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Article

Quality of Bowel Preparation in the General Population

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Abstract

Background and Objectives: With more than 1.9 million new cases and 0.9 million deaths in 2020, colorectal cancer (CRC) was the third most common cancer and the second most common cause of cancer mortality worldwide. The adenoma detection rate as a precursor to the formation of CRC is directly related to the degree of bowel preparation for colonoscopy. **Materials and Methods:** This is a retrospective single-center study on a total number of 4835 colonoscopies performed in a period of 34 months during the global COVID-19 pandemic. The main goal of the research was related to the emergence of differences in cleaning in relation to gender, age, days of preparation, the type of cleaning agent. **Results:** There is no significant difference between gender. Compared to younger respondents, older respondents had a lower likelihood of having adequate bowel preparation. Compared to PEG, other solutions had a lower probability of adequate bowel preparation. **Conclusions:** Better cooperation between patients and medical staff is needed, as well as public health campaigns that raise awareness of the importance of good preparation for colonoscopy.

Keywords: colorectal carcinoma; bowel preparation; PEG; adenomas

1. Introduction

The incidence of colorectal cancer (CRC) is constantly increasing, but with the introduction of a screening program with adequate bowel preparation, it is expected that the disease will be detected at an early stage with a decrease in the number of patients who, at the time of diagnosis, are in the terminal phase of the disease

Colonoscopy is the gold standard for CRC screening, but its accuracy is related to the high quality of bowel preparation. This study aimed to assess the validity and reliability of existing bowel preparation solutions regarding age, sex, indication, and season of preparation for colonoscopy. Following scientific recommendations, our country has introduced a screening program for colorectal cancer in the general population with the sole aim of early recognition of premalignant and malignant lesions in the curable phase of the disease. The indications for the procedure were different - a search as part of the national screening for colorectal cancer, in patients with various symptoms, preventive colonoscopies, and control colonoscopies. Compared to younger respondents, older respondents had a lower likelihood of having adequate bowel preparation (odds ratio (OR) = 0.98, 95% confidence interval (CI) = 0.97–0.99, $p < 0.001$). In addition, respondents who prepared in winter had less likelihood of having adequate bowel preparation. Compared to PEG, other solutions had a lower probability of adequate bowel preparation. To thoroughly and completely examine the colon, it is necessary to cooperate with the patient and be maximally engaged in preparing the intestine before the examination.

2. Materials and Methods

Participants

A retrospective descriptive analysis was performed on the clinical records of all patients who met the inclusion criteria. We performed a total of 4835 colonoscopies from June 2019 to April 2022, using Pentax colonoscopes of a different generation, without possibility of using the artificial intelligence (AI).

Inclusion criteria were age >18, indicated for colonoscopy from June 2019 to April 2022 (during Covid pandemic). The data comes from the hospital's electronic medical record system, including age, sex, the indication of colonoscopy, risk factors for colonoscopy, day of the week, conscious sedation (pethidine, midazolam) administered by gastroenterology-trained nurse, or propofol sedation administered by an anesthesiologist with or without an anesthesia assistant, diagnosis (irritable bowel disease, tumors, polyps, diverticula, anorectal changes), total colonoscopy time, withdrawal time, and Boston bowel preparation score (BBPS)

We excluded patients with contraindications for colonoscopy: pregnancy, intestinal occlusion, and perforation or threatening perforation (severe inflammation, etc).

Ethical consideration

This study was approved by the Ethics Committee of the Zadar General Hospital (No.01-2529/25-9/25, from 31st of March 2025.). All patients signed an informed consent for a colonoscopy before the exam. Following relevant ethical guidelines, all patient data were anonymized before analysis to protect privacy and confidentiality. As it is a retrospective analysis of existing clinical de-identified data, informed consent of the participants was not required for participation. The study complied with the Declaration of Helsinki and the law regulative on the use of retrospective data in clinical research.

