Digestive and Liver Disease 55 (2023) 99–106

Contents lists available at ScienceDirect

Digestive and Liver Disease

journal homepage: www.elsevier.com/locate/dld

Digestive Endoscopy

An Italian prospective multicenter study on colonoscopy practice and quality: What has changed in the last 10 years

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ARTICLE INFO

Article history:
Received 22 June 2022
Accepted 15 September 2022
Available online 17 October 2022

Keywords:
Colorectal cancer
Colonoscopy
Quality measures
Adenoma detection rate

ABSTRACT

Background: A relevant number of adenomas can be missed during colonoscopy.
Aims: Assess the current status of colonoscopy procedures in Italian centers.
Methods: A prospective observational study involving 17 hospitals (34 endoscopists) included consecutive patients undergoing standard colonoscopy. In the first phase, endoscopists performed consecutive colonoscopies. In the second phase, retraining via an online learning platform was planned, while in the third phase data were collected analogously to phase 1.
Results: A total of 3,504 patients were enrolled. Overall, a BBPS score ≥6 was obtained in 95.6% of cases (94.8% and 96.9% in the pre- and post-training phases, respectively). 88.4% of colonoscopies had a withdrawal time ≥6 min (88.2% and 88.7% in the pre- and post-training phases). Median adenoma detection rate (ADR) was 39.1%, with no significant differences between the pre- and post-training phases (40.1% vs 36.9%; $P = 0.83$). In total, 81% of endoscopists had a ADR performance above the 25% threshold.
Conclusion: High colonoscopy quality standards are achieved by the Italian hospitals involved. Quality improvement initiatives and repeated module-based colonoscopy-training have been promoted in Italy during the last decade, which appear to have had a significant impact on quality colonoscopy metrics together with the activation of colorectal cancer screening programs.

1. Introduction

Colorectal cancer (CRC) is one of the major causes of death from cancer worldwide. In 2020, up to 43,700 new diagnoses were made in Italy and CRC remains the most frequently diagnosed cancer alongside breast cancer, according to the latest joint report of the Italian Association of Medical Oncology (AIOM) and Italian Tumor Registry (AIRTUM) [1]. The 5-year survival rate for colorectal cancer is around 90% if diagnosed early, but decreases dramatically to 13% if diagnosed later [2]. Approximately 95% of CRC cases originate from colon adenomatous polyps [2], and their prompt identification and removal plays a pivotal role in preventing the disease.

Colonoscopy is considered the gold standard tool for CRC screening, and allows both identification and real-time removal of precancerous lesions. However, colonoscopy is a complex procedure requiring adequate training and experience to achieve opti-

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https://doi.org/10.1016/j.dld.2022.09.007

mal results. In order to reach this goal, it is important not only to monitor quality parameters on a daily basis, but also to establish efficient and regular training programs that should include manual and instrumental skills, as well as theoretical aspects. Training programs for both non-expert and expert colonoscopists have also been considered to play a pivotal role in the strategies of several endoscopic societies to achieve and maintain the quality of colonoscopy performance recommended by guidelines [3–5].

Several studies, including back-to-back colonoscopies, have shown that up to 25% of adenomas can be missed during screening colonoscopy [6,7], highlighting the need to perform high quality colonoscopy with measurable indicators [8], since a decrease in quality is associated with an increase in the risk of interval CRC [9,10]. The European Society of Gastrointestinal Endoscopy (ESGE) [11] has identified and recommended 9 intraprocedural colonoscopy quality indicators to encourage detailed mucosal evaluation during colonoscopy and improve overall colonoscopy performance, as have the American Society of Gastrointestinal Endoscopy (ASGE) together with the American College of Gastroenterology (ACG) [12] task force. Among those, bowel preparation quality, cecal intubation rate, withdrawal time of the colonoscope and adenoma detection rate (ADR) are of paramount importance and have been linked to interval (post-colonoscopy) colorectal cancer incidence. Moreover, type of sedation used, severity and recording of pain, and rate of retrieval of removed lesions for histology have also been reported as quality indicators by ESGE recommendations [13].

