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Efficacy and acceptability of bowel preparation strategies for inflammatory bowel disease colonoscopy: Systematic review and meta-analysis

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ABSTRACT

Background and study aims Patients with inflammatory bowel disease (IBD) frequently undergo colonoscopy, each requiring bowel preparation. European Society of Gastrointestinal Endoscopy (ESGE) 2019 guidelines recommended high- or low-volume polyethylene glycol (PEG)-based bowel prep for IBD patients; however other non-PEG-based preparations (sulphate and picosulphate-based) have now been studied in IBD.

Methods We searched CENTRAL, ClinicalTrials.gov, Embase, MEDLINE, and the World Health Organization International Clinical Trials Registry Platform for randomized controlled trials (RCTs) up to December 2024. Primary outcome was bowel prep success; secondary outcomes included tolerability, acceptability, cecal intubation rates (CIR) and safety. Pooled estimates used risk ratio (RR) and GRADE to assess evidence certainty.

Results Ten RCTs (1479 IBD patients) were included. There was no difference in prep success (relative risk [RR] 0.98, 95% confidence interval [CI] 0.88–1.09; I^2 = 33%, 2 RCTs; moderate certainty evidence) between 2 L vs. 4 L PEG, but higher acceptability for 2 L (RR 0.69, 95% CI 0.59–0.80; I^2 = 18%, 2 RCTs; high certainty evidence). Low-volume non-PEG vs. PEG are probably similar for prep success (RR 0.96, 95% CI 0.90–1.01; I^2 = 6%,3 RCTs; moderate certainty evidence). The evidence on tolerability and acceptability was very uncertain. Subgroup analysis revealed comparable effectiveness of picosulphate-based (RR 0.89, 95% CI 0.78–1.01; I^2 = 0%,1 RCT) and sulphate-based preps (RR 0.98, 95% CI 0.91–1.05; I^2 = 28%, 2 RCTs) compared with low-volume PEG. Safety data were inconsistently reported.

Conclusions High-certainty evidence supports low-volume PEG as comparably successful to high-volume PEG, with higher acceptability. Moderate-certainty evidence indicates similar success between non-PEG and PEG-based preps. Both low-volume PEG and non-PEG-based preps are supported for use in IBD, broadening options beyond current ESGE guidelines.

Introduction

Despite advancements in therapeutic options, patients with colonic inflammatory bowel disease (IBD), encompassing Crohn's disease (CD) and ulcerative colitis (UC), continue to face an elevated risk of colorectal cancer (CRC) and dysplasia, necessitating regular surveillance colonoscopies [1, 2, 3]. International guidelines typically recommend initiating surveillance colonoscopies 8 to 10 years after symptom onset, with subsequent 1 to 5 yearly examinations based on individual risk assessment,

including factors such as disease duration, severity, associated primary sclerosing cholangitis, and family history of CRC [4, 5].

The need for frequent endoscopies, particularly for those diagnosed at a young age, presents a significant challenge. Patients frequently find bowel preparation particularly distressing [6]. A recent discrete choice experiment among IBD patients highlighted bowel preparation as the most significant factor influencing adherence to CRC surveillance. It contributed to 40.5% of decision-making, outweighing the importance of surveillance intervals (31.1%) and CRC risk reduction (28.4%) [7].

The current European Society of Gastrointestinal Endoscopy (ESGE) guidelines recommend either high- or low-volume polyethylene glycol (PEG)-based bowel preparations for patients with IBD [8]. The evolving landscape of bowel preparation options, including non-PEG-based sulphate preparations, necessitates a comprehensive evaluation of their efficacy and safety in the IBD population [9].

With these expanded choices, patient preferences, including taste, tolerance to high liquid volumes, comorbidities, and other individual factors, should guide preparation selection. Balancing bowel cleansing and patient comfort is key to maintaining adherence to long-term surveillance [7]. As part of the British Society of Gastroenterology (BSG) guidelines update for colorectal IBD surveillance, the efficacy and safety of various bowel preparation regimens were identified as key areas of interest [10]. This systematic review and meta-analysis evaluated current evidence from randomized controlled trials (RCTs) to provide clinicians with evidence-based insights, guiding optimal bowel preparation strategies for IBD patients. These findings are intended to inform updates to BSG guidelines and future revisions of ESGE recommendations, ultimately enhancing patient care and adherence to surveillance programs.

