

## Comparative Analysis of Outpatient and Inpatient Bowel Preparation for Colonoscopy: Evaluating Quality Outcomes and Identifying Contributing Factors

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### Abstract:

**Objective:** Effective bowel preparation is crucial for a successful colonoscopy. Comparative analyses between inpatient and outpatient bowel preparations are limited and inconsistent. This study aimed to compare the outcomes of outpatient and inpatient bowel preparations and identify the factors contributing to suboptimal results.

**Material and Methods:** A retrospective analysis of colonoscopy reports from a single surgeon at a provincial hospital in Thailand was conducted. Data were collected from patients aged 18 or older who underwent colonoscopies between July 2021 and June 2023. The parameters analyzed included demographic information, underlying diseases, bowel preparation methods, medications, and quality indicators. The Boston Bowel Preparation Scale (BBPS) was used to assess preparation quality.

**Results:** Among the 222 patients included, 180 (81.1%) had outpatient and 42 (18.9%) had inpatient bowel preparation. Significant differences were found between the groups in age, BMI, underlying diseases, hemoglobin levels, symptoms, indications for colonoscopy, and choice of bowel preparation medication. Propensity score matching balanced baseline characteristics. In the matched cohort, the outpatient group had a higher rate of satisfactory bowel preparation (92.9%)

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compared to the inpatient group (78.6%), but this difference was not statistically significant ( $p$ -value=0.061). Within the inpatient subgroup, admission to a private room and choice of bowel preparation medication were linked to higher inadequate preparation likelihood.

**Conclusion:** This study found no significant differences between inpatient and outpatient bowel preparation. However, there was a trend suggesting better quality with outpatient bowel preparation. Thus, focusing on improving nursing interventions and selecting appropriate medications for inpatient bowel preparation may be beneficial.

**Keywords:** bowel preparation, colonoscopy, colon cancer, inpatients, outpatients

## Introduction

Colorectal malignancy screening typically involves a colonoscopy, the current gold standard procedure<sup>1,2</sup>. Bowel preparation prior to colonoscopy is imperative in order to ensure optimal visualization. Inadequate bowel preparation diminishes the opportunity to detect and remove potentially precancerous lesions, thus increasing the risk for future cancer<sup>3</sup>. The quality of bowel preparation directly impacts various aspects of the procedure, i.e., adenoma detection rate (ADR), cecal intubation rate (CIR), and withdrawal time (WT)<sup>4-6</sup>. Insufficient bowel preparation gives rise to various complications, including perforation and bleeding, which can lead to higher costs<sup>7,8</sup>. Previous research highlighted that numerous cases of incomplete colonoscopies did not result in subsequent re-colonoscopy, thereby compromising the capacity to detect precancerous lesions<sup>9</sup>.

Bowel preparation can be administered through outpatient or inpatient methods. In our practice, we have observed a difference in the quality of bowel preparation between outpatients and inpatients. Bowel preparation for inpatients at our hospital has been notably poorer, often leading to the need for rescheduling. In the literature, interventions to improve the quality of bowel preparations predominantly focus on inpatient bowel preparation<sup>10-14</sup>, while comparatively little attention has been given to the outpatient situation. This suggests that the current state of inpatient bowel preparation is suboptimal. According

to our current knowledge, only 2 studies have compared bowel preparation efficacy between inpatient and outpatient settings. One investigation indicated that inpatient bowel preparation had a higher risk of inadequacy<sup>15</sup>, while the other found no significant differences between the study groups<sup>16</sup>.

This investigation compared the effectiveness of bowel preparation techniques for inpatients and outpatients and identified the factors affecting suboptimal results. Based on the study findings, the goal was to improve colonoscopy bowel preparation outcomes.

## Material and Methods

This study employed a retrospective cohort design from a systematic collection of colonoscopy reports and the hospital medical records of an experienced single surgeon who had performed over 500 colonoscopies at a secondary care hospital. Our study is in line with the STROCSS criteria<sup>17</sup>. Demographic data were retrospectively collected from patients who underwent colonoscopies between July 2021 and June 2023. The data were obtained by reviewing electronic endoscopic reports and the hospital information database. We included patients who were 18 or older while excluding those with a history of previous colectomy, incomplete medical records, who had undergone an emergency colonoscopy or had a diagnosis of inflammatory bowel disease.

In our institution, we commonly employ a sodium phosphate (NaP) solution (Swiff®) as the medicinal agent for bowel preparation. We use the same protocol for both inpatients and outpatients. We utilize the split-dose technique to enhance the efficacy of the medication. The first dose consists of 45 mL of NaP followed by at least one liter of water. The second dose of 45 mL is administered 4 to 6 hours after the first dose. However, under certain circumstances, such as patients with abnormal electrolyte levels, chronic kidney disease, or those presenting with acute lower gastrointestinal (GI) bleeding, we use polyethylene glycol (PEG) as an alternative. To prepare the colon adequately, the split-dose technique is employed. Our PEG is in powder form. We instruct patients to mix one sachet of PEG with 2 liters of water and drink it within 2 hours for each dose. In addition to medical prescriptions, we instruct patients to follow a fiber-restricted diet for 2 days prior to the colonoscopy and to consume only a liquid diet on the day before the procedure. Every patient scheduled for a colonoscopy must undergo a pre-colonoscopy anesthetic care clinic assessment. The clinic is staffed by 5 specialized anesthesiologists who are responsible for evaluating patients and determining their eligibility for admission. The selection process for pre-procedural admission is based on several criteria, i.e., advanced age, underlying diseases, abnormal laboratory test results, or cardiac conditions. However, the decisions made by anesthesiologists in this context exhibit a degree of subjectivity and may exhibit variability. To ensure patient compliance with bowel preparation, our endoscopy room nurses contact each patient on the morning of their scheduled colonoscopy in order to confirm adherence to the prescribed medication. If a patient has not completed the preparation, the nurse notifies the physician, and the procedure is rescheduled accordingly. For inpatients, the ward nurses are responsible for administering the bowel preparation medication, ensuring that each patient takes the full prescribed dose. If a patient does not complete the

