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Nationally Automated Colonoscopy Performance Feedback Increases Polyp Detection: The NED APRIQOT Randomized Controlled Trial

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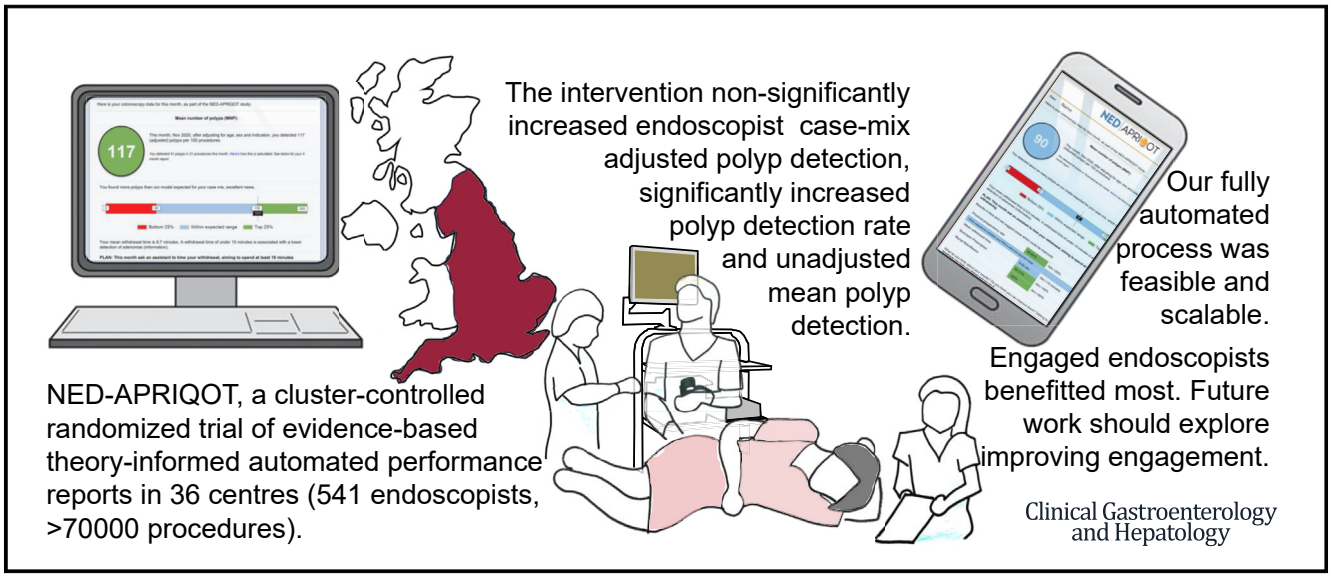

Abbreviations used in this paper: **A&F, audit and feedback; ADR, adenoma detection rate; aMNP, case-mix adjusted mean number of polyps; CRC, colorectal cancer; JAG, Joint Advisory Group; KPI, key performance indicators; MNP, mean number of polyps; NED, National Endoscopy Database; NED-APRIQOT, National Endoscopy Database Automated Performance Reports to Improve Quality Outcomes Trial; PCCRC, post-colonoscopy colorectal cancer; PDR, polyp detection rate; PPR, proximal polypectomy rate; RCT, randomized controlled trial.**

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BACKGROUND & AIMS: **Postcolonoscopy colorectal cancer incidence and mortality rates are higher for endoscopists with low polyp detection rates. Using the UK's National Endoscopy Database (NED), which automatically captures real-time data, we assessed if providing feedback of case-mix–adjusted mean number of polyps (aMNP), as a key performance indicator, improved endoscopists' performance. Feedback was delivered via a theory-informed, evidence-based audit and feedback intervention.**

METHODS: **This multicenter, prospective, NED Automated Performance Reports to Improve Quality Outcomes Trial randomized National Health Service endoscopy centers to intervention or control. Intervention-arm endoscopists were e-mailed tailored monthly reports automatically generated within NED, informed by qualitative interviews and behavior change theory. The primary outcome was endoscopists' aMNP during the 9-month intervention.**

RESULTS: **From November 2020 to July 2021, 541 endoscopists across 36 centers (19 intervention; 17 control) performed 54,770 procedures during the intervention, and 15,960 procedures during the 3-month postintervention period. Comparing the intervention arm with the control arm, endoscopists during the intervention period: aMNP was nonsignificantly higher (7%; 95% CI, -1% to 14%; $P = .08$). The unadjusted MNP (10%; 95% CI, 1%–20%) and polyp detection rate (10%; 95% CI, 4%–16%) were significantly higher. Differences were not maintained in the postintervention period. In the intervention arm, endoscopists accessing NED Automated Performance Reports to Improve Quality Outcomes Trial webpages had a higher aMNP than those who did not (aMNP, 118 vs 102; $P = .03$).**

