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Impact of fair bowel prep on adenoma and serrated polyp detection: Data from the New Hampshire Colonoscopy Registry using a standardized preparation quality rating

Joseph C. Anderson, M.D.¹, Lynn Butterly, M.D.^{2,3,*}, Christina M. Robinson, M.S.³, Martha Goodrich, M.S.³, and Julia E. Weiss, M.S.³

¹Department of Veterans Affairs Medical Center, White River Junction, VT and The Geisel School of Medicine at Dartmouth, Hanover NH

²Dartmouth Hitchcock Medical Center, Section of Gastroenterology, Lebanon, NH

³The Geisel School of Medicine at Dartmouth, Department of Community and Family Medicine, Hanover, NH

Abstract

Background—The effect of colon preparation quality on adenoma detection rates (ADR) is unclear, partly due to lack of uniform colon preparation ratings in prior studies. The New Hampshire Colonoscopy Registry collects detailed data from colonoscopies statewide, using a uniform preparation quality scale after the endoscopist has cleaned the mucosa.

Objective—To compare the overall and proximal ADR and serrated polyp detection rates (SDR) in colonoscopies with differing levels of colon preparation quality.

Design—Cross-sectional.

Setting—New Hampshire statewide registry.

Patients—Patients undergoing colonoscopy.

Interventions—We examined colon preparation quality for 13,022 colonoscopies, graded using specific descriptions provided to endoscopists. ADR and SDR are the number of colonoscopies

Corresponding: Joseph C Anderson: Joseph.Anderson@dartmouth.edu.

*Dr. Lynn Butterly is the senior author on the paper and the Director of the New Hampshire Colonoscopy Registry

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with at least one adenoma or serrated polyp (excluding those in the rectum/sigmoid) detected divided by the total number of colonoscopies, for the preparation categories: optimal (excellent/good), fair, and poor.

Main outcome measurements—Overall/proximal ADR/SDR.

Results—The overall detection rates in examinations with fair colon preparation (SDR: 8.9%; 95% CI, 7.4–10.7) (ADR: 27.1% 95% CI, 24.6–30.0) were similar to rates observed in colonoscopies with optimal preparations (SDR: 8.8%; 95% CI, 8.3–9.4) (ADR: 26.3%; 95% CI, 25.6–27.2). This finding was also observed for rates in the proximal colon. A logistic regression model (including withdrawal time) found that proximal ADR was statistically lower in the poor preparation category (odds ratio=0.45; 95% CI, 0.24–0.84; $p<0.01$) than in adequately prepped colons.

Limitations—Homogeneous population.

Conclusions—In our sample, there was no significant difference in overall or proximal ADR or SDR between colonoscopies with fair versus optimal colon preparations. Poor colonic preparations may reduce proximal ADR.

Introduction and Background

Colonoscopy is currently the most widely used screening test for colorectal cancer (CRC) prevention and early detection in the United States, and is a critical part of recommended screening guidelines^{1, 2}. Prevention of CRC is accomplished through removal of potentially precancerous polyps, both adenomas and the more recently described sessile serrated polyps, before those lesions can progress to CRC. Patients are instructed to prepare for colonoscopy by drinking colon-cleansing fluids and restricting their diet for 24 hours before the procedure. Variable compliance with these instructions results in patients arriving for colonoscopy with colons in varying stages of preparation, ranging from excellent to poor. It seems reasonable to expect that detection of precancerous lesions during colonoscopy could be affected by the quality of the colon preparation.