In order to monitor and improve the quality of colonoscopies in Italy, the Italian Society of Digestive Endoscopy (SIED) and Italian Association of Hospital Gastroenterologists and Endoscopists (AIGO) have conceived a project called INCIPIT (INtegrated Colonoscopy Improvement Program in ITaly), which includes a prospective observational multicenter study. Herein, we present data from the nationwide INCIPIT study to assess the current status of colonoscopy procedures in Italian centers, and to investigate factors linked to the quality of the procedure and possible advantages of a retraining policy.

2. Methods

2.1. Study design

This was an observational, prospective, multicenter study conducted over a two-year period (from July 2018 to July 2020) and involved 17 hospitals with 34 endoscopists distributed throughout Italy.

All patients enrolled in the study gave their informed consent for the procedures, for participation in the study, and for use of data for scientific purposes.

The study protocol (Supplementary material) was firstly approved on February 2018 by the institutional Ethics Committee of the coordinating center (Register of diagnostic and therapeutic colonoscopies - HSR Reg/Col) and subsequently in all centers involved. The study was registered on Clinical Trials Gov (NCT03661099).

The study included consecutive patients undergoing standard colonoscopy as per standard protocols in the centers involved, as follows:

Phase 1: over an estimated 4-month period all endoscopists involved in the study performed consecutive colonoscopies (target: 150–200) and data were prospectively collected through an online electronic case report form (eCRF) and recorded in a database.

Phase 2: retraining via an online learning platform was planned for all endoscopists. In this learning platform, experts presented and discussed current standards for quality colonoscopy, including technique for colonoscopy and reaching the cecum and other quality parameters recognized by the ESGE and ASGE [11,12]. Only endoscopists who completed the training modules were admitted to the third phase.

Phase 3: analogously to phase 1, data referring to all consecutive colonoscopies performed were prospectively collected using an eCRF and recorded in the database.

The ADR and polyp detection rate (PDR) were calculated for each endoscopist.

According to current guidelines of the ESGE, quality colonoscopy parameters assessed before and after the training period were: a) colon cleansing defined as score $\geq$ 6 at Boston bowel preparation scale (BBPS) assessment; b) intraprocedural pain, assessed by nurse-assessed patient comfort score (NAP-COMS); c) cecal intubation rate; d) time of instrument withdrawal; e) intra-procedural use of hyoscine N-butylbromide to distend colonic segments; f) adenoma and polyp detection rate (ADR and PDR); g) number of lesions per patient.

ADR, PDR, and number of lesions per patient were also analyzed in relation to the number of colonoscopies performed by each endoscopist in the same session (1–5 and >6), whether the colonoscopies were performed in the morning or afternoon, and number of colonoscopies performed the year preceding the study.

2.2. Inclusion and exclusion criteria

To ensure a homogeneous population and limit confounding factors, the study included only patients between 50 and 75 years of age, with at least one of the following indications to perform a colonoscopy: screening (due to age or presence of fecal occult blood); post-polypectomy surveillance; presence of symptoms related to the colon but without recent alarm signs/symptoms (anemia, clinically important bowel alteration, weight loss, or asthenia).

Patients were excluded if they showed the alarm signs or symptoms mentioned above, ASA class $\geq$3, colic strictures or resections, acute diverticulitis or diverticulitis episodes within the previous 6 weeks, inflammatory bowel disease, a known genetic polyposis syndrome, pregnant or breastfeeding women, severe cardiovascular disease, on anticoagulant therapy, contraindications to sedation or unable to provide informed consent, or colic melanosis.

2.3. Data collection

The data collected included sex, age, type of access (outpatient, day hospital, hospitalized), reason for colonoscopy, and whether the colonoscopy was performed for the first time. Data were also collected regarding the endoscopist and the procedure itself, including the above-mentioned quality indicators, complications during or immediately after the procedure, description of polyp morphology using the Paris and Kudo glandular pit pattern classifications, and histological diagnosis of resected/biopsied lesions.

2.4. Statistical analysis

Data were summarized using the appropriate descriptive statistics. Medians (with interquartile ranges, IQR) and percentages were used for continuous and categorical data, respectively. Multivariable logistic regression was performed to identify factors that were significantly associated with (i) the number of patients with at least one adenoma detected and (ii) proper cleansing of the right colon. Odds ratio (OR) estimates and 95% Wald confidence intervals (CI) were calculated. Analyses were performed using SAS software.