Methods

The detailed methodology follows the BSG guideline development process and is available in the Standard Operating Procedure [10]. The protocol was registered on University of Central Lancashire (UClan) online repository (https://clok.uclan.ac.uk/53314). At the outset of the guideline development process, the guideline development group (GDG) established critical and significant outcomes, as well as thresholds for assessing the magnitude of effect and imprecision (Supplementary Table 1) [10].

The Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) guidelines were used to design and conduct this systematic review [11].

Search strategy and study selection

A comprehensive literature search was conducted in Cochrane CENTRAL, ClinicalTrials.gov, Embase via Ovid, WHO ICTRP and MEDLINE via Ovid, covering RCTs published up to December 2024. Search strategies and results are show in the eAppendix for search strategies and results.

Inclusion criteria for this review were RCTs involving IBD patients undergoing colonoscopy, which compared different bowel preparation regimens (PEG-based, non-PEG-based, or combinations). Studies were required to report on outcomes of interest. Exclusion criteria included non-randomized studies, observational studies, and case reports. Studies not involving IBD patients or those with incomplete data or outcomes not relevant to this review were also excluded. Conference abstracts were eligible for inclusion.

The study selection was conducted independently by two reviewers, both at the title/abstract and full-text screening stages using the Covidence systematic review management software [12]. Any disagreements were resolved by a senior reviewer.

Data extraction and quality assessment

Data were independently extracted by two reviewers (AT and GBN) using a standardized data extraction form. Extracted data included study characteristics, patient demographics, intervention details, and outcomes. Quality of the included studies was assessed with the Cochrane Risk of Bias tool [13]. Recognizing that blinding of participants and personnel might not be feasible for the types of interventions assessed, this limitation was considered when making risk of bias evaluations. Any discrepancies were addressed through discussion and consensus. Authors were contacted for clarifications regarding missing or ambiguous outcome data and risk of bias (▶ **Table 1**).

Outcomes and statistical analysis

The GDG stakeholder expert members predetermined the primary and secondary outcomes using a Delphi process to reach consensus as follows [10].

The primary outcome was preparation success measured using validated scores.

Secondary outcomes (as described by the authors using dichotomous or continuous outcome measures) were patient acceptability, patient tolerability, adenoma/polyp detection rates, incidence of serious adverse events, cecal intubation rates, and patient withdrawals due to adverse events.

Disease flare-ups post bowel preparation and colonoscopy was evaluated as an additional safety outcome for this review.

Assumptions and standardizations

Given the variability in outcome reporting across different studies, the following assumptions and standardizations were made.

Preparation success was determined as a dichotomous variable (successful or unsuccessful) if the score met the threshold for adequate cleansing as defined by each study's authors, using a validated scoring system.

Tolerability was defined as completion of the current bowel preparation for the procedure, while acceptability was defined as the willingness to repeat the bowel preparation for the next procedure. In studies where these terms were used interchangeably, definitions were standardized as per the above criteria. Scores reported in different formats were combined and converted into categories of acceptable/not acceptable and tolerable/not tolerable to ensure uniformity in data analysis.

▶ **Table 1** Summary of study characteristics.

Study ID	Country	Abstract/ full paper	Study period	Setting and purpose of colonoscopy	Bowel prep choice 1	Bowel prep choice 2	Bowel prep choice 3	Numbers randomised in each group (Total)	Patient population	Reported outcomes of interest	Author contacted (Response)	Additional comments
Gould et al.1982 [14]	UK	Full paper	Not reported	Outpatient/ CRC screening	Castor oil	Senna	-	23/23 (46)	UC disease distribution not reported	Bowel prep success (perfect/adequate/ poor), serious adverse events	Not needed – historical study	-
Lazzaroni et al. 1993 [15]	Italy	Full paper	Not reported	Not reported	4 L PEG + Simethicone	4 L PEG + Placebo	-	Not reported (115) Patients completing study 57/48 (105)	UC and CD Choice 1–26 UC, 23 CD Choice 2–35 UC, 21 CD	Bowel prep success (excellent/adequate/ poor or unacceptable), tolerability, withdrawals due to adverse events	Not needed – historical study	-
Frankovic et al. 2014 [16]	Italy	Abstract	Not reported	Not reported	PEG	Sodium Picosulphate + Magnesium Citrate	-	Not reported (56)	UC and CD 34-UC and 22-CD (no data as per different arms)	Bowel prep success (OBPS), acceptability, tolerability (only p-values reported and actual numbers not reported)	Contacted (no response)	Volume of PEG preparation not reported Biochemical parameters checked pre and post bowel prep
Kato et al. 2015 [17]	Japan	Abstract	Not reported	Not reported	Niflec (4L PEG)	Moviprep (2L PEG)	-	(70)	UC and CD 36- UC and 34-CD (no data as per different arms)	Bowel prep success (Likert scale grading from good to bad), tolerability, acceptability, safety (reported as comparative scores with p values not as binary outcomes)	Contacted (no response)	Blood and urinary osmotic pressures checked, prep and post bowel prep