However, little is known about outcomes based on the quality of colonoscopy preparation. For example, are more lesions detected in colonoscopies with optimal (excellent or good) preparation quality, or does suboptimal colon preparation differentially affect findings in the right or left colon? A few studies have suggested that patients with suboptimal preparations may have a high rate of missed advanced adenomas^{3, 4}. However, lack of standardization for grading the quality of preparation has hindered investigation of the impact of sub-optimal preparation⁵. For example, one study found similar ADRs in examinations with fair, good and excellent preparation, but there was no standardization in preparation quality⁶, or in whether the preparation was graded before or after clearing of the colon. Another challenge has been the lack of information regarding related variables such as withdrawal time in studies examining colon preparation⁶. As a result, there are no clear recommendations regarding whether follow-up screening or surveillance intervals should be modified for examinations with suboptimal colon preparation. However, in practice, subsequent surveillance intervals are frequently shortened for patients with sub-optimal preparation, in

order to address the greater potential for missed lesions than exists for patients with optimal (good or excellent) preparation⁷.

Inadequate or suboptimal colon preparations in the right colon may partly explain the lack of protection from advanced neoplasia in the proximal versus the distal colon provided by colonoscopy^{8,9}. It is unclear whether suboptimal prep may disproportionately affect detection of serrated as opposed to adenomatous lesions. This may be especially true because sessile serrated adenomas, the more worrisome subset of these lesions, are often flat and proximally located¹⁰. These factors may play a role in the finding that interval cancers are more likely to be located proximally¹¹. Clarification of the impact of suboptimal preparation by location, incorporating patient risk factors, will allow more specific and targeted responses to the persistent question of when to repeat tests for which the preparation was sub-optimal (neither good nor excellent).

The New Hampshire Colonoscopy Registry (NHCR) is a population-based, statewide registry that collects comprehensive patient, procedure, and pathology information. Endoscopists complete a Procedure Form that provides a detailed description for each category of preparation quality, and instructs endoscopists to grade the prep according to the worst prepped segment *after clearing*, providing consistent terminology among the diverse group of participating endoscopists. The NHCR assesses colonoscopy quality measures, including adenoma detection rate (ADR) and serrated polyp (subset that does not include those in the rectum or sigmoid) detection rate (SDR). Our aim in this analysis was to examine the overall as well as the proximal ADR and SDR for colonoscopies performed in patients with varying levels of colon preparation quality, particularly to compare detection rates in fair and optimal preparations, which previously have been reported to be similar.⁶

Methods

The design and development of the NHCR is described in detail elsewhere.^{12–14} Nearly all endoscopy sites in New Hampshire currently contribute data to the NHCR, with a few sites currently undergoing human subjects review and implementation. The NHCR is a registry used to generate evidence for multiple studies; therefore, there are no specific criteria for endoscopists in New Hampshire to participate in the registry. Consenting patients complete a self-administered Patient Questionnaire before colonoscopy, providing information on demographic characteristics, health history, and risk factors for CRC. On the NHCR Procedure Form, completed during or immediately after colonoscopy, endoscopists or endoscopy nurses record the indication for the colonoscopy (specific options within screening, surveillance, or diagnostic categories), findings (location, size and specific treatment if any of polyps, cancer, or other findings), quality of colon preparation, sedation medication, region reached during the procedure, withdrawal time, follow-up recommendations, and immediate adverse events. The NHCR requests pathology reports for all colonoscopies with findings directly from the pathology laboratory used by each participating endoscopy facility. Trained NHCR staff abstract data from these pathology reports, including location, size, and histology of all findings, and enter it into the NHCR database, linking it to information from the Procedure Form at the polyp level.¹⁴ All data collection and study procedures were approved by the Committee for the Protection of

Human Subjects at Dartmouth College, as well as by other relevant human subjects reviewing bodies at participating sites.

