plot and supported by Peters' regression test of small-study effects, there was no suggestion of publication bias, although these tests may be unreliable with fewer than 10 studies (Supplement 5*F*).

Intervention: Withdrawal Time Monitoring

Adenoma detection rate. A total of 5 studies comprising 40 endoscopists and 5275 procedures evaluated the effect of withdrawal-time monitoring interventions on ADR (Figure 5). All were cohort studies using an interrupted time-series design. The median preintervention period, postintervention period, and interval between them were 4.5 months (IQR, 3–6 mo), 4.5 months (IQR, 3–6 mo), and 0 months (IQR, 0–0 mo), respectively. All studies used a similar intervention, which consisted of notifying the endoscopists that the nurse would be recording their withdrawal time. Most studies did not measure a baseline withdrawal time except for 2 studies that reported both preintervention and postintervention withdrawal times.[39,53] In 1 study,[53] the withdrawal time increased from 4.5 to 6 minutes whereas it increased from 4.5 to 6.4 minutes in the other study.[39] Two studies included only screening colonoscopies.[27,53]

Overall, the pooled OR for this intervention was 1.35 (95% CI, 0.93–1.96; $P = .11$). There was statistically significant heterogeneity among observed studies ($I^2 = 79.9\%$). Subgroup analysis limited to the 2 studies that reported significant increases in withdrawal time after the intervention had a higher point estimate (OR, 1.65; 95% CI, 1.09–2.50), but was not significantly different from the overall meta-analysis. Similarly, subgroup analysis limited to screening colonoscopies produced similar results. Based on the forest plot and supported by Peters' regression test of small-study effects, there was no suggestion of publication bias (Supplement 5*G*).

Other outcomes. There were 5 studies comprising 40 endoscopists and 5275 procedures that evaluated the effect of withdrawal-time monitoring interventions on PDR. Implementation of the intervention was not associated with a significant increase in the PDR (OR, 1.13; 95% CI, 0.89–1.43; $P = .33$). There was statistically significant heterogeneity among observed studies ($I^2 = 95.8\%$). Based on the forest plot and supported by Peters' regression test of small-study effects, there was no suggestion of publication bias (Supplement 5*H*).

Discussion

Colonoscopy has great potential in reducing the mortality and morbidity resulting from colorectal cancer, but only if precancerous adenomatous polyps are reliably detected and removed. To this end, the ADR has become one of the most widely accepted quality metrics for colonoscopy and 2 landmark studies have shown an

inverse correlation with the risk of PCCRC.[5,6] Accordingly, the ADR is a desirable target for quality improvement, but this should be guided by the best available evidence. In the first systematic review and meta-analysis of endoscopy unit–level interventions, involving 34 studies and 371,041 procedures, we found report cards and having an additional observer help identify polyps were associated with significant increases in the ADR. We found that benchmarking individual endoscopists against their peers was important for improving ADR performance because this was the common thread among all report card–based interventions. Overall, report cards increased the odds of detecting an adenoma by 28%. In terms of the method of delivery for feedback, only 1 study[26] used public reporting of colonoscopy quality indicators whereas the rest delivered report cards privately to physicians. This suggests that confidential feedback did not impede self-improvement, which is desirable to avoid stigmatization of low ADR performers.

In contrast to audit and feedback, multimodal interventions provided structured teaching in the form of a didactic session with or without a brief hands-on component to improve withdrawal technique and polyp detection. Overall, this intervention was borderline effective at increasing the ADR (OR, 1.18; 95% CI, 1.00–1.40; $P = .051$). Although subgroup analysis of the 3 RCTs reported a higher pooled OR, this difference was not statistically significant. Regardless, there is little evidence that study design in itself plays a large role in explaining differences in effect size estimates between observational studies and RCTs, and, instead, it is the inherent differences between studies beyond study design that likely is more important.[62] To this end, it should be noted that the trial conducted by Wallace et al[54] also could be interpretated as a negative study given the increase in ADR after the intervention was offset by an increased ADR in the control group, and the trial by Kaminski et al[36] only enrolled endoscopists with a low ADR, which may represent a group more suitable for this type of intervention.

We found the presence of additional observers, such as an endoscopy nurse, increased the ADR by 25%. This observation may be explained by the presence of a second set of eyes to identify polyps or, more pragmatically, by the Hawthorne effect, whereby endoscopists may be more careful because they know someone else is watching the screen. Regardless, extra training for the observer does not seem to be necessary because the 3 RCTs all used endoscopy nurses who did not receive any additional polyp detection training. Thus, endoscopy unit nurses should be encouraged to speak up should they see a polyp the endoscopist missed.

Although prior observational studies have reported an association between longer withdrawal time and higher ADR, we did not find implementation of withdrawal time monitoring improved ADR. It is plausible that a longer withdrawal time is a surrogate marker for a more meticulous endoscopist and the improved ADR seen in prior studies was a result of this rather than the withdrawal time itself. Furthermore, there is increasing consensus that inspection technique likely is more important than withdrawal time per se,[63,64] whereby withdrawing more slowly without spending the time washing, suctioning, looking behind folds, re-examining segments, and meticulously scrutinizing the mucosa, may by itself be insufficient. Unlike the other interventions, withdrawal time monitoring has never been studied using a randomized design, and, as such, the quality of evidence must be considered weaker. Ultimately, we are not advocating for shorter withdrawal times but instead suggest that it be recognized that a withdrawal time greater than 6 minutes is not a guarantee of quality. To this end, the limitations of withdrawal time as a quality measure increasingly is recognized, with the ASGE, ACG, and European Society of Gastrointestinal Endoscopy, suggesting it be used primarily for physicians with an ADR that is below the target.[64–66]

There were 4 limitations of our study that should be mentioned. First, because of the lack of a widely accepted standard for when postintervention outcomes should be assessed, different intervals between intervention implementation and outcome assessment were used by individual studies. To address this, we used the first time point for studies that measured postintervention ADR more than once. Reassuringly, the effect of the intervention on ADR generally held for subsequent measurements among these studies. Second, the majority of included studies were observational by design, and despite attempts to report results adjusted for known confounders, the inability to adjust for unknown confounders must be recognized. Third, there were subtle differences in how interventions were implemented, even within the same category of intervention. We addressed this by only combining studies with reasonably similar interventions and explored heterogeneity with meta-regression, when possible, and subgroup analyses. Lastly, the rigor of implementation for the report card intervention was unclear. Although report cards were issued, it could not be ascertained whether they were actually reviewed by the endoscopist in most studies. Nonetheless, suboptimal adherence to a quality improvement initiative is to be expected and our meta-analysis likely provides a more conservative estimate than if adherence was 100%, which is unlikely in clinical practice.

Conclusions

Audit and feedback in the form of report cards and having an additional observer were associated with a significant increase in ADR and should be considered in quality improvement programs in endoscopy units.

Supplementary Material

Note: To access the supplementary material accompanying this article, visit the online version of *Clinical Gastroenterology and Hepatology* at www.cghjournal.org, and at http://doi.org/10.1016/j.cgh.2023.03.049.

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Conflicts of interest
The authors disclose no conflicts.