medication, the nurses will inform the physician, who will then take steps to ensure the preparation is completed before the colonoscopy. For colonoscopic visualizations, we used a Pentax Model EPK-i5000.

The collected data encompassed various parameters, i.e., age, gender, body mass index (BMI), underlying diseases, bowel preparation methods (inpatient or outpatient), private room hospitalization, hemoglobin (Hb) level, previous colonoscopy status, previous surgery status, symptoms, indications for colonoscopy, medications used for bowel preparation, quality of bowel preparation, total procedure time (TT), WT, CIR, ileal intubation rate (IIR), ADR, and tumor detection rate (TDR). A CIR was defined as the percentage of successful visualizations of the cecum, ascertained by photographing specific landmarks, including the ileocecal valve, appendiceal orifice, and terminal ileum if intubated. An IIR was defined as the percentage of successful insertions of the colonoscope tip into the ileum. In our study, we exclusively measured the IIRs without assessing ileal intubation times. We defined the time between the point when the colonoscope reached the cecum and the time the scope was withdrawn from the anus as the WT<sup>6</sup>, which was analyzed separately in 2 categories, WT with polyp procedure (WT-PP) and WT with no polyp procedure (WT-noPP).

The quality of the bowel preparations was assessed using the Boston Bowel Preparation Scale (BBPS) score<sup>18</sup>. This scale divides the large intestine into 3 segments: right colon (RC), transverse colon (TC), and left colon (LC). Each part is assigned a score ranging from 0 to 3: A score of 0 represents an unprepared colon with unseen mucosa due to a solid stool that cannot be cleared; a score of 1 indicates a staining stool that hinders visualization of some areas of the colon segment; a score of 2 indicates a minor amount of residual staining stool but clear mucosa, and a score of 3 indicates entirely clear mucosa without any staining stool. The total BBPS score ranges from 0 to 9. Inadequate bowel

preparation was defined as a total BBPS score below 6 or any segment BBPS score below 2<sup>3, 19–21</sup>.

In our study, a screening colonoscopy was employed for asymptomatic patients. Diagnostic indications included GI bleeding/iron deficiency anemia (IDA), alterations in bowel habits, identification of suspected malignancies from alternative imaging modalities, and additional indications, such as abdominal pain or the presence of an abdominal mass.

Informed consent was waived due to the study's retrospective design and anonymous clinical information analysis. The study was approved by the Internal Ethics Committee of the Hospital, no. PTL 15/2566. This study has been registered on [www.researchregistry.com](http://www.researchregistry.com) with the unique identifying number (UIN) researchregistry10374.

### Statistical analysis

Descriptive statistics were employed to compare continuous variables, including means, medians, standard deviations (SDs), minimum and maximum values, frequencies of categorical variables, and 95% confidence intervals (95% CIs). The paired t-test was utilized for the hypothesis testing of the continuous variables with normal distribution, while the Wilcoxon Rank Sum test was employed as an alternative for non-parametric data. When appropriate, the Chi-square test was utilized to test the hypotheses regarding categorical variables, or the Fisher exact test, where appropriate. Univariate and multivariate logistic regression analyses were performed in order to determine the significance and odds ratios (ORs) of the various predictive factors and their corresponding 95% CIs. Statistical analysis was conducted using R Studio statistical software version 2023.06.0+421 packages dplyr and epicalc. A significance level at a p-value equal to or less than 0.05 was adopted, and no attempt was made to impute missing data.

### Propensity score matching

Propensity score-matched pairs were generated by matching patients who underwent outpatient bowel preparation with those who underwent inpatient bowel preparation. This matching was accomplished using 1:1 nearest-neighbor matching without replacement, based on the logit of the propensity score and within a specified caliper width. The matching process encompassed the entire cohort. The propensity scores were estimated using a logistic regression model that included covariates anticipated to impact the adequacy of bowel preparation, such as age, BMI, hemoglobin levels, presence of underlying disease, presenting symptoms, indications, and bowel preparation medication. The baseline covariate balance was assessed using standardized mean differences (SMD). Propensity score matching was performed using the R Studio statistical software version 2023.06.0+421, with the MatchIt, dplyr, and tableone packages.