Cohort

During the time period used for this analysis (4/6/2009 – 3/22/2011), 12 endoscopy facilities, including hospitals, ambulatory surgery centers, and community practices across New Hampshire, were participating in the NHCR, and 16,574 colonoscopies were performed by 54 endoscopists at these 12 facilities. Across these 12 facilities, pathology reports were received for a median of 92% of colonoscopies with polyps detected. Incomplete colonoscopies, those where colon preparation was not indicated, evaluation of inflammatory bowel disease (IBD) and colonoscopies in patients with familial syndromes (Familial Polyposis or Hereditary Non-Polyposis Colon Cancer) noted on the Procedure Form were excluded. Our analysis included data from patients 40 years and older who had either a screening or surveillance (personal history of colorectal cancer or adenomatous polyps) colonoscopy performed. Because colon preparation quality affects colonoscopies of all indications, we also included examinations in patients with diagnostic colonoscopies for indications such as gastrointestinal bleeding, anemia, and change in bowel habits. After excluding 3,552 colonoscopies, 13,022 colonoscopies for 12,948 patients remained for this analysis.

Exposure measure

The NHCR Procedure Form provides the four options for examination preparation quality (excellent, good, fair or poor) that were the basis of the exposure measure in this analysis. On the procedure form, endoscopists are instructed to score quality of colon preparation, based on the worst prepped segment of the colon, after clearing of the mucosa. The recommended colon preparation score options, which were created by NHCR staff after a review of the medical literature¹⁵, We developed our prep scoring system approximately 10 years ago, independently of the Boston¹⁶ or Ottawa preparation scores¹⁷, and have been using it since that time. This preparation rating is described in detail on every endoscopy form:

- ‘Excellent’: only scattered, tiny particles and/or clear liquid - 100% visualization possible throughout colon
- ‘Good’: easily removable small amounts of particles and/or liquid - very unlikely to impair visualization throughout colon
- ‘Fair’: residual feces and/or non-transparent fluid - possibly impairing visualization
- ‘Poor’: feces and/or non-transparent fluid - definitely impairing visualization

For this analysis, colon preparation was defined as “optimal” if the endoscopist selected “Excellent” or “Good.” Because the registry was designed to measure “real world practice,” outcomes were assessed based on the endoscopists’ usual practices. Therefore, we offered no guidance to endoscopists with regards to when to terminate clearing efforts.

Co Factors

Patient demographics, including age, gender, smoking status, family history of CRC and body mass index (BMI), as well as the colonoscopy characteristics of indication for examination (screening, surveillance, or diagnostic), and withdrawal time of the examination (dichotomized above and below 6 minutes) were examined in relation to colon preparation and outcome measures.

Outcome measures

We calculated the overall colon ADR (the number of colonoscopies with at least 1 adenoma detected (including tubular or villous adenomas, and adenomas with high grade dysplasia or adenocarcinoma), divided by the total number of colonoscopies), and 95% confidence interval (95% CI) for each preparation category.

We calculated the proximal ADR in a similar manner to that for the overall rate. Our primary definition of proximal colon included the cecum, ascending colon and the hepatic flexure. We also included the transverse colon in a secondary analysis to examine the potential effect of defining proximal lesions as those proximal to the splenic flexure, and to account for potential misclassification of hepatic flexure polyps.

We defined serrated polyps to include sessile serrated polyps and serrated adenomas, as well as hyperplastic polyps, as has been done in previous studies¹⁸. Our sample excluded those hyperplastic polyps in the rectum or sigmoid. Although hyperplastic polyps are traditionally considered benign lesions, their role in the serrated pathway to CRC remains unclear, and both inter-observer reliability in histologic diagnosis and the logistic challenges of re-examining over 1000 histology slides argued for their inclusion within our definition of serrated polyps for this analysis^{19, 20}. Our calculation of SDR was similar to that for ADR; we divided the number of colonoscopies with at least 1 serrated polyp by the total number of colonoscopies for each colon preparation category, using the 2 definitions described above. In addition, we calculated the proximal SDR.

Statistical analyses

ADR, SDR, and 95% CI were computed using a nonparametric statistical method for proportions,²¹ and the Fisher exact test was used to compare the rates. Univariate analyses were performed for all cofactors across the 3 categories of colon preparation. The ADR and SDR odds ratios (OR) and 95% CIs are presented for the colon preparation results from a logistic regression model adjusted for all cofactors. Additionally, this model incorporated clustering on the endoscopist because patients were nested within endoscopist, to give more conservative estimates of the standard errors. All analyses were conducted in SAS 9.3 and a p-value < 0.05 was considered significant.