Protocol of bowel preparation

Patients were advised to avoid eating fruits, vegetables, and seeds for five days before the procedure, and to take a bowel cleansing solution after a light lunch the day before the colonoscopy.

For bowel preparation, patients were offered two different solutions:

Solution 1 solution of macrogol 3350 (polyethylene glycol)+ sodium sulfate +sodium chloride + potassium chloride+sodium ascorbate, and ascorbic acid (PEG- Original name: Movi Prep).

Solution 2: bisacodyl + magnesium solution in amount of 3-4 liters

Patients who were examined in an emergency or who were not able to drink a cleansing agent (uncooperative, seriously ill, patients with active rectal bleeding...) were examined without using enemas.

The Boston Bowel Preparation Scale (BBPS), which has been validated in multiple clinical studies, has been used as a basic tool for determining the degree of bowel cleanliness) [2,3].The BBPS should be presented in the examination report using the following documentation: right/transverse / left; e.g. = 2/2/3, along with the corresponding total (BBPS = 7). Poorer adenoma detection rate is in correlation with poor bowel preparation (BBPS ≤ 5). [5].

Boston Bowel Preparation Scale (BBPS)	
Score	Description
0	Unprepared colon segment with mucosa not seen because of solid stool that cannot be cleared
1	Portion of mucosa of the colon segment seen, but other areas of the colon segment are not well seen because of staining, residual stool, and/or opaque liquid
2	Minor amount of residual staining, small fragments of stool, and/or opaque liquid, but mucosa of colon segment is seen well
3	Entire mucosa of colon segment seen well with no residual staining, small fragments of stool, or opaque liquid

Figure 1. Boston Bowel Preparation Scale [4]. Score - Excellent (BBPS 8-9), Good (BBPS 6-7), Average (BBPS 4-5), Poor (BBPS 0-3)Downloaded from the Internet on February 29, 2024.

3. Results

Differences by gender, age group, season, day of the week, and bowel preparation solution in the category of quality of bowel preparation(N=4609) (Table S1).

In the period from 06/2022 to 04/2023 we made a total of 4835 colonoscopies in the general population including hospitalized patients. Total colonoscopy up to the cecum in percentages was 89% (part due to impurity, part abandoned due to pain, stenosis, etc.).

Total number of ileoscopy was 783 (16.2%). The total number of colonoscopies by conscious sedation (pethidine, midazolam) administered by a gastroenterology-trained nurse, or propofol sedation administered by an anesthesiologist with or without an anesthesia assistant, etc, was 259 (5.3%)

Indications for colonoscopy were: national colorectal cancer prevention program (NPP) 237 colonoscopy, preventive colonoscopy 662, different symptomatic reasons (abdominal pain, constipation, etc) 2558, controls in 1378.

After randomization, the total number of colonoscopies undergoing statistical analysis was 4036.

Boston Bowel Preparation Scale was used to evaluate the success of bowel preparation with an overall score of adequate ≥ 6 , Inadequate 0 – 5.

Data analysis

The statistical analysis was conducted using Statistica 13 (TIBCO Software Inc., 2017) on a sample of 4036 Croatian respondents. The statistical significance was $p < 0.05$.

In the descriptive analysis, mean and standard deviation were used for numerical variables, while absolute number and percentage were used for categorical variables. In the bi-variate analyses, the chi-square test was used to examine the differences between variables for categorical variables, while the Student's t-test and ANOVA were used for numerical variables. The Pearson correlation coefficient was used to examine the relationship between variables.

The multivariate analysis included linear and logistic regression to assess the relationship between the variables. In the linear regression models, the quality of bowel preparation using the BBPS scale and withdrawal time were used as dependent variables. The predictors for these two models were age, gender, indication for colonoscopy (preventive and control examinations were referent group, RG); risk factors (no risk was the RG), season (summer was RG), the timing of bowel preparation (day before the examination was RG), bowel cleansing procedure (the working day was RG), bowel preparation medication (PEG solution was the reference group), premedication or sedation (no was RG), irritable bowel disease, tumor, polyp, diverticulum, anorectal changes, and adequate bowel preparation (no was RG). Logistic regression models were used to predict the probability of adequate bowel preparation and complete colonoscopy. The prior regression model described the predictors and the reference groups, while beta was converted to OR (odds ratio) with a 95% confidence interval.