## Results

The study enrolled 260 patients, of whom 38 with a history of previous colonic resection for any reason, emergency colonoscopy, or incomplete medical records were excluded, leaving 222 patients included in the analysis. Of these, 180 patients (81.1%) underwent outpatient bowel preparation, while 42 patients (18.9%) underwent inpatient bowel preparation (Table 1). Comparative analysis between the outpatient and inpatient groups revealed various significant differences. The outpatient group exhibited a lower median age (60 years; interquartile range [IQR] 51.8 to 67) compared to the inpatient group (69.5 years; IQR 62.2 to 75) (p-value<0.001.). The outpatient group had a higher BMI (23.7 kg/m<sup>2</sup>; S.D. 3.9) than the inpatient group (21.8 kg/m<sup>2</sup>; S.D. 4.1) (p-value 0.006). Pre-existing diseases were less prevalent in the outpatient group (106 patients; 58.9%) in contrast to the inpatient group (36 patients; 85.7%) (p-value 0.001). The median Hb levels were higher in the

**Table 1** Patient characteristics of the unmatched and matched cohorts

Variables	Unmatched cohort (222)				Matched cohort (84)			
	Outpatient	Inpatient	p-value	SMD	Outpatient	Inpatient	p-value	SMD
Number of patients	180 (81.1%)	42 (18.9%)			42 (50%)	42 (50%)		
Age – median (IQR) (years)	60 (51.8,67)	69.5 (62.2, 75)	<0.001	0.616	68.5 (61.2, 73)	69.5 (62.2, 75)	0.585	0.058
Gender – male	87 (48.3%)	25 (59.5%)	0.192	0.226	24 (57.1%)	25 (59.5%)	0.825	0.048
BMI – mean (S.D.) (kg/m <sup>2</sup> )	23.7 (3.9)	21.8 (4.1)	0.006	0.474	21.9 (3.3)	21.8 (4.1)	0.92	0.022
Presence of underlying diseases	106 (58.9%)	36 (85.7%)	0.001	0.628	35 (83.3%)	36 (85.7%)	0.763	0.066
Presence of 3 or more underlying diseases	23 (22.1%)	14 (38.9%)	0.049	0.358	11 (32.4%)	14 (38.9%)	0.568	0.164
Hb level – median (IQR) (g/dL)	12.9 (12.1, 13.9)	9.9 (8, 12.3)	<0.001	1.172	11.5 (2.3)	10.2 (2.7)	0.014	0.549
Prior colonoscopy	10 (5.6%)	4 (9.5%)	0.309	0.151	4 (9.5%)	4 (9.5%)	1	<0.001
Prior abdominal surgery	48 (26.7%)	5 (11.9%)	0.043	0.381	12 (28.6%)	5 (11.9%)	0.057	0.424
Symptoms			<0.001	0.913			0.435	0.367
Asymptomatic	69 (38.3%)	6 (14.3%)			9 (21.4%)	6 (14.3%)		
GI bleeding/IDA	23 (12.8%)	17 (40.5%)			11 (26.2%)	17 (40.5%)		
Bowel habit change	71 (39.4%)	11 (26.2%)			10 (23.8%)	11 (26.2%)		
Access malignancy	3 (1.7%)	0 (0%)						
Other reason <sup>a</sup>	14 (7.8%)	8 (19%)			12 (28.6%)	8 (19%)		
Indication			0.003	0.568			0.393	0.187
Screening	69 (38.3%)	6 (14.3%)			9 (21.4%)	6 (14.3%)		
Diagnosis	111 (61.7%)	36 (85.7%)			33 (78.6%)	36 (85.7%)		
Medication for bowel preparation			<0.001	1.087			0.001	0.740
NaP solution	175 (97.2%)	24 (57.1%)			37 (88.1%)	24 (57.1%)		
PEG	5 (2.8%)	18 (42.9%)			5 (11.9%)	18 (42.9%)		
TT – median (IQR) (minutes)	20 (15, 30)	25 (16.2, 40)	0.014	0.542	20 (20, 30)	25 (16.2, 40)	0.293	0.441
ADR	48 (26.7%)	17 (40.5%)	0.077	0.296	12 (28.6%)	17 (40.5%)	0.251	0.252
TDR	16 (8.9%)	8 (19%)	0.092	0.296	8 (19%)	8 (19%)	1	<0.001
CIR	179 (99.4%)	40 (95.2%)	0.093	0.264	42 (100%)	40 (95.2%)	0.494	0.316
IIR	149 (82.8%)	22 (52.4%)	<0.001	0.687	31 (73.8%)	22 (52.4%)	0.042	0.455
WT-PP – median (IQR) (minutes)	15 (10.8, 21.2)	12 (8, 25)	0.858	0.257	17.5 (12, 21.2)	12 (8, 25)	0.673	0.303
WT-noPP – median (IQR) (minutes)	7 (6, 9)	8 (7, 12)	0.069	0.498	7.5 (5.2, 10.8)	8 (7, 12)	0.258	0.342

<sup>a</sup>=abdominal pain or abdominal mass, SMD=standardized mean difference, IQR=interquartile range, S.D.=standard deviation, GI=gastrointestinal, IDA=iron-deficiency anemia, NaP=sodium phosphate, PEG=polyethylene glycol, TT=total procedure time, ADR=adenoma detection rate, TDR=tumor detection rate, CIR=cecal intubation rate, IIR= ileal intubation rate, WT-PP=withdrawal times with polyp procedure, WT-noPP=withdrawal times with no polyp procedure

outpatient group (12.9 g/dL; IQR 12.1 to 13.9) than in the inpatient group (9.9 g/dL; IQR 8 to 12.3) (p-value<0.001).