Results

Our cohort had a mean ($\pm$ SD) age of 59 ($\pm$ 9) years, and was 53% female and 94% Caucasian with 22% self-reporting a first-degree relative with CRC. Of the 13,022 colonoscopies, 11,620 (89%) were judged to have an optimal preparation, 1201 (9%) had a fair preparation

and 201 (2%) had a poor preparation. Participating endoscopists had a median of 14 years of experience (interquartile range: 7–21 years), and had performed a mean number of 241 examinations in this dataset. Less than 7% (n=894) of the examinations were performed by endoscopists with fewer than 100 examinations in this dataset. The number of examinations performed by each endoscopist that are included in this analysis does not reflect their entire colonoscopy caseload during this time period, due to exclusion criteria and the fact that not all endoscopists were participating in the NHCR for the full time period. With regards to variation in preparation, all endoscopists had mean colon preparation scores of either good or excellent. Thus, the mean score was in the optimal range for all endoscopists.

Table 1 presents ADR and SDR in the entire and proximal colon, calculated for all colonoscopies and by colon preparation quality. There was a trend toward statistical significance in the difference in proximal ADR between the optimal, fair and poor groups. For serrated polyps, there was a decrease in the proximal SDR across the 3 groups with poor prep having the lowest rate but this was not statistically significant. We performed the same analysis, adding polyps from the transverse colon to those from the original definition of proximal colon, and observed similar non-significant results for both ADR: optimal: 17.3% (95% CI, 16.6–18.0); fair: 18.2% (95% CI, 16.0–20.5) and poor: 13.4% (95% CI, 9.0–18.9) (p=0.26; Fisher exact test) and SDR: optimal: 7.0% (95% CI, 6.5–7.5); fair: 6.5% (95% CI, 5.2–8.0) and poor: 4.5% (95% CI, 2.1–8.3) (p=0.34; Fisher exact test).

In addition, we conducted a subset analysis in surveillance and screening examinations (N=10,310), dropping diagnostic examinations, and observed similar results. Specifically, in this subset analysis, of 10,310 examinations (optimal = 9263 examinations, 89.8%; fair = 899 examinations, 8.7%; poor = 148 examinations, 1.4%) the observed proximal ADRs for each group of colon preparation quality were: optimal: 13.9% (95% CI, 13.2–14.6); fair: 13.3% (95% CI, 11.2–15.7) and poor: 10.1% (95% CI, 5.8–16.2) (p=0.42; Fisher exact test) and proximal SDRs were: optimal: 5.0% (95% CI, 4.5–5.4); fair: 4.1% (95% CI, 2.9–5.6) and poor: 4.7% (95% CI, 1.9–9.5) (p=0.57; the Fisher exact test). We also performed sub analyses examining the ADR and SDR for screening and surveillance examinations separately²². These data are shown in Table 2.

In another sub-analysis, we examined the ADR by the four prep categories, with the following results: Excellent prep: 23.8 (95% CI, 22.5 – 25.1); Good: 28.0 (95% CI, 26.9 – 29.0), Fair; 27.1 (95% CI, 24.6 – 30.0) and Poor; 20.9 (95% CI, 15.5– 27.2). A similar analysis was done for SDR, with the following results: Excellent prep SDR; 8.1 (95% CI, 8.3 – 8.9); Good; 9.3 (95% CI, 8.6 – 10.0); Fair; 8.9 (95% CI, 7.4 – 10.7) and poor; 7.5 (95% CI, 4.2 – 12.0).