Characteristics of the study group (Table 1.)

The average age of the respondents was 62 (M=62; SD=14.0). Respondents aged between 61 and 75 were the most strongly represented, with a total of 43.9% (Table 1.). Women (53.7%) and men (46.3%) were approximately equally represented in the sample. The most common indications for colonoscopy was symptomatic (53.2%). The respondents were mostly risk-free for colonoscopy (96.3%) and without sedation (94.4 %). A certain percentage of subjects had irritable bowel disease (4.4 %), tumors (4.8 %), polyps (22.9 %), diverticula (24.8 %) and anorectal changes (59.8%).

The respondents were mainly examined in winter (30.6%) and spring (29.1%). The number of colonoscopies was evenly distributed across the days of the week. Bowel preparation was carried out the day before the examination (93.4%), with solution 1 (PEG).

The overall quality of bowel preparation (BPPS score) was 6.2, while the average quality of colon preparation ranged from 1.7 for the right colon, 2.1 for the transverse colon, and 2.4 for the left colon. Quality of bowel preparation was adequate (BBPS \geq 6) in 3268 (70.9%) patients, while it was inadequate (BBPS \leq 5) in 1341 (29.1%) patients. Excellent bowel preparation was in (BBPS 8–9) 1473 (32.0%), good (BBPS 6–7) in 1795 (38.9%), poor (BBPS 4–5) in 715 (15.5%) and inadequate (BBPS 0–3) in 626 (13.6%) patients. The withdrawal time was 8.7 \pm 2.7 minutes, while the complete colonoscopy was performed in 87.9% of the subjects (Table 1).

Table 1. Characteristics of study groups, quality bowel preparation and total colonoscopy for entire sample (N=4609).

Age (years; M, SD)	62.0 (14.0)
Age groups, N (%)	
\leq 30 years	130 (2.8)
31-45 years	484 (10.5)
46-60 years	1250 (27.1)
61-75 years	2025 (43.9)
\geq 76 years	720 (15.6)
Gender, N (%)	
Female	2136 (53.7)
Male	2473 (46.3)
Season, N (%)	
Autumn	1339 (29.1)
Winter	1409 (30.6)
Spring	840 (18.2)
Summer	1021 (22.2)
Indication for colonoscopy, N (%)	
Preventive	849 (18.4)
Symptomatic	2452 (53.2)
Control	1308 (28.4)
Risk factors for colonoscopy, N (%)	
Without risk	4437 (96.3)
Anticoagulant therapy	160 (3.5)
Anticoagulant and antibiotic therapy	12 (0.3)
Day of week, N (%)	
Monday	1097 (23.8)
Tuesday	779 (16.9)
Wednesday	928 (20.1)
Thursday	917 (19.9)
Friday	888 (19.3)
Time of bowel preparation, N (%)	
Day before the exam	4303 (93.4)
Day of the exam	261 (5.7)
Day before and on the day of the exam	45 (1.0)
Preparation of bowel preparation, N (%)	
Working day	3562 (77.3)
Sunday	1047 (22.7)
Medication of bowel preparation, N (%)	
MoviPrep solution	4282 (92.9)
Senna solution	77 (1.7)
Enema	161 (3.5)
Bisacodyl	89 (1.9)