▶ **Table 1** (Continuation)

Study ID	Country	Abstract/ full paper	Study period	Setting and purpose of colonoscopy	Bowel prep choice 1	Bowel prep choice 2	Bowel prep choice 3	Numbers randomised in each group (Total)	Patient population	Reported outcomes of interest	Author contacted (Response)	Additional comments
Manes et al. 2015 [18]	Italy	Full paper	May-Dec 2013	Outpatient, different indications	4L PEG	2L PEG +Bisacodyl	-	108/108 (216)	UC Choice 1- Left colitis-40/Right colitis-26/ Pancolitis-40 Choice 2- Left colitis-43/Right colitis-23/ Pancolitis-39	Bowel prep success (OBPS), tolerability, acceptability, withdrawals, serious adverse events, caecal intubation rate	Contacted (no response)	Patient choice for either split dose or full-dose ingestion. All patients to take low-fiber diet 3 days before
Kim et al. 2017 [19]	Korea	Full paper	Aug 2013 - Jan 2015	Outpatient, surveillance and assessment of mucosal healing	4L PEG	2L PEG +Ascorbic Acid	-	55/57 (112)	UC Choice 1- E1–23/ E2–17/ E3–13 Choice 2- E1–24/ E2–10/ E3–11	Bowel prep success (BBPS), acceptability, serious adverse events	Contacted (no response)	Patient choice for split dose or full-dose ingestion. All patients to take low-residue diet 2 days before procedures
Mohsen et al. 2021 [20]	Australia	Full paper	March 2013-December 2016	Outpatients, different indications	Moviprep (2L PEG)	Prep-Kit C (1.5L PEG)	-	64/61 (125)	UC and CD 52-UC and 73-CD (no data as per different arms)	Bowel prep success (OBPS), tolerability, safety	Contacted (no response)	Split dosing for all Blood with electrolyte levels checked pre and post bowel prep

▶ **Table 1** (Continuation)

Study ID	Country	Abstract/ full paper	Study period	Setting and purpose of colonoscopy	Bowel prep choice 1	Bowel prep choice 2	Bowel prep choice 3	Numbers randomised in each group (Total)	Patient population	Reported outcomes of interest	Author contacted (Response)	Additional comments
Kim et al. 2022 [21]	South Korea	Full paper	February 2020-March 2021	Outpatient, surveillance and assessment of mucosal healing	2L PEG + Ascorbic Acid	Oral Sulphate Tablet	-	55/55 (110)	UC and CD UC-75 Choice 1–35 (E1–8/ E2–10/ E3–17) Choice 2–37 (E1 -9/ E2–10/ E3–18) CD-35 Choice 1–17 (L1–4/ L2- 3/ L3–10) Choice 2–18 (L1–2/ L2–3/ L3–13)	Bowel prep success (HCS), tolerability, safety, caecal intubation rate	Contacted (author responded to all queries)	Split-dosing for all Bloods with electrolyte levels checked post bowel prep and compared with baseline results at routine follow-ups in the last 3 months before colonoscopy