Regarding symptoms at presentation, the groups also differed significantly (p-value<0.001): the outpatient group had a higher proportion of patients with no symptoms (69 patients; 38.3%) compared to the inpatient group (6

patients; 14.3%), which was also relevant for colonoscopy screening indications (p-value 0.003). The outpatient group had a higher proportion of patients with bowel habit change (71 patients; 39.4%) than the inpatient group (11 patients; 26.2%), while GI bleeding was more common in the inpatient group (17 patients; 40.5%) compared to the

outpatient group (23 patients; 12.8%). Only a small number of patients required a colonoscopy to assess a suspected malignancy, with 3 patients (1.7%) in the outpatient group and none in the inpatient group. Other reasons for the colonoscopy, such as abdominal pain or mass, were more common in the inpatient group (8 patients; 19%) compared to the outpatient group (14 patients; 7.8%).

Significant differences were observed between the groups ( $p$ -value<0.001) regarding the choice of bowel preparation medication. Most patients in the outpatient group were given the NaP solution (175 patients; 97.2%), while the inpatient group had a higher proportion of patients who received the PEG (18 patients; 42.9%). Other significant differences between the groups were observed in terms of median TT (outpatients: 20 minutes vs. inpatients: 25 minutes;  $p$ -value 0.025) and IIR (outpatients: 149 patients; 82.8% vs. inpatients: 22 patients; 52.4%;  $p$ -value<0.001).

The statistical analysis found no significant differences between the groups concerning gender, 3 or more underlying diseases, history of previous colonoscopy, history of prior abdominal surgery, ADR, TDR, CIR, and WT.

The significant differences between the outpatient and inpatient cohorts could introduce bias due to confounding by indication for inpatient bowel preparation. After propensity score matching, the matched cohort consisted of 84 participants, with 42 patients each in the outpatient and inpatient bowel preparation groups. The

baseline characteristics of the matched cohort were not significantly different, except for Hb levels and the choice of bowel preparation medication. The mean Hb level was 11.5 g/dL (S.D. 2.3) in the outpatient group and 10.2 g/dL (S.D. 2.7) in the inpatient group.

The results of our study evaluating the quality indicators of the colonoscopy procedure are presented in Table 2. The ADR was 34.5%. The CIR was successfully achieved in 97.6% of cases. The median WT-PP was 15 minutes (IQR, 11 to 22), while the median WT-noPP was 8 minutes (IQR, 6 to 12).

Both outpatient and inpatient groups demonstrated similar median total BBPS scores, each yielding a score of 9 (IQR 9,9 in both groups). However, an analysis of individual segment scores (RC, TC, and LC) revealed notable disparities between the 2 cohorts.

The study's primary outcome was the assessment of bowel preparation quality between outpatient and inpatient groups. In the unmatched cohorts, as shown in Figure 1a, the inpatient group had a significantly higher rate of inadequate preparations compared to the outpatient group (21.4% vs. 4.4%,  $p$ -value<0.001). However, in the matched cohort, the analysis revealed that the inpatient group still had a higher rate of inadequate bowel preparation compared to the outpatient group, but this difference was not statistically significant (21.4% vs. 7.1%,  $p$ -value=0.061) (Figure 1b).

**Table 2** Colonoscopy quality of the matched cohorts

Variables	Matched cohort (84)			
	Adequate preparation (72)	Inadequate preparation (12)	Total	p-value
ADR	25 (34.7)	4 (33.3)	20 (34.5)	1
CIR	70 (97.2)	12 (100)	82 (97.6)	1
WT-PP – median (IQR) (minutes)	15 (12,22)	16.5 (10.2,23.8)	15 (11,22)	1
WT-noPP –median (IQR) (minutes)	8 (6,12)	6 (4.8,7.2)	8 (6,12)	0.056

ADR=adenoma detection rate, CIR=cecal intubation rate, WT-PP=withdrawal times with polyp procedures, WT-noPP=withdrawal time with no polyp procedure

No statistically significant differences were observed in any of the factors when comparing the adequate and inadequate bowel preparation groups (Table 3). However, subgroup analysis of the inpatient group revealed significant differences between the adequate and inadequate bowel preparation cohorts regarding private room admission, symptoms, colonoscopy indication, and bowel preparation medication (Table 4). Private room admission in the inadequate bowel preparation cohort was higher (5 patients,

55.6%) than in the adequate preparation cohort (4 patients, 12.5%) with a p-value of 0.01. In terms of indication for colonoscopy, the adequate bowel preparation cohort had significantly more diagnostic indications (30 patients, 93.8%, p-value 0.02). In the inadequate cohort, all 9 patients (100%) received the NaP solution for bowel preparation, while in the adequate cohort, only 15 patients (46.9%) received the NaP solution for bowel preparation (p-value 0.01).