CONCLUSIONS: **Although our automated feedback intervention did not increase aMNP significantly in the intervention period, MNP and polyp detection rate did improve significantly. Engaged endoscopists benefited most and improvements were not maintained postintervention; future work should address engagement in feedback and consider the effectiveness of continuous feedback. Clinical trials registry: www.isrctn.org ISRCTN11126923 .**

Keywords: Endoscopy; Quality Improvement; Audit and Feedback; Detection.

Colorectal cancer (CRC) is diagnosed in 1.9 million people globally each year.[1] CRCs arise predominantly from adenomatous or serrated polyps; thus, colonoscopic polyp detection and resection are pivotal in preventing CRC. Serrated polyps often are subtle, difficult to detect, and usually occur in the proximal colon—potentially explaining why proximal CRCs are missed more than twice as often as distal CRCs.[2] Studies have shown significant variation in polyp detection between endoscopists[3]; those with lower polyp and adenoma detection rates (ADRs) have higher postcolonoscopy colorectal cancer (PCCRC) incidence and mortality rates: therefore, people die from unwarranted variation in colonoscopy quality.[4,5] The ADR has been criticized as a colonoscopy key performance indicator (KPI) for excluding serrated polyps, requiring histologic data, and fostering a one-and-done attitude.[6] A case-mix–adjusted mean number of polyps (aMNP), the total number of polyps detected divided by the number of colonoscopies performed, with a cap of 5 polyps per colonoscopy, addresses these criticisms. Pretrial work demonstrated that aMNP had face validity among endoscopists, accounts for endoscopist case mix, and correlated well with other detection KPIs.[7–9]

International studies have shown significant variation in quality markers of polyp detection and withdrawal time between endoscopists.[3,10] The extent endoscopy quality variation in the United Kingdom is unknown; previous data are derived from ad hoc audits, using nonstandardized approaches and lacking generalizability. This makes identification of underperformance and the development of audit and feedback (A&F) interventions difficult. In the United Kingdom, endoscopy services are provided by centers, with local endoscopy leads having responsibility for quality. The UK's endoscopy Joint Advisory Group (JAG) recommends providing 6-monthly detection feedback and supporting endoscopists demonstrating possible underperformance.[11]

The United Kingdom developed the first National Endoscopy Database (NED), automatically capturing real-time, patient-level data from almost all endoscopy centers.[12] Such health informatics systems offer delivery of theory-informed and timely feedback at low cost, but there is a paucity of evidence.[13]

A Cochrane review demonstrated providing clinicians with A&F interventions, including in the context of colonoscopy, is only modestly effective at changing behavior and improving performance.[14] To address this, behavioral theories are recommended in intervention design to facilitate an understanding of how interventions change behavior and maximize their impact.[15] Previous colonoscopy studies have

quasiexperimental and single-center designs; none report using empiric data or incorporating behavioral theories in intervention design.[16,17]

The pragmatic NED Automated Performance Reports to Improve Quality Outcomes Trial (NED-APRIQOT) randomized controlled trial (RCT) aimed to test the effectiveness of a theory-informed and evidence-based A&F intervention on polyp detection and associated detection behaviors. We sought to demonstrate an entirely automated, tailored, and personalized feedback system and hypothesized that our intervention would improve performance in colonoscopy polyp detection.

What You Need to Know

Background

Patients of endoscopists who detect fewer polyps have higher rates of cancer after colonoscopy. We assessed if theory-informed and evidence-based feedback intervention, automated through the national endoscopy database, improved detection.

Findings

Our intervention did not increase detection performance adjusted for case-mix significantly, however, it did improve traditional polyp detection measures significantly. Those who engaged in feedback were more likely to detect more polyps.

Implications for patient care

The NED Automated Performance Reports to Improve Quality Outcomes Trial delivered an entirely automated feedback loop nationally that improved polyp detection performance. The study demonstrates the benefit of developing and implementing learning health systems; creating an efficient, scalable, and automated process that is transferable across specialties to improve patient outcomes.