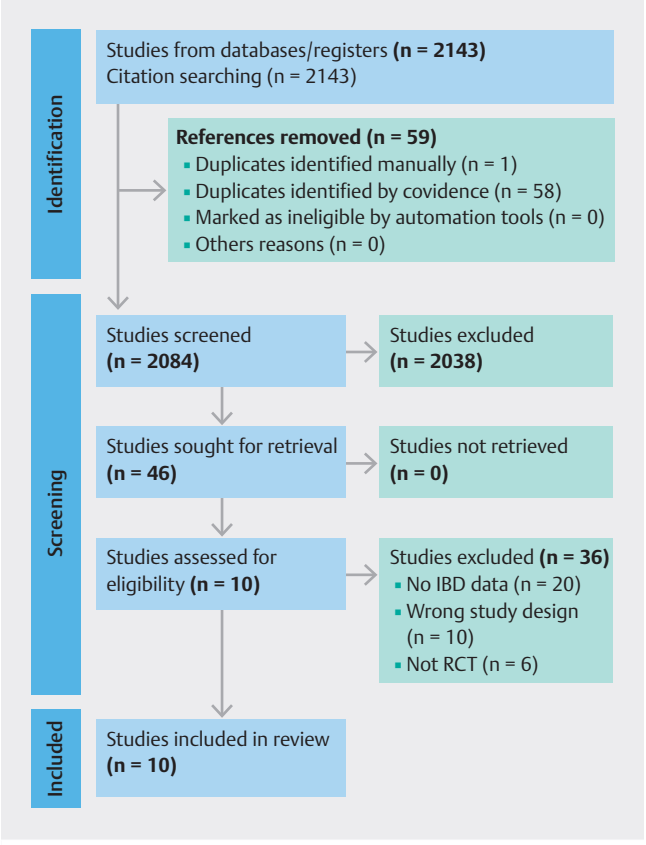
▶ **Table 1** (Continuation)

Study ID	Country	Abstract/ full paper	Study period	Setting and purpose of colonoscopy	Bowel prep choice 1	Bowel prep choice 2	Bowel prep choice 3	Numbers randomised in each group (Total)	Patient population	Reported outcomes of interest	Author contacted (Response)	Additional comments
Rueda García et al. 2023 [22]	Spain	Full paper	February 2019 -June 2021	Outpatient, surveillance and assessment of mucosal healing	2L PEG	1L PEG	SP	28/33/31 (92)	UC, CD AND IBD-U UC-42 Choice 1–16 (E1- 2/ E2–6/E3- 8) Choice 2–16 (E1–2/ E2–8/E3–6) Choice 3–12 (E1- 1/E2- 6/E3- 5) CD-43 Choice 1–11 (L1- 3/L2- 0/ L3–8) Choice 2–14 (L1- 4/ L2–3/ L3- 6) Choice 3–18 (L1- 6/L2- 7/ L3 -5) IBD-U-5 Choice 1–1 Choice 2–3 Choice 3–1	Bowel prep success (BBPS), tolerability, acceptability, safety	Contacted (author responded to all queries)	Split dosing for all All patients to take low-residue diet 3 days before procedures Blood checked

▶ **Table 1** (Continuation)

Study ID	Country	Abstract/ full paper	Study period	Setting and purpose of colonoscopy	Bowel prep choice 1	Bowel prep choice 2	Bowel prep choice 3	Numbers randomised in each group (Total)	Patient population	Reported outcomes of interest	Author contacted (Response)	Additional comments
Lee et al. 2023 [23]	Korea	Full paper	September 2017 -October 2019	Outpatient, not specified	2L PEG +Ascorbic Acid	Oral Sulphate Solution	-	100/199 (199)	UC Choice 1–93 (E1–33/ E2–29/ E3–31) Choice 2–92 (E1–33/ E2–37/E3–22)	Bowel prep success, acceptability, tolerability, safety	Contacted (no response) Bowel prep success, acceptability, tolerability, safety	Split dosing for all All patients to take low-residue diet 3 days before procedures All patients took 10-mL simethicone solution with last dose of the prep Bloods with electrolyte levels checked pre and post bowel prep

BBPS, Boston Bowel Preparation Scale; CD, Crohn's disease; CRC, colorectal cancer; HCS, Harefield Cleansing Scale; IBD-U, inflammatory bowel disease undifferentiated; OBPS, Ottawa Bowel Preparation Scale; PEG, polyethylene glycol; SP, sodium picosulphate; UC, ulcerative colitis.
E1/E2/E3 represent UC phenotype as per Montreal Classification and L1/L2/L3 represent CD phenotype based on location of disease as per Montreal classification.



▶ **Fig. 1** PRISMA flow diagram [11].

Serious adverse events (AEs) were defined as any undesirable experiences associated with the use of the bowel preparation regimens that resulted in significant morbidity or required medical intervention. These included severe gastrointestinal symptoms, allergic reactions, or any events necessitating hospitalization.