3. Results

All but one endoscopist initiating participating had performed >1000 colonoscopies lifelong and >150 colonoscopies per year. All

Table 1
Characteristics of patients.

Characteristic	Overall N = 3504n (%)	Pre-training N = 2314n (%)	Post-training N = 1190n (%)
Sex, n (%)			
- Male	1822 (52.0)	1197 (51.7)	625 (52.5)
- Female	1682 (48.0)	1117 (48.3)	565 (47.5)
Age (years), n (%)			
- <55	690 (19.7)	468 (20.2)	222 (18.7)
- 55 – 59	761 (21.7)	494 (21.3)	267 (22.4)
- 60 – 64	673 (19.2)	438 (18.9)	235 (19.7)
- 65 – 69	722 (20.6)	471 (20.4)	251 (21.1)
- ≥70	658 (18.8)	443 (19.1)	215 (18.1)
Access type, n (%)			
- Outpatient	3446 (98.3)	2268 (98.0)	1178 (99.0)
- Day hospital	37 (1.1)	34 (1.5)	3 (0.3)
- Hospitalized	21 (0.6)	12 (0.5)	9 (0.8)
ASA risk, n (%)			
- I: healthy patient	1852 (52.9)	1229 (53.1)	623 (52.4)
- II: patient with mild systemic disease but without functional limitation	1652 (47.1)	1085 (46.9)	567 (47.6)
Patient first colonoscopy, n (%)	1779 (50.8)	1213 (52.4)	566 (47.6)
Colonoscopy indication			
- Presence of symptoms (without alarm signs/symptoms)	893 (25.5)	572 (24.7)	321 (27.0)
- Positive for occult blood	1077 (30.7)	722 (31.2)	355 (29.8)
- Opportunistic screening/spontaneous presentation	573 (16.4)	375 (16.2)	198 (16.6)
- Post-polypectomy surveillance	961 (27.4)	645 (27.9)	316 (26.6)

ASA= American Society of Anesthesiologists; n/a= not available.

endoscopists were invited to complete the training and proceed with the last phase; however, due to organizational issues within their individual centers or because some no longer practiced in the same center, only 21 completed all phases of the study. They performed a median of 622 (IQR: 400–925) coloscopies in the previous year and had a median of 10 (IQR: 5–11) years of experience. Eleven (52%) had a specialization in gastroenterology and digestive endoscopy, 7 (33%) in gastroenterology, 2 (10%) in general surgery, and 1 (5%) was a resident in gastroenterology. A total of 3504 patients met inclusion criteria and were enrolled in the study, 2314 in the first phase and 1190 in the second phase. The 4-month of duration of planned recruitment referred to single investigators (there were differences regarding the actual starting period due to different timings to receive ethics committee approvals and activate the centers). Among the 21 investigators who completed both phases, 14 begun the post-training recruitment only in January 2020. Due to the outbreak of COVID-19 in Italy, the recruitment rate dropped to near zero starting in March 2020. Since heavy difficulties in recruitment persisted even until July, we decided to complete the study despite the differences in number of patients in the first and second phase. Characteristics, access type, and indications for colonoscopy are reported in Table 1.

Low-volume PEG preparations were used in 60.1% of patients and a split-dose regimen was adopted in 71.1% of cases. Overall, a BBPS score ≥6 was obtained in 95.6% of cases (94.8% and 96.9% in the pre- and post-training phases, respectively). The mean BBPS score was 7.69 ± 1.53 (7.60 ± 1.58 and 7.85 ± 1.40 in the pre- and post-training phases, respectively). Multivariable logistic regression analysis on proper cleansing of the colon (all three BBPS segment scores ≥2) highlighted the positive effect of the use of a 1 L PEG preparation and split-dose regimens (Table 2). In the subgroup of patients treated with low-volume preparations, the fractional intake of the preparation, with the last dose taken 3–5 h before the examination, was significantly associated with better cleansing of the colon compared to administration the day before (OR 3.0, 2.0–4.8 95% CI).

Overall, sedation and analgesia were offered to 3038/3504 patients (86.7%), in 85.5% and 89.1% of case prior and after training.

Table 2
Factors associated with the cleansing of the colon (all three BBPS segment scores ≥2).