Sedation/premedication, N (%)	
None	4353 (94.4)
Yes (Propofol, Pethidine, Midazolam, antibiotic or combinations)	256 (5.6)
Irritable bowel disease, N (%)	
No irritable bowel disease	4408 (95.6)
Morbus Chron	104 (2.3)
Ulcerative colitis	97 (2.1)
Tumors, N (%)	
Yes	219 (4.8)
No	4390 (95.2)
Polyps, N (%)	
Yes	1057 (22.9)
No	3552 (77.1)
Diverticula, N (%)	
Yes	1141 (24.8)
No	3468 (75.2)
Anorectal changes, N (%)	
Hemorrhoids and other	2756 (59.8)
Without anorectal changes	1853 (40.2)
Total BBPS score, M (SD)	
Right colon	1.7 (0.9)
Transverse colon	2.1 (0.9)
Left colon	2.4 (0.7)
Bowel preparation quality (BBPS), N (%)	
Inadequate (0–3)	626 (13.6)
Poor (4–5)	715 (15.5)
Good (6–7)	1795 (38.9)
Excellent (8–9)	1473 (32.0)
Total quality bowel preparation, N (%)	
Non-adequate (≤ 5)	1341 (29.1)
Adequate (≥ 6)	3268 (70.9)
Withdrawal time, (min; N (%))	
	8.7 (2.7)
Total colonoscopy, N (%)	
Yes	4050 (87.9)
No	559 (12.1)

Note: M-Mean; SD-standard deviation; N-absolute number; %-percentage; BBPS -Boston bowel preparation score.

Differences in bowel preparation quality according to respondents' characteristics (Table 2.)

No statistically significant difference was found between men and women about the level of bowel preparation ($p=0.176$). Subjects under 45 years of age ($M=6.7\pm 2.0$) showed a statistically significant better level of quality of bowel preparation than older subjects ($M=6.1\pm 2.0$), $p<0.001$). Older subjects had a lower level of bowel preparation quality ($p<0.001$) (Table 2.).

Table 2. Differences in bowel preparation quality according to respondents' characteristics (N=4609).

	Boston bowel preparation	p-value
Gender		
Female	6.2 (2.0)	0.176*
Male	6.3 (2.1)	
Age groups,		

≥45 years	6.7 (2.0)	<0.001*
≥46 years	6.1 (2.0)	
Age groups		
18-30 years	6.8 (2.2)	<0.001†
31-45 years	6.7 (1.9)	
46-60 years	6.4 (1.9)	
61-75 years	6.2 (2.0)	
>75 years	5.6 (2.2)	
Season		
Autumn	6.3 (2.0)	0.002†
Winter	6.1 (2.0)	
Spring	6.2 (2.0)	
Summer	6.4 (2.1)	
Indication for colonoscopy		
Preventive	6.6 (1.8)	<0.001†
Symptomatic	6.1 (2.1)	
Control	6.2 (2.0)	
Risk factors for colonoscopy, N (%)		
Without risk	6.2 (2.0)	0.134†
Anticoagulant therapy	5.9 (2.1)	
Anticoagulant and antibiotic therapy	6.3 (2.0)	
Day of week, N (%)		
Monday	6.3 (2.0)	0.001†
Tuesday	6.2 (2.2)	
Wednesday	6.2 (2.0)	
Thursday	6.4 (2.0)	
Friday	6.0 (2.0)	
Procedure of bowel preparation, N (%)		
Preparation on working day	6.2 (2.1)	0.008*
Preparation on Sunday	6.4 (2.0)	
Time of bowel preparation, N (%)		
the day before the exam	6.3 (2.0)	<0.001†
on the day of the exam	5.5 (2.5)	
the day before and on the day of the exam	6.1 (2.2)	
Medication of bowel preparation, N (%)		
MoviPrep solution	6.4 (1.9)	<0.001†
Senna solution	5.8 (2.2)	
Enema	3.9 (2.3)	
Bisacodyl	4.0 (2.6)	
Sedation/premedication, N (%)		
None	6.1 (2.0)	<0.001*
Yes (Propofol, Pethidine, Midazolam, antibiotic or combinations)	7.2 (1.7)	
Irritable bowel disease, N (%)		
No irritable bowel disease	6.2 (2.0)	<0.001†
Morbus Chron	7.2 (1.8)	
Ulcerative colitis	5.9 (2.3)	
Tumors, N (%)		
Yes	5.2 (1.7)	<0.001*
No	6.3 (2.0)	
Polyps, N (%)		
Yes	6.1 (1.9)	0.105*
No	6.2 (2.0)	