Methods

Study Design and Participants

The NED-APRIQOT (ISRCTN11126923) was a multicenter, prospective, cluster RCT. A full research protocol was published in 2020.[9] English National Health Service endoscopy centers performing >600 colonoscopies annually and uploading data to NED since August 2019 were eligible. All consenting independently practicing colonoscopists employed by and performing colonoscopy within the trial endoscopy centers were eligible, with colonoscopy procedures uploading to the NED during pre-intervention and intervention periods. Colonoscopists in supervised training were excluded. Eligible colonoscopists were provided with participant information and consented by local research teams. All colonoscopy procedures, complete to the cecum, performed by consenting colonoscopists within participating centers were included. Data fields collected automatically by NED from endoscopy reports are available on the NED website.[18]

Pre-intervention data capture (to establish baseline workload and performance) ran from August 1 to October 31, 2020, the intervention period from November 1, 2020, to July 31, 2021, and the post-intervention period (to establish maintenance of intervention effects) until October 31, 2021. There were no changes to trial methods after trial commencement.

The unit of randomization was the endoscopy center. Centers were randomized 1:1 to intervention or control using a minimization scheme (Supplementary Methods).

Intervention

Informed by analysis of earlier NED data and a Delphi process, aMNP was selected as the optimal detection KPI for feedback purposes.[8]

Intervention-arm participants received a monthly e-mail with a tailored A&F behavior change intervention (the intervention). Intervention design and content were informed by feedback intervention theory and empiric qualitative work; iterative refinement was undertaken through cognitive interviews with endoscopists.[19] The tailored report included participants' aMNP and a personalized action plan based on this and their detection behaviors recommended by JAG: overall and proximal withdrawal time, hyoscine butylbromide prescription, and rectal retroversion.[20] Participants' aMNP was compared with minimum (25th percentile baseline period detection) and aspirational (75th percentile) standards with a color-coded graphic social comparison. Detection behaviors were compared with UK standards, and the action plan targeted discrepancies.[21] Contact details for recipients' local endoscopy lead were provided for support, and hyperlinks to a bespoke NED-APRIQOT website provided further educational materials. An example report mapped to the behavior change taxonomy is shown in Supplementary Figure 1 and Supplementary Table 1.[22] Endoscopy leads received a summary of local participants' reports.

Control arm and usual audit and feedback practices. Control participants did not actively receive A&F data from NED and could not access the bespoke NED-APRIQOT website. Both control and intervention centers continued any usual and JAG-recommended A&F practices.[21]

Outcomes

The primary outcome measure was aMNP: the mean number of polyps per 100 procedures (MNP), adjusted for patient age, sex, and indication, with a cap of 5 polyps per procedure, measured during the intervention period.[8] Secondary outcomes (Supplementary Table 2)

included the following: unadjusted MNP, polyp detection rate (PDR), case-mix–adjusted proximal polypectomy rate (PPR); proportions of participants above a minimum (25th percentile aMNP during baseline) and target (75th percentile) standard; and colonoscopy withdrawal time and hyoscine butylbromide prescription.

To assess the impact on endoscopist performance, outcome variables were calculated and analyzed at the endoscopist level. Histology data were collected for all colonoscopies identifying at least 1 polyp at all sites over 2 weeks in April 2021, and assessed correlations between aMNP, MNP, PDR, ADR, mean number of adenomas, and serrated polyp detection rate.

Statistical Analysis

The statistical analysis plan was prespecified, and all analyses were by intention-to-treat. The coronavirus disease 2019 pandemic hampered recruitment of centers, necessitating a sample size re-estimation (Supplementary Methods).[9] An estimated 32,877 procedures in the intervention group and 29,718 procedures in the control group over 9 months were determined to detect an improvement of 5 per 100 in aMNP with 80% power.

The difference in aMNP between trial arms across the intervention and postintervention periods was analyzed using a negative-binomial model with adjustment for aMNP during the baseline period and stratification variables. Sensitivity analyses for the primary outcome accounted for clustering by site using generalized linear mixed models for the negative binomial family. The prevalence of missing data for the primary outcome was $<10\%$, therefore missing data imputation were not considered. Subgroup analyses were conducted to investigate differences in treatment effects by center workload and baseline PDR, and endoscopist-level factors including length of experience, training status, Bowel Cancer Screening Programme accreditation, annual workload, and baseline aMNP. Secondary outcome statistical analyses are described in the Supplementary Methods.

All models were adjusted for stratification variables and those covering the intervention period also were adjusted for baseline values. Analyses were conducted using R version 4.1.2. Significance was considered at the 5% level (2-sided test).