Factor	OR	95% Wald CIs
Bowel preparation (vs high volume preparation)		
1 L PEG preparation (Plenvu)	**4.011***	**1.738 - 9.254**
2 L PEG preparation + ASC (Moviprep)	1.134	0.827 - 1.554
2 L PEG preparation + Bisacodyl	1.580	0.882 - 2.832
2 L PEG preparation + simethicone (Clensia)	1.763	0.841 - 3.696
Other	0.578	0.300 - 1.116
Period of administration (vs day before exam)		
Split-dose regimen, < 3 h since last dose	**2.231***	**1.061 - 4.691**
Split-dose regimen, 3–5 h since last dose	**2.595***	**1.903 - 3.539**
Split-dose regimen, ≥ 6 h since last dose	**1.726***	**1.67- 2.792**

BBPS= Boston bowel preparation scale; OR= odds ratio; CI= confidence interval; *significant association,.

Table 3
Distribution by severity of intra-procedural pain.

Pain severity	Overall N = 3504n (%)	Pre-training N = 2314n (%)	Post-training N = 1190n (%)
None or minimal	1810 (51.7)	1226 (53.0)	584 (49.1)
Mild	1308 (37.3)	825 (35.7)	483 (40.6)
Moderate	332 (9.5)	223 (9.6)	109 (9.2)
Severe	54 (1.5)	40 (1.7)	14 (1.2)

Intraprocedural pain was reported as absent or mild in 89.0% of cases and moderate to severe in 11.0% of cases. In the pre- and post-training phases, intraprocedural pain was absent and mild in 88.6% and 89.7%, respectively (Table 3).

Whether or not the cecum was reached was reported in all 3504 colonoscopies. Overall, cecal intubation was achieved in 98.0% of procedures (97.9% and 98.2% in the pre- and post-training phases, respectively).

Withdrawal time was reported for 3433 colonoscopies. The overall rate of colonoscopies in whom the withdrawal time was ≥6 min was 88.4% (88.2% and 88.7% in the pre- and post-training phases).

Table 4
Distribution of intra-procedural use of hyoscine N-butylbromide and pain severity according to air or CO_2 insufflation method.

Characteristic	Air insufflation $N = 2366$n (%)	CO_2 insufflation $N = 1138$n (%)	P value
Intra-procedural use of hyoscine N-butylbromide	26 (1.1%)	113 (9.9%)	<0.001
Pre-training (Air: $N = 1571$: CO_2: $N = 742$)	22 (1.4%)	18 (2.4%)	†
Post-training (Air: $N = 795$: CO_2: $N = 396$)	4 (0.5%)	95 (24%)	
Pain severity			
None or minimal	1241	569 (50.0)	<0.001
Mild	(52.5)	478 (42.0)	
Moderate	830 (35.1)	80 (7.0)	
Severe	252 (10.7)	11 (1.0)	
	43 (1.8)		

Note: The association between variables has been evaluated with Chi-squared tests.
† Pre- and post-training differences among subgroups: $P = 0.16$ for air insufflation, $P<0.001$ for CO_2 insufflation.

Intra-procedural hyoscine N-butylbromide was used to distend colon segments in 1.9% of patients before training and in 8.3% of patients after training ($p<0.001$). Curiously, stratifying by insufflation method, the change was significant only among the operators adopting CO_2 insufflation (Table 4; $p<0.001$). Air and CO_2 were used in 67.5% (2366) and 32.5% (1138) colonoscopies. The rate did not substantially change after training. CO_2 usage appear to be significantly associated to both higher hyoscine N-butylbromide administration (9.9% vs 1.1%, $p<0.001$) and reduced pain severity (Table 4; $p<0.001$). Only 7 adverse events were observed (0.19%), 5 bleedings during or after polyp removal and 2 hypotensive events.

Lesions were found in 49.9% of colonoscopies (50.9% and 47.9% in the pre- and post-training phases). The mean number of lesions per colonoscopy was 2.11±1.65 (2.15±1.73 and 2.02±1.49 in the pre- and post-training phases). The characteristics of lesions found are reported in Table 5.