Patient withdrawals due to AEs were the number of patients who discontinued the bowel preparation regimen due to adverse events.

Synthesis of results

Meta-analyses were conducted using random-effects models. Risk ratios (RRs) and 95% confidence intervals (CIs) were calculated for dichotomous outcomes. Heterogeneity was assessed using the I^2 statistic. Pairwise meta-analyses were performed by grouping studies into comparisons of non-PEG-based preparations, high vs. low-volume PEG and PEG vs. non-PEG preparations. (Supplementary Table 2 and Supplementary Table 3)

A network meta-analysis (NMA) was deemed inappropriate due to the sparse network of studies and significant variability in patient populations, intervention protocols, and outcomes. Sparse networks relying on single studies reduce result reliability, and the dataset's heterogeneity prevented adequate testing of NMA's consistency and transitivity assumptions. Instead, pairwise meta-analyses focusing on broad categories like high- vs. low-volume and PEG- vs. non-PEG-based preparations offered more actionable and clinically relevant comparisons.

Funnel plots were used to assess publication bias for pairwise analyses where there were at least ten studies. Statistical analyses were performed using Review Manager (RevMan) version 5.4.

Subgroup analysis

Subgroup analyses were conducted to compare non-PEG sulphate-based preparations vs. PEG-based preparations and non-PEG picosulphate-based preparations vs. PEG-based preparations.

A further subgroup analysis based on use of same-day vs split dosing, between UC and CD was also planned.

GRADE assessment for the certainty of the evidence

Certainty of the evidence was assessed using the GRADE (Grading of Recommendations, Assessment, Development and Evaluations) approach [24]. This method evaluates certainty of the outcome results based on risk of bias, imprecision, inconsistency, indirectness, and publication bias. Each outcome was categorized into one of four levels: high, moderate, low, or very low certainty. High certainty means that further research is very unlikely to change confidence in the estimate of the effect, moderate certainty means there is a possibility the true estimate could be different, low certainty means that the true estimate may be quite different, and very low certainty means that there is significant uncertainty about the estimate. Disagreements in the GRADE assessments were resolved through discussion and consensus among the reviewers.

Results

Study characteristics

Ten RCTs involving 1479 IBD patients were included in the analysis (▶ **Fig. 1**) [14, 15, 16, 17, 18, 19, 20, 21, 22, 23]. The studies compared various bowel preparation regimens, including 4 L PEG with/without simethicone [15], castor oil vs. senna [14], two commercial low-volume PEG-based preparations [20], 2 L PEG vs. 4 L PEG [17, 18, 19], and low-volume PEG (≤ 2 L) with additives vs. non-PEG-based preparations [16, 21, 22, 23]. Of the included studies, eight were published as full papers [14, 15, 18, 19, 20, 21, 22, 23], whereas two were reported in abstract form [14, 15, 16, 17, 18, 19, 20, 21, 22, 23]. ▶ **Table 1** presents the main characteristics of the included studies, and Supplementary Table 2 and Supplementary Table 3 provide details on the different bowel preparation types used, including their constituents.

Non-PEG-based preparations

One of the earliest studies on non-PEG-based preparations was conducted by Gould et al. (1982), comparing castor oil to senna in 46 patients with inactive UC [14].

Polyethylene glycol (PEG)-based preparations

Research on PEG-based bowel preparations spans both high-volume (4 L) and low-volume (≤ 2 L) formulations, with or without additives. Lazzaroni et al. (1993) conducted one of the earlier studies involving 115 patients with UC and CD, comparing 4 L PEG with simethicone to 4 L PEG with placebo [15].

More recent studies have focused on comparing low-volume PEG (≤2 L) preparations with 4 L PEG. Kato et al. (2015) evaluated 70 patients with UC and CD, comparing 2 L PEG (Moviprep) to 4 L PEG (Niflec), utilizing a 1-to-5 cleansing scale where scores of 1 or 2 were deemed successful [17]. The same year, Manes et al. evaluated 216 UC patients by comparing 2 L PEG plus bisacodyl to 4 L PEG, using the Ottawa Bowel Preparation Scale (OBPS) with success defined as an OBPS score ≤ 2 in each segment [18].