**Table 3** Patient characteristics: a comparison between the adequate and inadequate bowel preparation groups

Variables	Matched cohort (84)		
	Adequate preparation (72)	Inadequate preparation (12)	p-value
Age – median (IQR) (years)	68.5 (62, 74.2)	70 (64.5, 73.2)	0.985
Gender – Male	42 (58.3%)	7 (58.3%)	1
BMI – mean (S.D.) (kg/m <sup>2</sup> )	21.9 (3.7)	21.8 (3.4)	0.934
Hemoglobin (Hb) level – median (IQR) (g/dL), mean (S.D.)	10.8 (2.6)	11.4 (2.2)	0.424
Presence of underlying disease	62 (86.1%)	9 (75%)	0.387
Presence of 3 or more underlying diseases	20 (32.8%)	5 (55.6%)	0.265
Diabetes	15 (20.8%)	2 (16.7%)	1
Hypertension	38 (52.8%)	8 (66.7%)	0.371
Dyslipidemia	28 (38.9%)	7 (58.3%)	0.206
Chronic kidney disease	10 (13.9%)	1 (8.3%)	1
Psychiatric disease	7 (9.7%)	0 (0%)	0.586
Stroke	7 (9.7%)	1 (8.3%)	1
Dementia	1 (1.4%)	0 (0%)	1
Hypo/hyperthyroidism	2 (2.8%)	0 (0%)	1
COPD/asthma	6 (8.3%)	0 (0%)	0.587
Coronary artery disease	6 (8.3%)	0 (0%)	0.587
GERD/Dyspepsia			
Cirrhosis	2 (2.8%)	0 (0%)	1
Gouty arthritis	5 (6.9%)	2 (16.7%)	0.261
BPH	3 (4.2%)	0 (0)	1
Infectious disease	3 (4.2%)	1 (8.3%)	0.467
History of malignancy	3 (4.2%)	1 (8.3%)	0.467
Gynecologic disease			
Prior colonoscopy	8 (11.1%)	0 (0%)	0.595
Prior abdominal surgery	14 (19.4%)	3 (25%)	0.702
Medication for bowel preparation			0.031
NaP solution	49 (68.1%)	12 (100%)	
PEG	23 (31.9%)	0 (0%)	

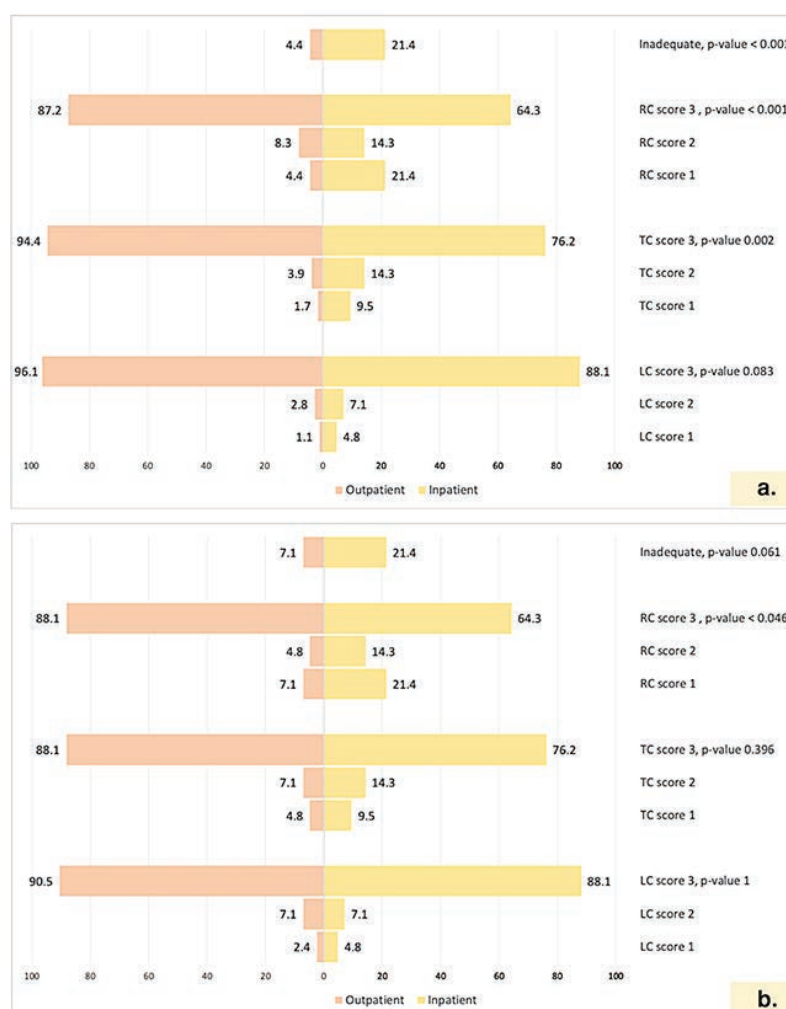
COPD=chronic obstructive pulmonary disease, GERD=gastroesophageal reflux disease, BPH=benign prostate hyperplasia, NaP=sodium phosphate, PEG=polyethylene glycol, S.D.=standard deviation, IQR=Interquartile range



**Table 4** Inpatient bowel preparation subgroup analysis according to the adequacy of preparation

Variables	Adequate preparation (32)(%)	Inadequate preparation (9)(%)	p-value
Private room admission	4 (12.5)	5 (55.6)	0.01
Indication			0.02
Screening	2 (6.2)	4 (44.4)	
Diagnosis	30 (93.8)	5 (55.6)	
Medication for bowel preparation			0.01
NaP solution	15 (46.9)	9 (100)	
PEG	17 (53.1)	0 (0.0)	

NaP=sodium phosphate, PEG=polyethylene glycol



RC=right colon, TC=transverse colon, LC=left colon

**Figure 1** Percentages of inadequate bowel preparations and separate segment scores between the outpatient and inpatient groups (a) unmatched cohort, (b) matched cohort