A process evaluation questionnaire was sent to all participants in November 2022 using Microsoft and Google Forms concerning engagement in the intervention, wider A&F support, and perceptions of being in the trial. All authors had access to the study data and reviewed and approved the final manuscript.

Results

Thirty-six centers and 541 endoscopists participated and were included in the analysis (Table 1, Supplementary Tables 3 and 4). Nineteen endoscopists were excluded and 1 endoscopist withdrew after consent (Consolidated Standards of Reporting Trials [CONSORT] diagram is shown in Figure 1). A total of 16,322 baseline, 54,770 intervention, and 15,960 postintervention procedures were analyzed (Supplementary Tables 5 and 6). Descriptive statistics of aMNP, unadjusted MNP, PDR, and procedure-adjusted PPR for all periods and treatment effects are shown in Table 2.

Primary Outcome

Compared with the control arm, aMNP was 7% higher in the intervention arm during the intervention period (95% CI, -0.01 to 0.14; $P = .08$) and 9% higher in the postintervention period (95% CI, -0.06 to 0.23; $P = .25$); these differences were not statistically significant. aMNP was significantly higher at month 9 in both the intervention (baseline, 98.18; SD, 68.92; vs month 9 mean, 114.92; SD, 78.33; $P = .003$) and control arms (87.91; SD, 46.93; vs 103.73; SD, 79.98; $P = .02$).

Secondary Outcomes

Polyp detection measures. During the intervention period, both unadjusted MNP (10%; 95% CI, 1%–20%) and PDR (10%; 95% CI, 4%–16%) were significantly higher in the intervention arm vs the control arm; the difference between arms in the postintervention period was nonsignificant. The procedure-adjusted PPR was not significantly different between arms (Table 2), and the unadjusted PPR was nonsignificantly higher in the intervention arm compared with the control arm during the intervention and postintervention periods.

Minimum and target standards. Based on the baseline period aMNP distribution, the minimum and target standards were 58 and 136 polyps per 100 procedures, respectively. Intervention-arm participants were significantly more likely than controls to be above this minimum standard during the intervention period (Table 3); there was no difference in the postintervention period. There was no significant difference between arms in the likelihood of being above the target standard during the intervention period; however, intervention-arm participants were significantly more likely to be above the target standard in the postintervention period compared with controls. There was no significant difference between arms in the likelihood of being above the minimum or target standards of adjusted PPR (Supplementary Table 7).

Participant detection behavior analyses. Descriptive statistics for KPIs are shown in Table 2. Intervention-arm participants prescribed hyoscine butylbromide significantly more often than control-arm participants both during the intervention (intervention, 38.9%; vs control, 27.6%; estimated coefficient, 0.50; 95% CI, 0.32–0.68) and postintervention periods (40.8% vs 28.7%; estimated coefficient, 0.45; 95% CI, 0.19–0.71)

Table 1. Summary of Categoric Endoscopist-Level Demographic Data at Baseline

	Intervention (n = 283)		Control (n = 258)		Overall (n = 541)	
Variables	n	%	n	%	n	%
Gender						
Male	196	69.3	201	77.9	397	73.4
Female	82	29.0	55	21.3	137	25.3
Missing	5	1.8	2	0.8	7	1.3
Clinical specialty category						
Gastroenterology consultant	147	51.9	134	51.9	281	51.9
Surgeon consultant	76	26.9	64	24.8	140	25.9
Clinical and nurse endoscopist (nonmedical)	37	13.1	37	14.3	74	13.7
Nonconsultant medical	22	7.8	21	8.1	43	7.9
Other consultant endoscopist	1	0.4	2	0.8	3	0.6
Train colonoscopy trainer course status						
TCT accredited	151	53.4	137	53.1	288	53.2
Not TCT accredited	132	46.6	121	46.9	253	46.8
BCSP status						
Yes	53	18.7	44	17.1	97	17.9
No	230	81.3	214	82.9	444	82.1
Annual workload[a]						
High (148–778)	86	30.4	90	34.9	176	32.5
Medium (56–147)	87	30.7	90	34.9	177	32.7
Low (1–55)	103	36.4	74	28.7	177	32.7
Missing	7	2.5	4	1.6	11	2.0

BCSP, Bowel Cancer Screening Programme; TCT, train colonoscopy trainer course.
[a]The annual workload refers to the number of procedures conducted between baseline and the end of the intervention. This variable is missing for endoscopists not conducting any eligible procedures during that period.