In more recent studies, Kim et al. (2017) compared 4 L PEG to 2 L PEG with ascorbic acid (PEG/Asc) in 112 patients with UC [19]. Success was measured with the Boston Bowel Preparation Scale (BBPS) where scores ≥ 6 indicated successful preparation. Similarly, Mohsen et al. (2021) compared two commercial low-volume PEG-based preparations (Prep Kit-C and Moviprep) in 338 patients, including 125 with IBD and reported bowel prep success using OBPS [20].

Low-volume PEG vs. sodium picosulphate (non-PEG)-based preparations

Frankovic et al. (2014) and Rueda Garcia et al. (2023) investigated the efficacy of low-volume PEG compared with sodium picosulphate-based preparations [16, 22]. Frankovic et al. studied 56 patients with UC and CD, comparing PEG to sodium picosulphate plus magnesium citrate (PICO), using the OBPS for assessment [16]. Rueda Garcia et al. involved 92 patients with UC and CD, comparing 1 L PEG with 2 L PEG combined with sodium picosulphate (SP), utilizing the BBPS to evaluate preparation success [22].

Low-volume PEG vs. oral sulphate (non-PEG)-based preparations

Recent studies have compared oral sulphate preparations with PEG-based regimens in IBD patients. Kim et al. (2022) evaluated 110 patients with clinically inactive UC and CD, comparing oral sulphate tablets (OST) to 2-L PEG/Asc [21]. Preparation success was measured using the Harefield Cleansing Scale (HCS) within the acceptable range. Lee et al. (2023) further compared oral sulphate solution with 2 L PEG/Asc in 199 patients with inactive UC, utilizing the BBPS to define success as a score ≥ 6 [23].

Assessment tools and success criteria

The included studies utilized a range of tools to evaluate bowel preparation success. Lazzaroni et al. (1993) reported bowel preparation quality based on the presence of bubbles, haziness, and overall cleansing, rated on a scale from excellent to unacceptable [15]. The OBPS was used in studies by Frankovic et al. (2014), Manes et al. (2015), and Mohsen et al. (2021), where lower scores indicated better preparation quality [16, 18, 20]. The BBPS was used by Kim et al. (2017), Rueda Garcia et al. (2023), and Lee et al. (2023), where higher scores denoted successful preparation [19, 22, 23]. The HCS was used by Kim et al. (2022) to assess acceptable bowel preparation [21]. Proprietary cleansing scales, such as the 1-to-5 scale used by Kato et al. (2015), were also employed, with lower scores representing successful preparation [17]. Gould et al. (1982) relied on endoscopist assessments, categorizing preparations as successful if rated as perfect or adequate [14].

The summary of the RoB assessment for the included studies is presented in Supplementary Fig. 1 with detailed judgements provided in Supplementary Table 4.

Effects of the intervention

Castor oil vs senna

One study (Gould et al) examined 46 patients with inactive UC, comparing castor oil and senna [14]. For the primary outcome of preparation success, no conclusions can be drawn due to very low-certainty evidence (Senna 19/23 vs Castor oil 20/23, RR 0.95, 95% CI 0.74–1.21, trivial difference (moderate for to moderate against); very low-certainty evidence). Minor bowel disturbances were reported in 30% of patients, and three patients in each group required temporary treatment modifications after preparation. In addition, three out 23 patients in each group (castor oil and senna) had to alter their treatment temporarily post bowel preparation.

High-volume (4 L) vs low-volume (≤ 2 L) PEG-based preparations

Bowel preparation success

Meta-analysis of two RCTs comparing high-volume (4 L) to low-volume (≤ 2 L) PEG-based preparations showed there is probably no significant difference in bowel preparation success (RR 0.98, 95% CI 0.88–1.09; I^2 = 33%, no difference in magnitude (small for to small against); moderate-certainty evidence) (▶ **Fig. 2a**) [18, 19].

Patient acceptability (willingness to repeat)

Meta-analysis of two RCTS showed higher acceptability for low-volume (≤ 2 L) PEG compared to high-volume (4 L) PEG (RR 0.69, 95% CI 0.59–0.80; I^2 = 18%; large difference in magnitude (large to large); high-certainty evidence) (▶ **Fig. 2b**) [18, 19].