Diverticula, N (%)		
Yes	6.3 (1.9)	<0.001*
No	6.2 (2.1)	
Anorectal changes, N (%)		
Hemorrhoids and other	6.4 (1.9)	<0.001*
Without anorectal changes	5.9 (2.2)	
Total quality bowel preparation		
Adequate (≥ 6)	7.3 (1.1)	<0.001*
Non-adequate (≤ 5)	3.6 (1.3)	
Total colonoscopy		
Yes	6.6 (1.7)	<0.001*
No	3.1 (1.7)	
*t -test †-ANOVA		

Subjects who underwent colonoscopy in summer had a better degree of quality of bowel preparation (6.4 ± 2.1), while they were least prepared in winter (6.1 ± 2.0), $p=0.002$. Respondents with the colonoscopy performed on Thursday had the best bowel preparation score (6.4 ± 2.0) and the lowest on Friday (6.0 ± 2.0), $p=0.001$. Respondents who had performed bowel preparation on Sunday had a higher degree of bowel preparation (6.4 ± 2.0) than on weekdays (6.2 ± 2.1), $p=0.008$ (Table 2.)

Subjects with a preventive indication for colonoscopy showed a statistically significantly better degree of bowel preparation (6.6 ± 1.8), compared to symptomatic (6.1 ± 2.1) and control subjects (6.2 ± 2.0), $p<0.001$. PEG showed the best bowel preparation effect compared to the other preparations (6.4 ± 1.9), while the enema showed the worst results (3.9 ± 2.3), $p<0.001$ (Table 2.).

The differences by age group, gender, season, day of the week, and bowel preparation solution in the category of quality of bowel preparation (inadequate (0–3), poor (4–5), good (6–7), excellent (8–9)) are shown in Supplementary Table 1.

Subjects who received conscious sedation (pethidine, midazolam) administered by a gastroenterology-trained nurse, or propofol sedation administered by an anesthesiologist had the highest quality of bowel preparation (7.2 ± 1.7), $p<0.001$). Subjects with Chron's disease (7.2 ± 1.8) had significantly better bowel preparation quality, while patients with tumors had poorer (5.2 ± 1.7), $p<0.001$). No statistically significant difference in bowel preparation was found between subjects with and without polyps ($p=0.105$). Subjects with hemorrhoids and other anorectal changes had statistically significantly higher quality of bowel preparation (6.4 ± 1.9) than subjects without hemorrhoids (5.9 ± 2.2), $p<0.001$.

Subjects with adequate bowel preparation had a significantly higher degree of cleanliness (7.3 ± 1.1) than subjects with inadequate bowel preparation (3.6 ± 1.3), $p<0.001$. Subjects with complete colonoscopy had better bowel preparation (6.6 ± 1.7) when compared to those with incomplete colonoscopy (3.1 ± 1.7), $p<0.001$ (Table 2.).

Relationship between quality of bowel preparation and characteristics of the study group (Table 3)

The linear regression model confirms that older respondents have a lower quality of bowel preparation ($\beta=-0.03$, $p=0.001$). Respondents who had a colonoscopy in summer had a better quality of bowel preparation when compared to autumn ($\beta=-0.03$, $p=0.009$), winter ($\beta=-0.03$, $p=0.004$), and spring ($\beta=0.04$, $p<0.001$). The linear regression model did not confirm that the solution senna was better compared to Movi Prep (PEG), while Enema ($\beta=-0.07$, $p<0.001$) and Bisacodyl ($\beta=-0.06$, $p<0.001$) showed a lower impact on the quality of bowel preparation compared to MoviPrep (PEG) (Table 3.).