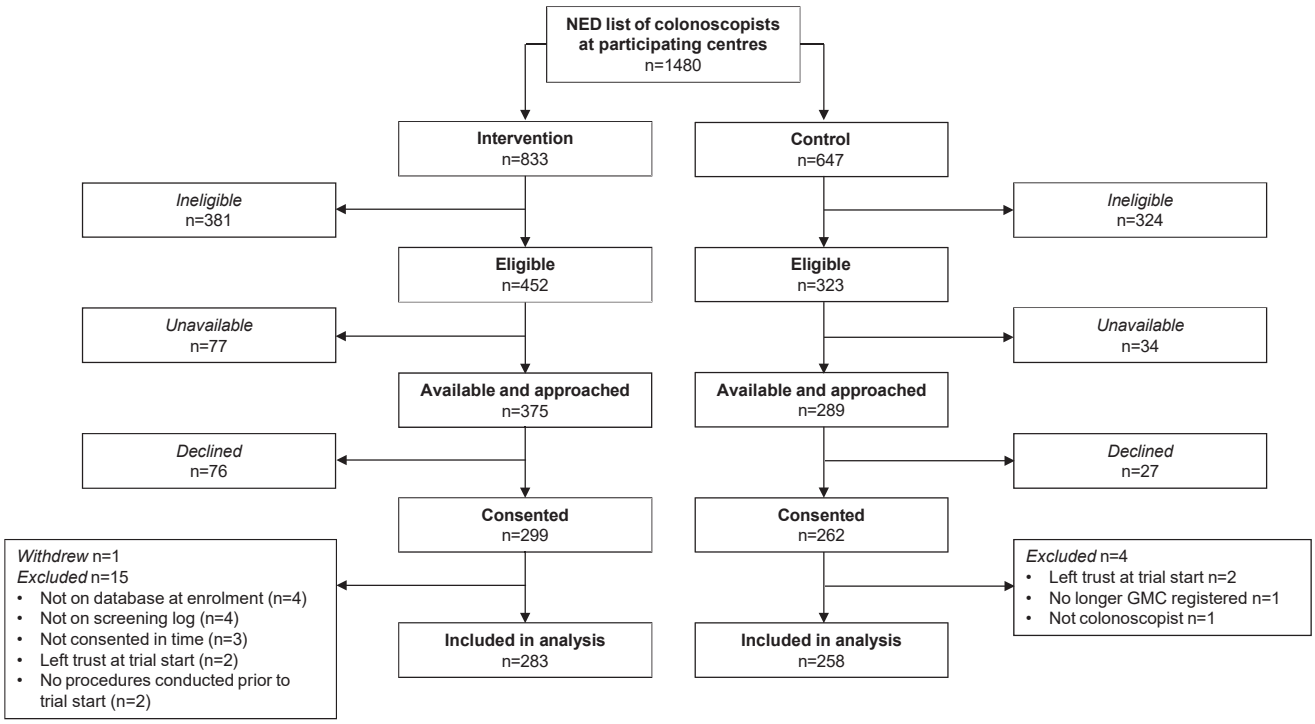

Figure 1. CONSORT diagram of National Endoscopy Database (NED) Automated Performance Reports to Improve Quality Outcomes Trial participants. CONSORT, Consolidated Standards of Reporting Trials; GMC, General Medical Council.

Table 2. Descriptive Statistics and Treatment Effects of the Intervention for All Outcome Variables