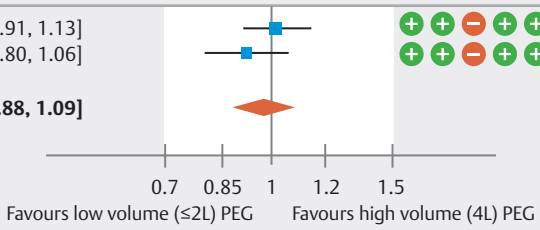
Patient tolerability

Meta-analysis of one RCT showed higher tolerability for low-volume (≤ 2 L) PEG compared to high-volume (4 L) PEG (RR 0.18, 95% CI: 0.09–0.32; large difference in magnitude (large to large); high-certainty evidence) (▶ **Fig. 2c**) [18].

Forest plot comparing high volume (4L) PEG to low volume (≤2L) for bowel preparation success

Study or subgroup	High volume (4L) PEG Events	Total	Low volume (≤2L) PEG Events	Total	Weight	Risk ratio M-H, Random, 95% CI
Kim, 2017	51	55	52	57	58.4%	1.02 [0.91, 1.13]
Manes, 2015	81	108	88	108	41.6%	0.92 [0.80, 1.06]
Total (95% CI)		**163**		**165**	**100.0%**	**0.98 [0.88, 1.09]**
Total events	132		140			

Heterogeneity: Tau² = 0.00; Chi² = 1.49, df = 1 (*P* = 0.22); I² = 33%
Test for overall effect: Z = 0.46 (*P* = 0.65)



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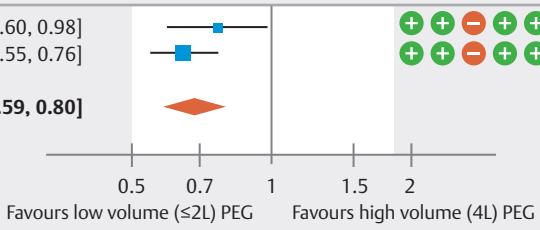
Risk of bias legend
(**A**) Random sequence generation (selection bias) (**B**) Allocation concealment (selection bias) (**C**) Blinding of participants and personnel (performance bias) (**D**) Blinding of outcome assessment (detection bias) (**E**) Incomplete outcome data (attrition bias) (**F**) Selective reporting (reporting bias) (**G**) Other bias

Forest plot comparing high volume (4L) PEG to low volume (≤2L) for acceptability

Study or subgroup	High volume (4L) PEG Events	Total	Low volume (≤2L) PEG Events	Total	Weight	Risk ratio M-H, Random, 95% CI
Kim, 2017	34	55	46	57	34.2%	0.77 [0.60, 0.98]
Manes, 2015	65	108	100	108	65.8%	0.65 [0.55, 0.76]
Total (95% CI)		**163**		**165**	**100.0%**	**0.69 [0.59, 0.80]**
Total events	99		146			

Heterogeneity: Tau² = 0.00; Chi² = 1.21, df = 1 (*P* = 0.27); I² = 18%
Test for overall effect: Z = 4.81 (*P* <0.00001)



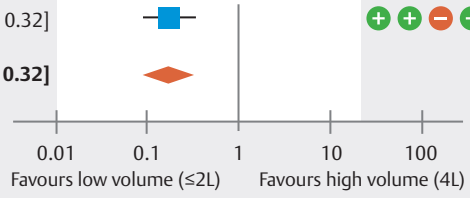
b

Risk of bias legend
(**A**) Random sequence generation (selection bias) (**B**) Allocation concealment (selection bias) (**C**) Blinding of participants and personnel (performance bias) (**D**) Blinding of outcome assessment (detection bias) (**E**) Incomplete outcome data (attrition bias) (**F**) Selective reporting (reporting bias) (**G**) Other bias

Forest plot comparing high volume (4L) PEG to low volume (≤2L) for tolerability

Study or subgroup	High volume (4L) PEG Events	Total	Low volume (≤2L) PEG Events	Total	Weight	Risk ratio M-H, Random, 95% CI
Manes, 2015	47	108	88	108	100.0%	0.18 [0.09, 0.32]
Total (95% CI)		**108**		**108**	**100.0%**	**0.18 [0.09, 0.32]**
Total events	47		88			

Heterogeneity: Not applicable
Test for overall effect: Z = 5.54 (*P* <0.00001)



c

Risk of bias legend
(**A**) Random sequence generation (selection bias) (**B**) Allocation concealment (selection bias) (**C**) Blinding of participants and personnel (performance bias) (**D**) Blinding of outcome assessment (detection bias) (**E**) Incomplete outcome data (attrition bias) (**F**) Selective reporting (reporting bias) (**G**) Other bias

▶ **Fig. 2** Forest plot comparing high-volume (4 L) PEG to low-volume (≤ 2 L) for **a** bowel preparation success; **b** acceptability; and **c** tolerability.