Overall, the median ADR was 39.1%, ranging from a minimum of 21.1% to a maximum 59.3% (IQR 31.6–43.7%). No significant differences were observed between the pre- and post-training phases (40.1% vs 36.9%; $P = 0.83$). Considering the ADR threshold of 30% for males and 20% for females [14], 71.4% of endoscopists exceeded the thresholds. The mean number of adenomas detected per patient was 1.87±1.43 (1.90±1.46 and 1.80±1.36 in the pre- and post-training phases). In total, 80.95% (17 of 21) of endoscopists had a ADR performance above the 25% threshold identified by ESGE and ASGE guidelines. The median PDR was 47.4%, ranging from 26.3% to 73.7%. The mean number of polyps detected per patient was 2.11±1.65 (2.15±1.73 and 2.02±1.49 in the pre- and post-training phase). Removed lesions were retrieved in 96.1% of colonoscopies (96.6% and 95.1% in the pre- and post-training phases).

The results of multivariable logistic regression analysis for the number of patients with at least one adenoma detected is reported in Table 6. The single most impactful factor was cecal intubation (OR 14.2).

4. Discussion

The ESGE has identified pre-, intra-, and post-procedural colonoscopy quality indicators to improve mucosal evaluation during colonoscopy and the overall quality of colonoscopy performance. Among the intra-procedural indicators, bowel preparation quality, cecal intubation rate, withdrawal time of colonoscope, and ADR are of paramount importance and have been significantly linked to interval colorectal cancer [9,10]. Nonetheless, how to measure and apply these colonoscopy quality indicators in daily clinical practice still remains a challenge for endoscopists. Indeed, nationwide training programs and monitoring colonoscopists' performance is still scarce.

The aim of the present study was to assess quality performance in colonoscopy practice in Italy, among expert endoscopists, and whether a training period could further improve performance. To the best of our knowledge, this is the largest multicenter observational study on colonoscopy diagnostic yields and quality indicators performed in Italy [15,16]. The data can be compared to those reported in a similar multicenter prospective observational study carried out in 2010 by the SIED in 28 Italian endoscopy centers including 3150 consecutive colonoscopies [17], and to that reported in a previous Italian survey published in 2008 [18].

Inadequate bowel preparations limit colon visualization and are associated with an adenoma miss rate of up to 47.9% [19]. Poor quality of cleansing also leads to repeat procedures, with increased costs for the healthcare system. The BBPS is the most widely used in clinical practice due to its reliability and ease of use [20]. Over 85% of colonoscopies for all indications and approximately 90% of screening colonoscopies should be rated as at least adequate (BBPS ≥6) to meet the ESGE-ASGE/ACG quality indicator goals. In two meta-analyses, split-dose bowel preparations and same-day preparations were reported to improve bowel preparation outcomes [21,22].

Herein, adequate bowel preparation (BBPS ≥6) was reported in 95.6% of cases, with a 22% increase compared to the 78% reported 10 years ago [17]. The current percentage of adequate bowel cleansing was above the recommended ESGE/ASGE-ACG threshold. The use of low-volume preparations (1 L) allowed for significantly better cleansing of the colon compared to high volume preparations (OR 4.0). This is in agreement with another study from Italy [23]. While using low-volume preparations, the split-dose intake of the preparation (with the last dose taken 3–5 h before examination) was also associated with significantly better cleansing and was adopted in 71.1% of cases. In an Italian survey on quality indicators for colonoscopy carried out in 2016, a split-dose was routinely adopted in only 18% of centers [24]. In a comparable study which was carried out in Poland, adequate bowel preparation was seen on 91.3% of cases, which ranged from 79.2 to 99.2% among individual centers [25].

Increased rates of adequate bowel preparation, including the adoption of a split-dose, likely reflects an increased awareness of adequate cleansing that in turn leads to better patient education about the importance of cleansing [26].

High cecal intubation rates have been proven to be associated with high ADR and a lower incidence of interval cancers, providing protection from right-sided colon cancer [27]. The performance target reported in guidelines is at least 90% for all colonoscopies and 95% for screening colonoscopies. The reported cecal intubation rate (98%) was above the guideline threshold required for all and screening colonoscopies (≥90% and ≥95%, respectively); 10 years ago, the 93% cecal intubation rate was above the guideline thresh-

Table 5
Characteristics of lesions in the 3504 patients.