	Intervention (n = 283)		Control (n = 258)		Treatment effect during the intervention period		Intervention (n = 283)	Control (n = 258)	Treatment effect during the postintervention period	
	Baseline, mean (SD)	Intervention, mean (SD)	Baseline, mean (SD)	Intervention, mean (SD)	Coefficient (95% CI)	*P* value	Postintervention, mean (SD)	Postintervention, mean (SD)	Coefficient (95% CI)	*P* value
aMNP	102.13 (69.02)	107.39 (50.07)	96.08 (52.17)	98.25 (46.80)	0.07 (-0.01 to 0.14)	.08	108.32 (62.98)	99.24 (56.05)	0.09 (-0.06 to 0.23)	.25
Polyps (unadjusted), mean, n	110.13 (89.11)	130.30 (85.39)	99.47 (77.98)	114.93 (75.88)	0.10 (0.01–0.20)	**.04**	127.45 (95.98)	121.32 (107.34)	0.08 (-0.10 to 0.26)	.38
Polyp detection rate	42.42 (24.57)	48.07 (19.17)	39.69 (19.69)	43.76 (18.50)	0.10 (0.04–0.16)	**.002**	46.90 (23.99)	44.44 (22.64)	0.07 (-0.05 to 0.20)	.25
Procedure adjusted proximal polypectomy rate	25.04 (19.84)	25.67 (13.90)	22.61 (16.31)	24.10 (16.43)	0.05 (-0.06 to 0.15)	.37	26.94 (18.91)	24.12 (16.91)	0.10 (-0.09 to 0.28)	.32
Cecal intubation rate	92.89 (8.32)	91.78 (9.28)	93.05 (6.90)	93.39 (4.80)	-0.01 (-0.03 to 0.01)	.15	93.85 (8.67)	92.63 (9.76)	0.01 (-0.01 to 0.03)	.19
Terminal ileal intubation rate	45.95 (28.71)	43.26 (26.23)	44.03 (26.88)	42.23 (25.25)	0.00 (-0.09 to 0.10)	.96	44.05 (27.27)	42.20 (26.58)	0.05 (-0.11 to 0.21)	.52
Rectal retroversion rate	91.45 (15.11)	92.66 (11.40)	92.07 (13.83)	91.38 (14.14)	0.01 (-0.01 to 0.04)	.22	93.96 (10.22)	93.65 (8.66)	0.00 (-0.02 to 0.02)	.92
Polyp retrieval success	93.20 (13.05)	93.50 (9.58)	94.27 (14.02)	94.46 (10.73)	-0.02 (-0.04 to 0.00)	.08	94.05 (10.63)	94.37 (11.18)	0.00 (-0.03 to 0.02)	.84
Colonoscopy withdrawal time	5.36 (2.69)	4.94 (2.17)	5.87 (3.06)	5.44 (2.87)	-0.04 (-0.12 to 0.05)	.41	5.32 (2.76)	5.35 (3.22)	-0.02 (-0.13 to 0.09)	.69

NOTE. All models adjusted for stratification variables and models of treatment effect during the intervention period were adjusted additionally for baseline value of each respective outcome. Bold represents statistical significance. aMNP, case-mix–adjusted mean number of polyps.

Table 3. Proportions of Endoscopists Above the Minimum and Target Standards for aMNP During the Intervention and Postintervention Periods

	Intervention (n = 283)			Control (n = 258)				
	Above minimum standard	Below minimum standard	Missing	Above minimum standard	Below minimum standard	Missing	OR (95% CI) of being above minimum standard	*P* value
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)		
Baseline	184 (65.0)	68 (24.0)	31 (11.0)	193 (74.8)	58 (22.5)	7 (2.7)	NA	NA
Intervention	234 (82.7)	39 (13.8)	10 (3.5)	204 (79.1)	44 (17.1)	10 (3.9)	1.77 (1.02–3.10)	.04
Postintervention	193 (68.2)	49 (17.3)	41 (14.5)	175 (67.8)	44 (17.1)	39 (15.1)	1.04 (0.65–1.67)	.86
	Above target standard	Below target standard		Above target standard	Below target standard		OR (95% CI) of being above target standard	
Baseline	73 (25.8)	179 (63.3)	31 (11.0)	51 (19.8)	200 (77.5)	7 (2.7)	NA	NA
Intervention	63 (22.3)	210 (74.2)	10 (3.5)	45 (17.4)	203 (78.7)	10 (3.9)	1.05 (0.64–1.73)	.85
Postintervention	70 (24.7)	172 (60.8)	41 (14.5)	41 (15.9)	178 (69.0)	39 (15.1)	1.73 (1.11–2.73)	.02

NOTE. The control group is the referent group in the logistic regression.
aMNP, case-mix–adjusted mean number of polyps; NA, not applicable; OR, odds ratio.

Table 4. Exploratory Analysis of aMNP Within the Intervention Arm by Indicators of Engagement

Variable	n	%	Mean aMNP	SD	Regression coefficient (95% CI)	*P* value
Engagement with intervention link						
Clicked	18	6.6	122.00	32.53	0.14 (-0.10 to 0.39)	.28
Did not click	255	93.4	106.36	50.97	Referent	
Engagement with NED-APRIQOT website						
Accessed site	91	33.3	118.05	40.77	0.15 (0.02–0.28)	.03
Did not access site	182	66.7	102.06	53.43	Referent	
Logins to NED-APRIQOT						
Logged in	108	39.6	115.19	43.08	0.12 (-0.01 to 0.25)	.06
Did not login	165	60.4	102.28	53.67	Referent	

NOTE. Endoscopists in the intervention arm who conducted eligible procedures during the intervention period (n = 273).
aMNP, case-mix–adjusted mean number of polyps; NED-APRIQOT, National Endoscopy Database Automated Performance Reports to Improve Quality Outcomes Trial.