Table 3 shows the clinically important characteristics of the 3 preparation groups. Patients with poor preparations were more likely to be younger, male, obese and current smokers than patients in the optimal or fair groups. A larger proportion of colonoscopies in the poor colon preparation group were performed for a diagnostic indication as compared with the other preparation groups. There were no differences in family history of CRC or withdrawal time between the three preparation groups. The examinations with missing withdrawal times

have a similar bowel preparation quality distribution to those examinations for which withdrawal times were collected.

A multivariable logistic regression analysis, adjusting for age, gender, BMI, smoking, family history of CRC, indication for examination, withdrawal time and endoscopist (Table 4), showed that the proximal ADR for colonoscopies in the poor colon preparation group was lower than the ADR for the optimal or fair groups (OR=0.45; 95% CI, 0.24,0.84). This difference was not observed for proximal SDR (OR=0.75; 95% CI, 0.31, 1.80). When we included the transverse colon we obtained similar results in the poor group for both ADR (OR =0.48; 95% CI, 0.33, 0.73) and SDR (OR =0.70; 95% CI, 0.37, 1.35).

The proximal SDR varied among the 54 endoscopists with a median of 4.5% and interquartile range (IQR) of 2.4% to 7.5%. To determine whether endoscopists with higher ADR gave lower scores for colon preparation quality (as has been reported previously)²³, we examined the correlation between the endoscopists' ADR and the percentage of colonoscopy preparations that they rated as optimal. We found no correlation between the endoscopist's mean proximal ADR and mean quality of reported preparation (Spearman correlation coefficient = -0.09; p=0.50).

Discussion

In data collected for the NHCR, we observed that the overall ADR in colonoscopies with a fair colon preparation was similar to the ADR observed in examinations with an optimal preparation (good or excellent). This relationship was also observed for the proximal ADR. As expected, the proximal ADR was lower in poor preparation groups than the optimal or fair groups. With regard to serrated polyps we observed a decrease in proximal SDR across the 3 preparation groups from optimal to poor but this difference was not statistically significant.

Colorectal cancer (CRC) prevention with colonoscopy relies on the ability to detect and resect potentially pre-cancerous polyps before further development to adenocarcinoma. The ADR is a quality indicator that has been shown to be inversely associated with the interval cancer rates for endoscopists²⁴; patients of endoscopists with lower ADRs have higher rates of interval CRC. Thus adequate detection of adenomas is a crucial component of colonoscopy practice.

An optimal colon preparation is vital to ensure complete mucosal inspection for adenomas. An analysis of Clinical Outcomes Research Initiative (CORI) data demonstrated that an "adequate" colon preparation was achieved in approximately three quarters of all examinations¹⁵. Patients with suboptimal colon preparations have been observed to have high rates of missed advanced neoplasia; one recent study observed that patients with poor or fair colonic preparations had a miss rate of 27% for advanced lesions³. Another study observed that a better colon preparation was correlated with a higher rate of detection for adenomas but not serrated polyps²⁵. A recent study of Veterans Affairs (VA) patients observed that examinations in patients with fair preparations had similar rates of adenomas and advanced lesions as those with optimal preparations⁶. Although this study provides

intriguing data, it is limited by its inability to standardize preparation scores or to include withdrawal times, as well as its reliance on data from a single site. Our study, which incorporated data from 12 practices using standardized preparation quality scores and factoring in withdrawal time, substantiated the findings of the VA study, finding similar detection rates in examinations with fair and optimal bowel preparation quality.

Poor colonic preparations have been implicated in the development of interval cancers, which are often proximal in location¹¹. The serrated pathway has been shown to share molecular abnormalities with interval cancers²⁶, suggesting detection of serrated lesions may be essential to preventing interval cancers. A recent study found that colonoscopy conferred a statistically significant reduction in the future risk of proximal advanced adenomas, but not proximal sessile serrated polyps.²⁷ It is unclear whether inadequate colonic preparation in the proximal colon might have played a role in this finding. To date, there have been little data in the medical literature regarding ADR and SDR in the proximal colon of patients with inadequate or suboptimal preparations, leading to our current investigation.