Characteristic	
Total lesions found, n (%)	3684
Patients with ≥1 lesion - PDR, n (%)	1748 (49.9)
Lesions per patient, median (interquartile range)	2 (1 – 3)
Adenomas found, n	2576
Patients with ≥1 adenomas, n (%)	1376 (39.3)
Adenomas per patient (in those with ≥1 adenomas), median (interquartile range)	1 (1 – 2)
Lesion location, n (%)	
- Right colon - Cecum	447 (12.1)
- Right colon - Ascending	859 (23.3)
- Transverse colon - Hepatic flexure	168 (4.6)
- Transverse colon - Transverse	649 (17.6)
- Transverse colon - Splenic flexure	54 (1.5)
- Left colon - Descending	399 (10.8)
- Left colon - Sigma	726 (19.7)
- Left colon - Rectum	382 (10.4)
Lesion size, n (%)	
- <5 mm	2559 (69.5)
- 6–10 mm	805 (21.9)
- 11–20 mm	245 (6.7)
- >20 mm	75 (2.0)
Lesion morphology, n (%)	
- 0-Ip pedunculated	268 (7.3)
- 0-Isp semi-pedunculated	140 (3.8)
- 0-Is sessile	2490 (67.6)
- 0-IIa slightly detected	701 (19.0)
- 0-IIb flat	48 (1.3)
- 0-IIc depressed	10 (0.3)
- 0-IIa + 0-IIc depressed area in slightly raised lesion	16 (0.4)
- 0-IIc + 0-IIa slightly raised area in depressed lesion	6 (0.2)
- 0-III slightly excavated	5 (0.1)
Laterally spreading tumor (Ø >10 mm, LST), n (%)LST subtype	95 (2.6)
- Granular, Uniform (0-IIa)	47 (49.5)
- Granular, Nodular mixed (0-IIa; 0-Is + IIa; 0-IIa + Is)	17 (17.9)
- Non-Granular Mildly Detected (0-IIa)	17 (17.9)
- Non-Granular Pseudodepressed (0-IIa + 0-IIc; 0-IIc + IIa)	14 (14.7)
Removed and recovered lesions, n (%)	3545 (96.2)
Dysplasia, n (% of recovered lesions)	
- Absent	950 (26.8)
- Low grade	2363 (66.7)
- High grade	145 (4.1)
- Indefinite	87 (2.5)
Typology, n (%)	
- Tubular adenoma	2056 (58.0)
- Villous adenoma	32 (0.9)
- Tubular-villous adenoma	247 (7.0)
- Hyperplastic	625 (17.6)
- Traditional serrated adenoma (TSA)	34 (1.0)
- Adenoma/Serrated sexile polyp (SSA/P)	210 (5.9)
- Carcinoma	38 (1.1)
- Inflammatory	28 (0.8)
- Normal mucosa	249 (7.0)
- Submucosal leiomyoma	1 (<0.1)
- Adenoma (not otherwise specified)	1 (<0.1)
- n/a	24 (0.7)

PDR= polyp detection rate; n/a= not available; Ø= diameter; LST= laterally spreading tumor; TSA= traditional serrated adenoma; SSA= serrated sexile adenoma.

old for all colonoscopies, too, but below that for screenings. In the 2008 survey, the cecal intubation rate was 80.7%, with a threshold of ≥90% reached in only 22.1% of colonoscopies [18].

A withdrawal time ≥6 min for diagnostic colonoscopies has been found associated with a higher detection of lesions during colonoscopy and a lower risk of interval cancers [28–30]. In the study by Barclay et al., there was a wide difference (from 9.4% to 32.7%) in ADR depending on the duration of withdrawal (which ranged from 3.1 to 16.8 min) [28]. Colonoscopists with withdrawal times >6 min had higher detection of any neoplasia (28.3% vs. 11.8%). The detection of advanced neoplasia was also significantly different (6.4% vs. 2.6%). The English screening program data published in 2011 showed that withdrawal times of 10 min were associated with the best ADR [31]; Shaukat et al. [30] suggested that in presence of high ADR rates (25%) the withdrawal time rather than ADR could be a more sensitive marker of colonoscopy quality. The percentage of colonoscopies with withdrawal time ≥6 min herein was slightly inferior (88% compared with at least 90% recommended for purely diagnostic examinations).