## Discussion

Bowel preparation plays a vital role. Achieving adequate bowel preparation can significantly enhance colonoscopy quality<sup>4</sup>. The 2021 American College of Gastroenterology (ACG) colorectal cancer screening guidelines recommend a minimum ADR of 25% for the general population, 30% for males, and 20% for females<sup>5</sup>. Additionally, the CIR ought to exceed 95%, and the WT-noPP should be no less than 6 minutes<sup>6</sup>. Our study achieved a total ADR of 34.5%. The median WT-noPP was 8 minutes, and the CIR was 97.6%. These results confirm our adherence to ACG guideline quality standards. The American Society for Gastrointestinal Endoscopy (ASGE) recognized the number of procedures performed in determining the proficiency of an endoscopist<sup>22</sup>. Our endoscopist had successfully completed over 500 colonoscopies, a threshold first established by Bret J. Spier et al. as a requirement for achieving competency<sup>23</sup>. A later study also found that endoscopists who had conducted more than 500 colonoscopies achieved quality standards<sup>24</sup>. Our data showed that the inadequate bowel preparation group had a significantly lower median WT-noPP than the adequate group, in contrast to previous studies<sup>8,25</sup>. We hypothesize that the inability to clean the colon mucosa during withdrawal led to the shorter WT-noPP.

When comparing a whole cohort of patients between the outpatient and inpatient bowel preparation groups, we observed statistically significant differences in several characteristics. The inpatient bowel preparation group was statistically significantly older and had more underlying diseases than the outpatient group. Additionally, the Hb level in the inpatient bowel preparation group was lower than in the outpatient group. Certain experts have asserted that geriatric patients over the age of 80, with a history of multiple comorbidities, are more likely to be admitted for colonoscopy<sup>26</sup>. Similarly, our inpatient group had older patients with more underlying diseases. After adjusting for

confounders using propensity score matching, the baseline characteristics between the outpatient and inpatient groups in the matched cohort appeared to be balanced. However, some variables remained imbalanced between the groups, such as Hb levels and the choice of bowel preparation medication.

The global trend is an increase in anesthesia services for endoscopic procedures<sup>27</sup>. Every patient scheduled for a colonoscopy at our hospital requires pre-anesthetic care, similar to the global trend. Our anesthesiologists have indications for selecting patients for inpatient colonoscopies. However, their decisions exhibited considerable variability. Through our literature review, we identified a lack of certain criteria in selecting patients for elective hospitalized colonoscopies. An observational prospective study reported that elective inpatient colonoscopies were more common in patients aged 55 years and older or who presented with multiple comorbidities<sup>28</sup>. Another study by Krygier D., et al.<sup>26</sup> reported that the elective inpatient group had a higher incidence of GI bleeding than the outpatient group, while the outpatient group typically presented with changes in bowel habits or were non-symptomatic. Our own study's findings aligned with these observed patterns.

In our practice, a NaP solution is preferred for bowel preparation due to its high patient compliance from a smaller volume, except when patients have contraindications. Our anesthesiologists routinely test blood electrolyte levels, allowing early identification of potential contraindications with a NaP solution. Regarding differences in medications for our bowel preparation, numerous studies consistently reported no significant quality differences in bowel preparation between a NaP solution and PEG<sup>29-32</sup>. The inpatient group received PEG more frequently in our study. This result might be from the prominence of chronic kidney disease (19.5% vs 5.6%, p-value 0.008) and diagnosis indication.

In 2007, Anderson E. et al. reported a non-significant difference in the quality of bowel preparations

between outpatient and inpatient groups<sup>16</sup>. Conversely, an earlier retrospective study by Almadi M.A. et al. in 2018 reported contrasting findings, which found that outpatient colonoscopies were associated with better quality bowel preparation<sup>15</sup>. Our study observed no significant difference in the quality between groups.

When investigating patient characteristics, no significant differences were observed between patients with adequate and inadequate bowel preparation. However, significant differences were observed in the inpatient subgroup based on bowel preparation quality (Table 4), including private room admission, colonoscopy indication, and medication.

While the existing literature does not address the association between private room admission and quality of preparation, our study revealed an association between private room admission and inadequate bowel preparation in the inpatient group. Our hypothesis is that private rooms in government hospitals lack sufficient nurses to provide adequate patient care. Another hypothesis is that private rooms have shorter bed-to-restroom distances than the general ward, potentially leading to increased walking for patients in the general ward<sup>33</sup>. This extra physical activity could enhance bowel movement, which may directly improve the preparation quality<sup>34</sup>. Further research is required in order to substantiate these hypotheses regarding private room admission.

The inpatients' bowel preparation medication was also found to be significantly different between the adequate and inadequate groups. Specifically, the patients who were prescribed the NaP solution were likelier to have inadequate bowel preparation. Our hypothesis is that individuals receiving the NaP had less water consumption than PEG. Consequently, this reduction in water intake might result in a comparatively diminished effectiveness of bowel preparation when compared to PEG<sup>30,35</sup>.

## Conclusion

In summary, our data indicate that patients undergoing colonoscopy on an outpatient basis were more likely to achieve satisfactory bowel preparation compared to those undergoing the procedure as inpatients; however, this difference was not statistically significant. Several hypotheses could explain this finding, including the inadequacy of nursing staff<sup>36</sup> and the bed-to-restroom distances, which could be conducted in further clinical trials addressing this knowledge gap and serve as a means of problem-solving. Subsequent research could delve into the correlation between patient acuity, room type, and healthcare outcomes, particularly focusing on procedural preparation and patient safety. In practice, emphasizing the importance of proper bowel preparation to inpatients undergoing colonoscopy may be beneficial. Additionally, implementing targeted educational interventions and providing additional nursing support could help improve the quality of bowel preparation among inpatients.