A better quality of bowel preparation was found in subjects who received premedication ($\beta=0.04$, $p<0.001$), in subjects with Chron's disease ($\beta=0.03$, $p<0.001$), diverticulitis ($\beta=0.02$, $p=0.043$) and anorectal changes ($\beta=0.03$, $p=0.002$), while those with a tumor were associated with poor quality of bowel preparation ($\beta=-0.02$, $p=0.010$). There was no association between polyposis and quality of bowel preparation ($\beta=-0.01$, $p=0.122$).

Adequate bowel preparation was associated with better quality of bowel preparation ($\beta=0.78$, $p<0.001$). Longer withdrawal time is positively associated with the symptomatic indication for colonoscopy ($\beta=0.06$, $p<0.001$), spring ($\beta=0.07$, $p<0.001$), bowel preparation on Sunday ($\beta=0.04$, $p=0.002$) and polyposis ($\beta=0.12$, $p<0.001$). A negative association was found with bisacodyl ($\beta=-0.08$, $p<0.001$), ulcerative colitis ($\beta=-0.03$, $p=0.027$), and anorectal changes ($\beta=-0.19$, $p<0.001$).

A longer withdrawal time was associated with a better quality of bowel preparation ($\beta=0.15$, $p<0.001$), (Table 3.).

Table 3. Association between bowel preparation quality and withdrawal time with patients' characteristics using linear regression models.

	Bowel preparation quality (BBPS score)			Withdrawal time		
	β	t	p	β	t	p
Age	-0.03	-3.40	0.001	0.00	0.10	0.917
Gender (male was referent group)						
Female	0.00	0.08	0.934	-0.01	-1.02	0.307
Indication for colonoscopy (prevention and control exams were referent group)						
Symptoms	-0.01	-0.81	0.417	0.06	4.10	<0.001
Risk factors (no risk was referent group)						
Risk yes	-0.01	-0.83	0.409	-0.02	-1.16	0.247
Season (summer was referent group)						
Autumn	-0.03	-2.62	0.009	0.01	0.28	0.779
Winter	-0.03	-2.85	0.004	0.01	0.72	0.473
Spring	-0.04	-4.31	<0.001	0.07	3.87	<0.001
Time of bowel preparation (day before the exam was referent group)						
On the day	0.00	0.49	0.622	0.01	0.94	0.346
Day before and on the day	0.01	1.12	0.262	0.02	1.09	0.275
Procedure of colon cleansing (working day was referent group)						
Cleaning on Sunday	0.01	1.12	0.265	0.04	3.07	0.002
Medications of bowel preparation (MoviPrep solution was referent group)						
Senna solution	-0.01	-1.45	0.148	-0.01	-1.00	0.319
Enema	-0.07	-7.06	<0.001	-0.01	-0.47	0.637
Bisacodyl	-0.06	-7.08	<0.001	-0.08	-5.17	<0.001
Premedication or sedation (no was referent group)						
Yes	0.04	5.23	<0.001	0.00	-0.02	0.985
Irritable bowel disease (no was referent group)						
Morbus Chron	0.03	3.92	<0.001	-0.03	-1.72	0.085
Ulcerative colitis	-0.01	-0.77	0.441	-0.03	-2.21	0.027
Tumor (no was referent group)						
Tumor (yes)	-0.02	-2.59	0.010	-0.02	-1.21	0.226
Polyp (no was referent group)						
Polyp (yes)	-0.01	-1.55	0.122	0.12	8.13	<0.001
Diverticula (no was referent group)						
Diverticula (yes)	0.02	2.02	0.043	-0.01	-0.73	0.468
Anorectal changes (no was referent group)						
Anorectal changes (yes)	0.03	3.07	0.002	-0.19	-13.40	<0.001
Adequate Bowel preparation*						
Yes	0.78	89.44	<0.001	-0.08	-3.35	0.001
Bowel preparation quality (BBPS score)	-	-	-	0.15	6.11	<0.001

Withdrawal time, (min)	0.05	6.11	<0.001	-	-	-
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Note: BBPS - Boston bowel preparation score; β - beta coefficient, t- t statistics, p-p value