(Supplementary Figure 2). There was no difference between trial arms in colonoscopy withdrawal time.

Subgroup and Sensitivity Analyses

The intervention effect on aMNP was modified by center workload ($P = .01$ for interaction test); in low-volume centers the aMNP in the intervention arm was 108.8, vs 92.76 in the control arm, and in high-volume centers the aMNP was 100.48 in the intervention vs 102.51 in the control (Supplementary Figure 3). There were no significant interactions between intervention effect and center baseline PDR or endoscopist factors (Supplementary Table 8).

Within the intervention arm, endoscopists who accessed supporting educational material on the NED-APRIQOT website had significantly higher aMNP during the intervention period than those who did not, equating to an average of 1.2 times more polyps detected compared with control-arm endoscopists (Table 4).

Sensitivity analysis accounting for site clustering and the likelihood of being within target are shown in Supplementary Tables 9 and 10.

Detection of Key Performance Indicator Correlations

Histologic data were recorded on 4966 procedures for 2 weeks; aMNP was correlated with the mean number of polyps (Spearman $\rho = 0.91$; 95% CI, 0.89–0.92), and correlated moderately with PDR ($\rho = 0.75$; 95% CI, 0.71–0.78), ADR ($\rho = 0.65$; 95% CI, 0.61–0.70), mean number of adenomas ($\rho = 0.67$; 95% CI, 0.62–0.71), and serrated polyp detection rate ($\rho = 0.33$; 95% CI, 0.27–0.40). Correlations were stronger in the intervention group (Hotelling T2 test, $P = .005$).

Process Evaluation

The process evaluation questionnaire was completed by 93 intervention-arm (18 centers) and 74 control-arm participants (14 centers). Responses are summarized in the Supplementary Results. Of intervention-arm respondents, 72% agreed aMNP data were credible and 78% engaged in strategies to improve performance. Two (2%) participants described using a gaming strategy. Of control respondents, 11% reported awareness of the trial impacting their clinical behavior.

Discussion

NED-APRIQOT is the largest randomized controlled trial of endoscopists in Europe. It tested the effectiveness of a theoretically informed, evidence-based, tailored A&F intervention, delivered through an entirely automated feedback loop. Trial participants' professional backgrounds reflected the UK's endoscopy workforce, suggesting our results are generalizable.[23] Moreover, the study demonstrates the benefit of developing and implementing learning health systems[24]; creating an efficient, scalable, and automated process (including data capture, analysis, personalized report construction, and automated personalized e-mails) was an important aim. Our approach, although within endoscopy, could be transferrable across specialties to improve clinical practice and patient outcomes.

Intervention Effect

The primary outcome measure, aMNP, was nonsignificantly higher in the intervention arm during the intervention period. Unadjusted MNP and PDR both were significantly higher; the magnitude of this difference

(10%) suggests clinical significance and the potential to reduce the risk of postcolonoscopy colorectal cancer. Consistent with this, a larger proportion of endoscopists in the intervention group had detection above a minimum standard.

The intervention significantly impacted endoscopist behavior through increased hyoscine butylbromide prescription. This is a simple behavior, but has limited evidence for improving detection[25] and is not widely used in endoscopy internationally. The intervention did not increase withdrawal time, a behavior with a robust evidence base.[26] Average withdrawal times were below national recommendations in both arms[21]; it is worth noting that withdrawal times recorded in NED often are self-reported. Prolongation of withdrawal time may be more challenging for endoscopists to implement than prescribing hyoscine butylbromide, especially given time pressures identified in the process evaluation. Interventions to prevent list overbooking may facilitate optimal withdrawal time.[27] In addition, monitoring withdrawal time has been demonstrated to improve performance.[28] Our intervention recommended asking assistants to time withdrawal, yet most process evaluation respondents did not, reporting availability of timing equipment and assistant training was variable. Future interventions should consider organizational approaches to improving withdrawal times, as a complex behavior dependent on the actions and training of others.