We observed that there was a slight decrease in the proximal SDR as colon preparation quality moved from optimal to poor, but this trend was not statistically significant. De Wijkerslooth et al recently demonstrated no relationship between detection of proximal serrated lesions and colon preparation quality as graded by the Ottawa bowel preparation score²⁵. Given the flat nature of proximal serrated polyps, the authors of this study were surprised at this finding, and postulated that perhaps poorer colon preparations may allow serrated polyps to be detected more easily due to residual stool attaching to the mucous cap.

We were equally surprised that the difference in SDR among the 3 levels of preparation quality was not more pronounced in our study. It is possible, as De Wijkerslooth has suggested, that serrated polyps are made more visible when residual stool is attached to their mucus caps. Perhaps in the colons with poorer preparation, the additional washing helped to focus the attention of the endoscopist more closely to the mucosa thus allowing for higher detection of serrated polyps. Due to the lower incidence of proximal serrated polyps, it is possible that our study may have been underpowered with regards to these lesions as compared with adenomas. It is unlikely that the lack of a difference in SDR by colon preparation quality can be explained by anatomical location because the overall SDR for the entire colon had similar results. Although we cannot readily explain why suboptimal colon preparation quality does not affect SDR at this time, we strongly agree with quality standards that assert that an adequate colon preparation is an important quality measure for screening colonoscopy, especially in the proximal colon².

There are a few significant differences between our current study and that of De Wijkerslooth²⁵. Our analysis was designed to examine the impact of colon preparation whereas the other study examined withdrawal time. Furthermore, de Wijkerslooth examined the results of only 5 endoscopists, whereas our analysis included data from 54 endoscopists. Because SDR may vary widely among endoscopists¹⁸, our results may provide more reliable data. It has been suggested that endoscopists with higher ADR may rate the quality of colon preparations lower than endoscopists with lower ADR²³. We were able to examine this

potential confounding factor among the 54 endoscopists in this analysis, and we found no correlation between endoscopist's ADR and quality of reported preparation.

A limitation of our study is the potential lack of generalizability due to the limited racial diversity of the population of New Hampshire. In addition, we do not know the salvage efforts of the participating endoscopists who achieved high rates of optimal colon preparations (89%). The ratings of the prep before irrigation and clearing and the prep ratings for individual colon segments are unknown. This may be problematic if only the proximal colon, for example, had a "fair" preparation whereas the rest of the bowel had a "good" quality preparation. Thus, in our sample, the endoscopist would have rated the overall preparation as "fair" (the prep quality in the worst prepped segment) despite the quality of the preparation of the remainder of the colon having a "good" quality preparation. It is also possible that the proximal colon may have been flooded in an effort to preferentially clean this particular segment. Estimations of these efforts to clear the colonic mucosa of residual stool and yield of additional adenomas and serrated polyps during these salvage efforts or "pre irrigation prep ratings" might have provided more valuable information than the absolute percentages of ADR and SDR in the various categories of colon preparation. Although we use a uniform preparation rating we do not have data such as videos and do not examine available photos to provide feedback to the endoscopists or perhaps to validate the rating. Thus we may be limited in assessing concordance of colon preparation among endoscopists or whether some had veered away from the written definitions during the course of the study. We also do not provide data regarding the type of prep used at different sites. This would allow us to determine the optimal prep for maximizing proximal polyp detection. In addition, we do not have data regarding the specific morphology (flat vs. sessile) or type (microvesicular versus goblet cell) of hyperplastic polyps. Finally, we acknowledge the heterogeneity of pathologists' interpretation of serrated polyps at the different pathology laboratories across New Hampshire.