## Limitations

This study was conducted retrospectively, relying on existing data, which introduces the possibility of selection bias in grouping patients undergoing inpatient and outpatient colonoscopies. Furthermore, since the data for this study were obtained from a single provincial hospital, they may not adequately represent the diversity of patients typically encountered in a broader population. Socioeconomic or educational status specific to the province could have influenced the results. Additionally, the study suffered from a relatively small sample size, which limited its statistical power to reject null hypotheses, especially when analyzing subgroups such as patients undergoing inpatient bowel preparation. Further studies are needed with a larger sample size in order to identify the significant differences and independent factors that may have been associated

with the quality of bowel preparation. Finally, the study only observed short-term outcomes, and it would be beneficial to investigate the long-term consequences, such as the development of colonic malignancy in patients with poor-quality bowel preparation.

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## References

1. Siegel RL, Wagle NS, Cercek A, Smith RA, Jemal A. Colorectal cancer statistics, 2023. *CA Cancer J Clin* 2023;73:233–54. doi: 10.3322/caac.21772.
2. Ranganath R, Al-maamari LSS, Al Saidi AAR, Al Dujaili AHB, Mahmood MA-F. Knowledge and awareness of colorectal cancer among university students in Oman. *J Health Sci Med Res* 2022;40:215–22.
3. Kluge MA, Williams JL, Wu CK, et al. Inadequate Boston Bowel Preparation Scale scores predict the risk of missed neoplasia on the next colonoscopy. *Gastrointest Endosc* 2018;87:744–51. doi: 10.1016/j.gie.2017.06.012.
4. Jang JY, Chun HJ. Bowel preparations as quality indicators for colonoscopy. *World J Gastroenterol* 2014;20:2746–50. doi: 10.3748/wjg.v20.i11.2746.
5. May FP, Shaukat A. State of the science on quality indicators for colonoscopy and how to achieve them. *Am J Gastroenterol* 2020;115:1183–1190. doi: 10.14309/ajg.0000000000000622.
6. Shaukat A, Kahi CJ, Burke CA, Rabeneck L, Sauer BG, Rex DK. ACG Clinical Guidelines: Colorectal Cancer Screening 2021. *Am J Gastroenterol* 2021;116:458–79. doi: 10.14309/ajg.0000000000001122.
7. Harewood GC, Sharma VK, de Garmo P. Impact of colonoscopy preparation quality on detection of suspected colonic neoplasia. *Gastrointest Endosc* 2003;58:76–9. doi: 10.1067/mge.2003.294.
8. Froehlich F, Wietlisbach V, Gonvers JJ, Burnand B, Vader JP. Impact of colonic cleansing on quality and diagnostic yield of colonoscopy: the european panel of appropriateness of gastrointestinal endoscopy european multicenter study. *Gastrointest Endosc* 2005;61:378–84. doi: 10.1016/s0016-5107(04)02776-2.
9. Hendry PO, Jenkins JT, Diamant RH. The impact of poor bowel preparation on colonoscopy: a prospective single centre study of 10,571 colonoscopies. *Colorectal Dis* 2007;9:745–8. doi: 10.1111/j.1463-1318.2007.01220.x.
10. Gao H, Liu C, Yuan X, Lu H, Xia Y, Zhang Z, et al. Face-to-face instruction and personalized regimens improve the quality of inpatient bowel preparation for colonoscopy. *Dig Dis Sci* 2022;67:3592–600. doi: 10.1007/s10620-021-07290-x.
11. Rosenfeld G, Krygier D, Enns RA, Singham J, Wiesinger H, Bressler B. The impact of patient education on the quality of inpatient bowel preparation for colonoscopy. *Can J Gastroenterol* 2010;24:543–6. doi: 10.1155/2010/718628.
12. Guo B, Zuo X, Li Z, et al. Improving the quality of bowel preparation through an app for inpatients undergoing colonoscopy: a randomized controlled trial. *J Adv Nurs* 2020;76:1037–45. doi: 10.1111/jan.14295.
13. Strauss AT, Yeh J, Martinez DA, Yenokyan G, Yoder J, Nehra R, et al. A patient-centered framework for health systems engineering in gastroenterology: improving inpatient colonoscopy bowel preparation. *BMC Gastroenterol* 2021;21:89. doi: 10.1186/s12876-021-01661-4.
14. Guardiola-Arévalo A, Granja Navacerrada A, García-Alonso FJ, Bernal Checa P, Piqué Becerra R, Guerra I, et al. Randomized clinical trial evaluating the effect of a visual educational leaflet on the preparation of colonoscopies in hospitalized patients. *Rev Esp Enferm Dig* 2019;111:946–52. doi: 10.17235/reed.2019.6317/2019.
15. Almadi MA, Alharbi O, Azzam N, Altayeb M, Thaniyah S, Aljebreen A. Bowel preparation quality between hospitalized patients and outpatient colonoscopies. *Saudi J Gastroenterol* 2018;24:93–9. doi:10.4103/sjg.SJG\_485\_17.
16. Anderson E, Baker JD. Bowel preparation effectiveness: inpatients and outpatients. *Gastroenterol Nurs* 2007;30:400–4. doi: 10.1097/01.SGA.0000305220.78403.a0.
17. Mathew G, Agha R, Albrecht J, Goel P, Mukherjee I, Pai P, et al. STROCSS Group. STROCSS 2021: strengthening the reporting of cohort, cross-sectional and case-control studies in surgery. *Int J Surg* 2021;96:106165. doi: 10.1016/j.ijsu.2021.106165.
18. Lai EJ, Calderwood AH, Doros G, Fix OK, Jacobson BC. The boston bowel preparation scale: a valid and reliable instrument for colonoscopy-oriented research. *Gastrointest Endosc* 2009;69:620–5. doi: 10.1016/j.gie.2008.05.057.