Predicting Adequate Bowel Preparation and Total Colonoscopy Completion (Table S2)

Compared to younger respondents, older respondents had a lower likelihood of having adequate bowel preparation (odds ratio (OR) = 0.98, 95% confidence interval (CI) = 0.97–0.99, $p < 0.001$). In addition, respondents who prepared in winter had less likelihood of having adequate bowel preparation (OR = 0.74; 95% CI = 0.60–0.91; $p = 0.004$) than those who prepared in summer. Compared to PEG, other solutions had a lower likelihood of adequate bowel preparation (Senna solution (OR = 0.57; 95% CI = 0.34–0.96; $p = 0.035$), enema (OR = 0.22; 95% CI = 0.14–0.36; $p < 0.001$), bisacodyl (OR = 0.35; 95% CI = 0.20–0.61; $p < 0.001$). Longer withdrawal time is associated with lower odds of adequate bowel preparation (OR = 0.94; 95% CI = 0.92–0.97; $p < 0.001$) (Table S2.).

Lower odds of a complete colonoscopy were associated with older age (OR = 0.99; 95% CI = 0.98–1.00; $p = 0.041$), female (OR = 0.77; 95% CI = 0.57–0.90; $p = 0.004$), symptomatic indication (OR = 0.54; 95% CI = 0.42–0.68; $p < 0.001$), patient with enema (OR = 0.36; 95% CI = 0.22–0.58; $p < 0.001$), bisacodyl (OR = 0.24; 95% CI = 0.13–0.45; $p < 0.001$) and tumor (OR = 0.22; 95% CI = 0.14–0.34; $p < 0.001$). Higher odds for total colonoscopy associated with polyposis (OR = 1.43; 95% CI = 1.06–1.91; $p = 0.018$) and with longer withdrawal time (OR = 1.27; 95% CI = 1.22–1.33; $p < 0.001$). The odds ratio for completeness of colonoscopy was OR = 27.91; 95% CI = 0.92–0.97; $p < 0.001$, indicating that those with adequate bowel preparation were 27.9 times more likely to have a total colonoscopy than those with inadequate bowel preparation, (Table S2.).

4. Discussion

Zadar General Hospital attracts about 170,000 patients, which is 4.85% of the total population of the Republic of Croatia (about 3.5 million). The objective of this study was to assess the validity and reliability of existing bowel preparation solutions about age, sex, indication, season, and day at week of preparation for colonoscopy. Following scientific recommendations, our country has introduced a screening program for colorectal cancer in the general population with the sole aim of early recognition of premalignant and malignant lesions in the curable phase of the disease. The indications for the procedure were different - a search as part of the national screening for colorectal cancer, in patients with various symptoms, preventive colonoscopies, and control colonoscopies. Boston Bowel Preparation Scale was used to evaluate the success of bowel preparation with an overall score of Adequate ≥ 6 , Inadequate 0 – 5.

We hypothesized that people's different activities, and food-taking habits in different seasons contribute to the quality of bowel preparation varied in different seasons. Also, we hypothesized that gender isn't an independent risk factor for quality in bowel preparation. A similar study was performed by Liu Shi and Co in 2023 [6]. Male gender, inpatient status, and spring season were the independent risk factors for inadequate bowel preparation [6]. Results in our study are different - no statistically significant difference was found between men and women about the level of bowel preparation ($p = 0.176$), and subjects who underwent colonoscopy in summer had a better degree of quality of bowel preparation (6.4 ± 2.1), while they were least prepared in winter (6.1 ± 2.0), $p = 0.002$. There is no adequate explanation for this kind of different results. We may speculate that there are differences in food-taking habits, between the Chinese and Croatian populations.

That age was a key factor in predicting poor bowel preparation in hospitalized patients. For every 10-year increase in age, the odds of having poor bowel preparation increased by 1.29 [7]. In our study, compared to younger respondents, older respondents had a lower likelihood of having adequate bowel preparation (odds ratio (OR) = 0.98, 95% confidence interval (CI) = 0.97–0.99, $p < 0.001$). Subjects under 45 years of age ($M = 6.7 \pm 2.0$) showed a statistically significant better level of quality of bowel preparation than older subjects ($M = 6.1 \pm 2.0$), $p < 0.001$. Older subjects had a lower level of bowel preparation quality ($p < 0.001$) (Table 2.).