ADR is considered as a pivotal measure of the quality of colonoscopy performance since it correlates with interval colorectal cancer risk [10]. The current benchmarks are 20% for women and 30% for men 50 years and older, with a blended rate of 25% [14], but the ADR rate remains highly variable among endoscopists. Since ADR does not include other polypoid non-adenomatous lesions (mainly serrated ones), other parameters have been proposed

Table 6
Factors associated with the number of patients with at least one adenoma detected.

Factor	OR	95% Wald CIs
Patient female sex (vs male sex)	**0.639***	**0.554 – 0.737**
Age (years) (vs <55)		
55 - 59	**1.475***	**1.175 – 1.851**
60 - 64	**1.474***	**1.165 – 1.865**
65 - 69	**1.950***	**1.549 – 2.455**
≥70	**2.313***	**1.822 – 2.937**
No. exams (vs 1–5)		
6–10	1.128	0.943 – 1.349
>10	1.130	0.718 – 1.780
Exam done in the morning (vs in the afternoon)	1.053	0.869 – 1.277
No. colonoscopies in the last year (vs 1–500)		
>500	**1.652***	**1.422 –1.919**
n/a	0.862	0.610 – 1.218
No antidote used (vs antidote used)	**2.059***	**1.484 – 2.857**
Patient first colonoscopy (vs not the first colonoscopy)	**1.440***	**1.192 – 1.739**
Colonoscopy indication (vs symptoms without alarm signs)		
Positive for occult blood	**1.757***	**1.440 – 2.142**
Opportunistic screening/spontaneous presentation	1.234	0.974 – 1.564
Post-polypectomy surveillance	**2.203***	**1.745 – 2.782**
Use of HD endoscope (vs non-HD endoscope)	**1.372***	**1.094 – 1.720**
Cecal intubation (vs no cecal intubation)	**14.184***	**4.427 – 45.448**

OR= odds ratio; CI= confidence interval; *significant association.

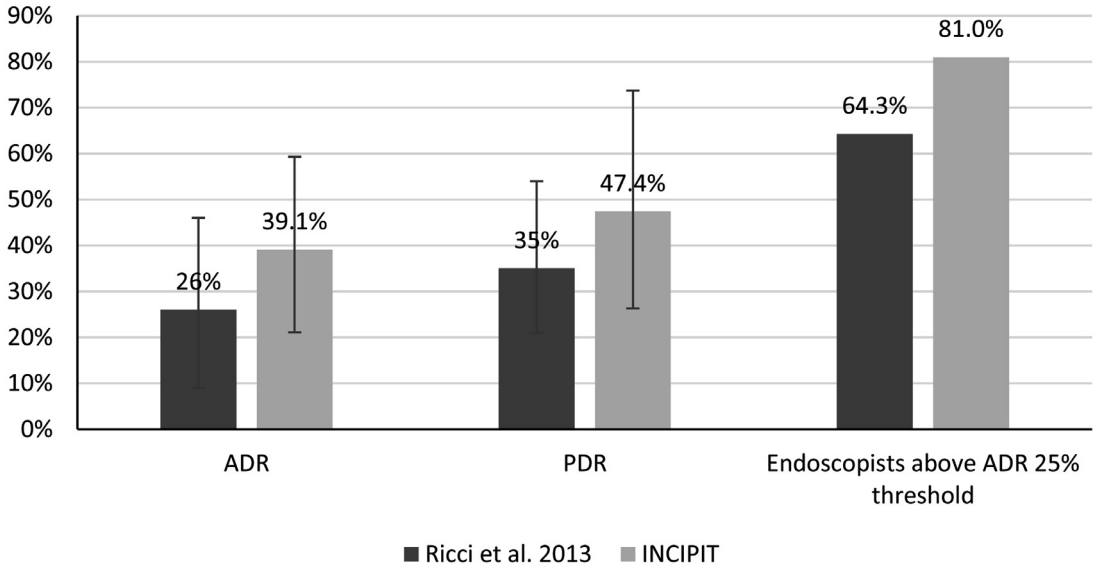

Fig. 1. Comparison of adenoma detection rate (ADR), polyp detection rate (PDR), and endoscopists above the ADR 25% threshold here and in the study by Ricci et al. from 2013. Error bars represents ADR and PDR ranges among endoscopists.

to measure the quality of colonoscopy performance such as the polyp detection rate and the number of adenomas/polyps detected per colonoscopy, which have been associated with a low adenoma miss rate [32]. However, ADR, PDR, and number of adenomas detected per colonoscopy depend on other quality parameters such as colon cleanliness, rate of cecal intubation, and withdrawal time.