Strengths of this study include large numbers of colonoscopies and endoscopists. In addition, the NHCR collects colonoscopy characteristics such as withdrawal time, and information regarding CRC risk factors including BMI, smoking and family history of CRC, all of which have been shown to be important predictors of adenomas and serrated polyps^{10, 28, 29}. The linked pathology data, available for over 90% of examinations with findings, is a unique strength of the NHCR's comprehensive data collection protocol. A particular strength was the method for collecting data regarding the quality of colon preparation. Endoscopists were provided with clear descriptions of each category of preparation quality on the endoscopy form, and were instructed to provide a preparation rating after they had cleaned the colon. Because preparation scored as 'fair' in studies lacking this standardization might actually be 'good' or 'excellent' when the endoscopist finished clearing the colon, the standardization of our preparation data strengthens the validity of our findings. Although not validated our rating system enables consistency by using actual descriptions, rather than just terminology, to describe what we mean by each term and because the same endoscopists have been using those terms for almost 10 years.

Our goal was to measure and compare the overall and proximal ADR and SDR between colonoscopies with varying colon preparation quality in the statewide, population-based NHCR. We observed no significant difference between fair and optimal preparations with regards to proximal ADR or SDR. The decision to recommend similar surveillance intervals for fair and optimal preparations should be based on further research, including studies that examine the longitudinal risk of advanced neoplasia in patients with varying quality of colon preparation.

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Acronyms

CRC	Colorectal cancer
SDR	Serrated detection rate
ADR	Adenoma detection rate
CORI	Clinical Outcomes Research Initiative
NHCR	New Hampshire Colonoscopy Registry
BMI	Body mass index
VA	Veterans Affairs
PF	Procedure form

Take-Home Message

Using a standardized preparation quality rating, we observed that patients with a fair colonic preparation had similar proximal adenoma and serrated polyp detection rates to those with an excellent or good preparation.

Table 1
Colon adenoma detection rate and serrated polyp detection rate by colon preparation quality

	Total N=13,022 Rate % (95% CI)	Optimal (Excellent/Good) N=11,620 (89.5%) Rate % (95% CI)	Fair N=1,201 (9%) Rate % (95% CI)	Poor N=201 (1.5%) Rate % (95% CI)	p-value*
Adenoma detection (ADR) in entire colon	26.3 (25.6 – 27.1)	26.3 (25.6 – 27.2)	27.1 (24.6 – 30.0)	20.9 (15.5 – 27.2)	0.18
Serrated polyp detection (SDR) in entire colon	8.8 (8.3 – 9.3)	8.8 (8.3 – 9.4)	8.9 (7.4 – 10.7)	7.5 (4.2 – 12.0)	0.84
Adenoma detection (ADR) in proximal colon	12.8 (12.2 – 13.4)	12.9 (12.3 – 13.5)	12.4 (10.6 – 14.4)	8.0 (4.6 – 12.6)	0.10
Serrated polyp detection (SDR) in proximal colon	4.7 (4.4 – 5.1)	4.8 (4.5 – 5.3)	3.9 (2.9 – 5.2)	3.5 (1.4 – 7.0)	0.24

* Fisher's Exact Test

Table 2

ADR and SDR for screening versus surveillance examinations

	Total Rate % (95% CI)	Excellent/Good Rate % (95% CI)	Fair Rate % (95% CI)	Poor Rate % (95% CI)
Adenoma detection (ADR) in screening cohort	24.1 (23.1 – 25.1)	24.1 (23.0 – 25.2)	24.0 (20.5 – 27.7)	24.5 (16.4 – 34.2)
Adenoma detection (ADR) in surveillance cohort	36.4 (34.7 – 38.0)	36.5 (34.7 – 38.2)	36.6 (31.4 – 42.0)	28.0 (16.2 – 42.5)
Serrated polyp detection (SDR) in screening cohort	8.4 (7.7 – 9.1)	8.4 (7.8 – 9.1)	8.2 (6.0 – 10.7)	6.1 (2.3 – 12.9)
Serrated polyp detection (SDR) in surveillance cohort	10.7 (9.7 – 11.8)	10.6 (9.6 – 11.8)	10.4 (7.4 – 14.2)	8.0 (7.2 – 29.1)