19. Calderwood AH, Jacobson BC. Comprehensive validation of the boston bowel preparation scale. *Gastrointest Endosc* 2010;72:686–92. doi: 10.1016/j.gie.2010.06.068.
20. Calderwood AH, Schroy PC, 3rd, Lieberman DA, Logan JR, Zurfluh M, Jacobson BC. Boston Bowel Preparation Scale scores provide a standardized definition of adequate for describing bowel cleanliness. *Gastrointest Endosc* 2014;80:269–76. doi: 10.1016/j.gie.2014.01.031.
21. Clark BT, Protiva P, Nagar A, Imaeda A, Ciarleglio MM, Deng Y, et al. Quantification of adequate bowel preparation for screening or surveillance colonoscopy in men. *Gastroenterology* 2016;150:396–405; quiz e14–5. doi: 10.1053/j.gastro.2015.09.041.
22. Adler DG, Bakis G, Coyle WJ, DeGregorio B, Dua KS, Lee LS, et al. Principles of training in GI endoscopy. *Gastrointest Endosc* 2012;75:231–5. doi: 10.1016/j.gie.2011.09.008.
23. Spier BJ, Benson M, Pfau PR, Nelligan G, Lucey MR, Gaumnitz EA. Colonoscopy training in gastroenterology fellowships: determining competence. *Gastrointest Endosc* 2010;71:319–24. doi: 10.1016/j.gie.2009.05.012.
24. Zhan Q, Xiang L, Zhao X, An S, Zhou Y, Xu Y, et al. Determination of withdrawal times in individualized opportunistic screening colonoscopies. *Medicine (Baltimore)* 2019;98:e16819. doi: 10.1097/MD.00000000000016819.
25. Kössi J, Kontula I, Laato M. Sodium phosphate is superior to polyethylene glycol in bowel cleansing and shortens the time it takes to visualize colon mucosa. *Scand J Gastroenterol* 2003;38:1187–90. doi: 10.1080/00365520310006180.
26. Krygier D, Enns R. The inpatient colonoscopy: a worthwhile endeavour. *Can J Gastroenterol* 2008;22:977–9. doi: 10.1155/2008/576987.
27. Tetzlaff JE. Practical considerations in the management of sedation for colonoscopy. *Curr Opin Anaesthesiol* 2016;29:512–8. doi: 10.1097/aco.0000000000000352.
28. Frazzoni L, Radaelli F, Spada C, Mussetto A, Frazzoni M, Laterza L, et al. The diagnostic yield of colonoscopy in hospitalized patients. an observational multicenter prospective study. *Dig Liver Dis* 2021;53:224–30. doi: 10.1016/j.dld.2020.10.029.
29. Bitoun A, Ponchon T, Barthet M, Coffin B, Dugué C, Halphen M. Results of a prospective randomised multicentre controlled trial comparing a new 2-L ascorbic acid plus polyethylene glycol and electrolyte solution vs. sodium phosphate solution in patients undergoing elective colonoscopy. *Aliment Pharmacol Ther* 2006;24:1631–42. doi: 10.1111/j.1365–2036.2006.03167.x
30. Juluri R, Eckert G, Imperiale TF. Polyethylene glycol vs. sodium phosphate for bowel preparation: a treatment arm meta-analysis of randomized controlled trials. *BMC Gastroenterol* 2011;11:38. doi: 10.1186/1471–230x–11–38.
31. Jung YS, Lee CK, Kim HJ, Eun CS, Han DS, Park DI. Randomized controlled trial of sodium phosphate tablets vs polyethylene glycol solution for colonoscopy bowel cleansing. *World J Gastroenterol* 2014;20:15845–51. doi: 10.3748/wjg.v20.i42.15845.
32. Hung SY, Chen HC, Ke TW, Chen JH, Hsiao KH, Wang HM, et al. Noninferiority clinical trial comparing the bowel cleansing efficacy of sodium phosphate tablets (Quiklean®) with a polyethylene glycol/bisacodyl kit. *World J Gastroenterol* 2021;27:428–41. doi: 10.3748/wjg.v27.i5.428.33.
33. van Grootel J, Bor P, Netjes J, Veenhof C, Valkeniet K. Improving physical activity in hospitalized patients: The preliminary effectiveness of a goal-directed movement intervention. *Clin Rehabil* 2023;37:1501–9.
34. Nunan D, Cai T, Gardener AD, Ordóñez-Mena JM, Roberts NW, Thomas ET, et al. Physical activity for treatment of irritable bowel syndrome. *Cochrane Database Syst Rev* 2022;6:CD011497. doi: 10.1002/14651858.CD011497.pub2.
35. Rocha RSP, Ribeiro IB, de Moura DTH, Bernardo WM, Minata MK, Morita FHA, et al. Sodium picosulphate or polyethylene glycol before elective colonoscopy in outpatients? A systematic review and meta-analysis. *World J Gastrointest Endosc* 2018;10:422–41. doi: 10.4253/wjge.v10.i12.422.
36. Amarnah BH. Social support behaviors and work stressors among nurses: a comparative study between teaching and non-teaching hospitals. *Behavioral Sciences* 2017;7:5.