Within the intervention arm, performance differed by engagement: endoscopists who accessed the NEDAPRIQOT trial website had a higher intervention period aMNP; however, given the e-mail nature of the intervention, assessing engagement was limited. It is possible that modest engagement contributed to the statistically null effect of the trial. Our trial and preceding qualitative work are unlikely to have recruited or explored the views of the entirely unengaged. The real-world effectiveness of the intervention, pragmatically sending the intervention to all endoscopists outside a trial without individual written consent, is unknown. In A&F interventions, recipient capability and beliefs about data have been demonstrated to influence engagement and, as identified in this study, its impact on behaviors.[29] Future studies should explore the barriers to engagement for endoscopists and identify optimal mechanisms to address them.

A&F interventions are shown to be most effective when baseline performance is low.[14] In the baseline period, both arms had higher detection KPIs than national averages, and within study centers enrolled endoscopists had a higher aMNP than nonconsenting endoscopists (mean aMNP, 103 vs 79.5). The requirement for centers to be using NED may have selected early adopters of NED and participants with an interest in endoscopy quality. Moreover, it is recognized that research-active centers (and also probably individuals) deliver higher-quality care.[30] This high overall baseline performance might have impacted the ability of the trial to detect a performance improvement. As all endoscopy centers join NED, future trials should assess the effectiveness of this type of A&F intervention specifically in lower-performing units. Notwithstanding this, it is worth noting that the subgroup analysis suggested that the intervention effect was greater in lower-workload centers; in early career endoscopists doing fewer procedures has been associated with poorer performance, however, the relationship is complex.[20]

Performance improvements were generally not sustained postintervention, suggesting ongoing feedback is required. A Cochrane review identified feedback may be more effective if delivered more frequently.[14] Recent retrospective data on quarterly feedback over 7 years in a small group of endoscopists demonstrated some long-term improvement in overall ADR.[31] It is unclear if indefinite continuous feedback would have such sustained benefits, or whether the impacts would diminish. Future research should consider this and the effect of ongoing feedback monitoring.

Limitations

Our original power calculation indicated 50 endoscopy centers were required; however, because of the coronavirus disease 2019 pandemic, this proved impossible. Ultimately, 36 centers participated and fewer than anticipated procedures were performed, possibly contributing to a lack of statistical power. Because blinding was impossible, control participants were aware their performance was being scrutinized and all centers continued their usual A&F processes. A year after study enrollment, 11% of control respondents reported awareness of the trial and that this influenced their behavior. The implementation of symptomatic fecal immunochemical testing for blood as a triaging tool partly may explain the increase in detection in both arms.[32] These may have diminished between-arm effects.

Because NED does not collect histologic data, it was not possible to consider ADR as an outcome. However, some trials have moved away from using ADR given concerns with the one and done phenomenon and its exclusion of serrated polyps.[9,33] Since the completion of our trial a German research database has shown a continuum of improvement in polyp detection associated with reduction in PCCRC, suggesting the clinical importance of a mean detection measure.[34] Similarly, recent Polish screening data demonstrated ADR, PDR, and adenomas per colonoscopy (APC) had comparable inverse associations with PCCRC. Top PDR and adenomas-per-colonoscopy performers had the lowest hazard ratio for PCCRC; an analysis of MNP, a combination of these KPIs, may have been informative.[35] All targets in health care create a gaming risk,[36] and this was identified in our process evaluation. Our nested study confirmed correlations between ADR and aMNP; these were stronger in the intervention group, with no evidence of increased gaming through excessive distal hyperplastic polyp

resection. The use of PPR was used to flag discrepancy between distal and proximal detection, and our analysis suggests a similar detection effect across the whole colon.

Written feedback is more effective when combined with face-to-face interaction with a trusted other.[14] Although such support is difficult to quantify, prior qualitative work demonstrated that personalized support was heterogeneous across centers,[19] which is likely to impact engagement with the intervention. The intervention did not include endoscopy lead training, such training is shown to be effective at improving center-level detection.[37] National quality improvement programs should consider training endoscopy leads in assessing the needs of their endoscopists in engaging with data and exploring their beliefs around detection behaviors.[19] Although the effect size was nonsignificant, our intervention provides a feedback resource and support for endoscopists and unit leads. Centrally providing feedback data on an ongoing basis may help reduce the heterogeneity of feedback available to endoscopists nationally.

Conclusions

Although our automated feedback intervention did not increase aMNP significantly in the intervention period; MNP and PDR did significantly improve. Differences were not maintained postintervention, suggesting feedback should be ongoing. Engaged endoscopists benefited the most; future work should address engagement in performance feedback.

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.2024.03.048.

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