Table 3

Characteristics* and quality of colon preparation

Characteristics*	Quality of Colon Preparation				χ^2 p value
	Optimal (Excellent/ Good)* N=11554 (89%)	Fair N=1194 (9%)	Poor N=200 (2%)	Total N=12948 (100%)	
Age	N (%)	N (%)	N (%)	N (%)	0.05
40–64	8499 (74)	840 (70)	150 (75)	9489 (73)	
65 or more	3055 (26)	354 (30)	50 (25)	3459 (27)	
Gender	N (%)	N (%)	N (%)	N (%)	<0.001
Male	5122 (47)	585 (52)	103 (54)	5810 (47)	
Female	5880 (53)	550 (48)	86 (46)	6516 (53)	
BMI	N (%)	N (%)	N (%)	N (%)	<0.0001
<25 (underweight & normal)	3127 (29)	286 (26)	35 (19)	3448 (28)	
25 to < 30 (overweight)	4177 (38)	389 (35)	66 (36)	4632 (38)	
30 to <35 (Obesity Class I)	2287 (21)	252 (22)	45 (25)	2583 (21)	
35 (Obesity Classes II & III)	1333 (12)	194 (17)	37 (20)	1564 (13)	
Smoking status	N (%)	N (%)	N (%)	N (%)	<0.0001
Never	5491 (49)	465 (41)	68 (36)	6024 (48)	
Past	4677 (42)	510 (44)	91 (48)	5278 (42)	
Current	1079 (10)	173 (15)	30 (16)	1282 (10)	
Family History of CRC	N (%)	N (%)	N (%)	N (%)	0.94
No	8968 (78)	920 (77)	155 (78)	10043 (78)	
Yes	2568 (22)	270 (23)	44 (22)	2882 (22)	
Indication for Exam	N (%)	N (%)	N (%)	N (%)	<0.001
Screening	6310 (56)	563 (50)	97 (50)	6970 (55)	
Surveillance	2906 (26)	329 (29)	50 (26)	3285 (26)	

Characteristics *	Quality of Colon Preparation				[†] p value
	Optimal (Excellent/Good) * N=11554 (89%)	Fair N=1194 (9%)	Poor N=200 (2%)	Total N=12948 (100%)	
	N (%)	N (%)	N (%)	N (%)	
Diagnostic	2024 (18)	235 (21)	47 (24)	2306 (18)	
Withdrawal Time [‡]					0.47
<=6 minutes	2136 (21)	219 (21)	41 (25)	2396 (21)	
> 6 minutes	8054 (79)	834 (79)	124 (75)	9012 (79)	

* Missing (N, %): Gender (622, 5), BMI (721, 6), Smoking status (364, 3), Family history of CRC (23, <1), Indication for exam (387, 3), [‡]Withdrawal Time (1540, 12).

[†] Chi-square test compares Quality of Bowel Prep categories for each characteristic

[‡] The exams with missing withdrawal times have a similar bowel preparation quality distribution to those exams for which withdrawal times were collected.

Table 4

Logistic regression model* results for colon preparation for proximal colon Adenoma Detection Rate (ADR) and Serrated Polyp Detection Rate (SDR)

Colon preparation	Proximal Adenoma Detection Rate (ADR) <i>OR (95% CI)</i>	Proximal Serrated Detection Rate (SDR) <i>OR (95% CI)</i>
Optimal [^]	Reference (1.0)	Reference (1.0)
Fair	0.89 (0.71, 1.14)	0.82 (0.58, 1.15)
Poor	0.45 (0.24, 0.84)	0.75 (0.31, 1.80)

* Adjusted for age, gender, Body Mass Index, smoking, family history of colorectal cancer, indication for exam, withdrawal time and endoscopist.

[^] Optimal= Excellent/Good