Propofol or conscious sedation led to no difference in colonoscopy related quality metrics. [9]. In our study, subjects who received conscious sedation (pethidine, midazolam) administered by a Gastroenterology-trained nurse, or propofol sedation administered by an anesthesiologist had the highest quality of bowel preparation (7.2 ± 1.7), $p < 0.001$). Subjects with Chron's disease (7.2 ± 1.8) had significantly better bowel preparation quality. The reason for this result is probably the motivation of the patients, as they are young people suffering from inflammatory bowel diseases, which require frequent colonoscopy check-ups.

Monday had the highest rate of inadequate preparation (BBPS < 6) compared to other days of the week. Post-holiday procedures were not associated with poor bowel preparation [10]. In our study, patients with the colonoscopy performed on Thursday had the best bowel preparation score (6.4 ± 2.0) and the lowest on Friday (6.0 ± 2.0), $p = 0.001$. Patients who performed bowel preparation on Sunday had a higher degree of bowel preparation (6.4 ± 2.0) than on weekdays (6.2 ± 2.1), $p = 0.008$ (Table 2.).

5. Conclusions

In Europe, in 2022, according to the European Cancer Information System (ECIS), there were an estimated 361,986 new cases of colorectal cancer. Among them, there are almost 10,000 patients with Post-Colonoscopy Colorectal Cancer (PCCR). The main causes of PCCR are missed lesions like adenomas, short withdrawal-observation time, rectal retroflexion, differences between endoscopist's skill, fatigue, and attention of team, but inadequate bowel preparation is the leading reason for PCCR and missing adenoma. In an era where artificial intelligence is making a big entrance into colonoscopy, an adequately prepared bowel is the first step in reliably detecting small lesions and distinguishing adenomas from lesions that need to be resected. This is especially important for lesions in the left colon. According to Michael F Kaminski and Co, key performance measures – minimum target are: rate of adequate bowel preparation of $\geq 90\%$ and cecal intubation rate of $\geq 90\%$ [8].

Compared to younger respondents, older respondents had a lower likelihood of adequate bowel preparation. In addition, respondents who were prepared in winter had less adequate bowel preparation. Compared to PEG, other solutions had a lower likelihood of adequate bowel preparation. To thoroughly and completely examine the colon, it is necessary to cooperate with the patient and be maximally engaged in preparing the intestine before the examination. To achieve adequate bowel preparation, a conversation with the patient is required with a thorough interpretation of the need to follow the dietary instructions, and the need to drink the cleansing solution in an adequate way and at an adequate time. The target group is patients 50+, preparation during summer and recommendation for using PEG solution.

The present study was a single-center retrospective study. The findings of the present study need to be validated by multi-center prospective studies.

Supplementary Materials: The following supporting information can be downloaded at: https://drive.google.com/file/d/1igb7-px3bWdBSzZ87bPAngCQlhmF5n_R/view?usp=sharing Table S1. Differences by gender, age group, season, day of the week, and bowel preparation solution in the category of quality of bowel preparation, <https://drive.google.com/file/d/1py7itR3fcEAnnF5RY7qIu3mlGw2ByEQ0/view?usp=sharing> Table S2. Associations adequate bowel preparation and complete total colonoscopy using logistic regression models (N=4609).

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The dataset analysed in this study is available from the corresponding author upon request.

Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

AI	artificial intelligence
BBPS	Boston bowel preparation score
CI	confidence interval
CRC	colorectal cancer
ECIS	European Cancer Information System
GI	Gastro intestinal
OR	odds ratio
PCCR	Post Colonoscopy Colorectal Cancer
PEG	polyethylene glycol
RG	referent group

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