Focused training interventions have been associated with a strong trend toward increased ADRs, also among certified endoscopists. Three training studies, including 119 endoscopists, showed an improvement of ADRs (odds ratio 1.16 and 1.17 in all and screening colonoscopies), PDRs, adenocarcinoma detection, and withdrawal times after training. However, a high level of heterogeneity was reported in this systematic review [33].

In the present study the majority of endoscopists (81%) had an ADR performance above the ESGE/ASGE-ACG thresholds, with a median rate of 39.1%; in the previous multicenter Italian study carried out in 2013 [17], the median ADR was 22% and only 64.3% of endoscopists met the ESGE/ASGE-ACG thresholds (≥25%). At that time a similar mean ADR (24.2% ± SD 11.6%) was reported by the Austrian nationwide quality control program for screening colonoscopy [34].

Over a 10-year period, the median ADR calculated for endoscopists and the percentage of endoscopists who met the ≥25% threshold increased by approximately 78% and 26%, respectively. Similarly, the current median PDR was 47.4%, with a 34% increasing rate compared to 35% median PDR reported in the previous multicenter Italian study (Fig. 1). Consistent with previous multivariable analyses [15,16,27], we found that older age, male gender, use of HD endoscopes, and cecal intubation are associated with an increased ADR.

Similar improvement in the ADR has been reported by the Polish Colonoscopy Screening Program which analyzed database records for 43,277 colonoscopies, reporting a cecal intubation rate of 97.4% (range: 93.4% - 99.4%) and an ADR of 29.8% (range: 19.1% - 39.1%) [25].

We also evaluated the potential influence of the number of exams performed during the day and the periods of the day on ADR to explore whether the endoscopist fatigue could impact the quality of the procedure. One study found that an increase in the number of hours during which endoscopies were performed before the index colonoscopy negatively affects ADR [35], while another did not find any evidence that time of day or number of procedures performed before the colonoscopy may decrease ADR [29]. In our study, we found an association between increased ADR and more than 500 colonoscopies performed in the previous year, but with no effect of the time of day or number of exams performed in the day. However, confidence intervals were too broad to draw any meaningful conclusions, and more studies with larger sample sizes are needed.

We cannot compare other parameters such as intra-procedural pain assessment, withdrawal time, use of hyoscine N-butylbromide, and percentage of removed lesions retrieved for histology with previous Italian multicenter studies because these were not previously assessed.

Although there is general agreement that retraining has a favorable impact on ADR and other metrics in colonoscopy practice, even among expert endoscopists [12,36,37], considered the planned training period between the two phases of the study only use of hyoscine N-butylbromide showed a significant increase. This could be explained by the high colonoscopy quality standards that are already achieved by the Italian hospitals involved in this study. Among those below the 30% ADR threshold, on the other hand, 4 of 5 investigators improved after training, although the difference was not statistically significant. Quality improvement initiatives and repeated module-based colonoscopy-training developed for junior and certified endoscopists have been promoted in Italy during the last decade, stimulated by the activation of colorectal cancer screening programs, which appear to have had a significant impact on quality colonoscopy metrics and allowed achieving almost all quality parameters recommended by the ESGE, ASGE, and ACG. Awareness of quality metrics among individual and endoscopy practices and patients very likely played a pivotal role in this improvement.

Declaration of Competing Interest

None to declare.

Funding

The study was promoted by the Italian Society of Digestive Endoscopy (SIED) and the Italian Association of Hospital Gastroenterologists and Endoscopists (AIGO) and was unconditionally supported by Norgine Italia Srl.

Acknowledgments

The authors thank Matteo Mucchetti of Health Publishing & Services Srl for project coordination and Patrick Moore who provided medical writing assistance on behalf of Health Publishing & Services Srl. This unconditional support was provided by Norgine Italia Srl.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.dld.2022.09.007.

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