Adenoma/polyp detection rates

No data were reported on adenoma/polyp detection rates in any of the included studies, and no conclusions can be drawn for this outcome.

Incidence of serious adverse events

No serious AEs were reported in any of the included studies. and no conclusions can be drawn for this outcome. It was noted in Kim et al. (2017) that SCCAI scores increased in 23.8% of patients within 4 weeks post-colonoscopy, though without significant differences between groups [19].

Cecal intubation rates

No data on cecal intubation rates were in any of the included studies. and no conclusions can be drawn for this outcome.

Low-volume (≤ 2 L) PEG vs. low-volume non-PEG-based preparations

Bowel preparation success

The comparison between low-volume (≤ 2 L) PEG- and non-PEG-based preparations from three RCTs showed there is probably no significant difference in bowel preparation success (RR 0.96, 95% CI 0.90–1.01; I^2 = 6%, no difference in magnitude (small for to trivial against); moderate-certainty evidence) (▶ **Fig. 3**) [21, 22, 23].

Subgroup analysis for subtypes of non-PEG-based preparations revealed comparable effectiveness of picosulphate-based (RR 0.89, 95% CI 0.78–1.01; I^2 = 0%, 1 RCT)[22] and sulphate-based preparations (RR 0.98, 95% CI 0.91–1.05; I^2 = 28%, 2 RCTs) compared with low-volume PEG-based preparations (▶ **Fig. 3**) [21, 23].

Patient acceptability (willingness to repeat)

Meta-analysis comparing low-volume (≤ 2 L) PEG- and non-PEG-based preparations included three RCTs but the results are very uncertain (RR 0.77, 95% CI 0.59–0.99; I^2 = 83%, large difference in magnitude (large to trivial); low-certainty evidence) (▶ **Fig. 4**) [21, 22, 23].

Subgroup analysis for subtypes of non-PEG-based preparations revealed comparable acceptability of picosulphate-based (RR 0.62, 95% CI 0.33–1.16; I^2 = 86%, 1 RCT)[22] and sulphate-based preparations (RR 0.88, 95% CI 0.65–1.20; I^2 = 86%, 2 RCTs) compared to low-volume PEG-based preparations (▶ **Fig. 4**) [21, 23].

Patient tolerability

Meta-analysis comparing low-volume (≤ 2 L) PEG- and non-PEG-based preparations included three RCTs and showed that there may be moderate difference in tolerability favouring non-PEG-based preparations (RR 0.81, 95% CI 0.67–0.99; I^2 = 76%; large difference in magnitude (large to trivial); low-certainty evidence) (▶ **Fig. 5**) [21, 22, 23].

Subgroup analysis for subtypes of non-PEG-based preparations revealed comparable tolerability of picosulphate-based (RR 0.86, 95% CI 0.73–1.01; I^2 = 22%, 1 RCT)[22] and sulphate-based preparations (RR 0.76, 95% CI 0.45–1.26; I^2 = 91%, 2 RCTs) compared to low-volume (≤ 2 L) PEG-based preparations (▶ **Fig. 5**) [21, 23].

Adenoma/polyp detection rates

No data were reported on adenoma/polyp detection rates in any of the included studies, and no conclusions can be drawn for this outcome.

Incidence of serious adverse events

No serious AEs were reported in any of the included studies. and no conclusions can be drawn for this outcome. It was noted that two studies reported disease flare up data. Kim et al. (2022) reported 3.6% of patients in the OST group experienced flare-ups, within 4 weeks post colonoscopy, compared to none in the PEG/Asc group [21]. Frankovic et al. (2014) reported mild disease relapse, within 20 days post colonoscopy, in two patients (one in each group) [16].

Cecal intubation rates

Meta-analysis comparing low-volume (≤ 2 L) PEG- and non-PEG-based preparations two RCTs showed there may be no difference in caecal intubation rates between the two preparations (RR 0.98, 95% CI: 0.93–1.03; I^2 = 0%; no difference in magnitude (moderate for to trivial against); low-certainty evidence) (Supplementary Fig. 2) [21, 23].

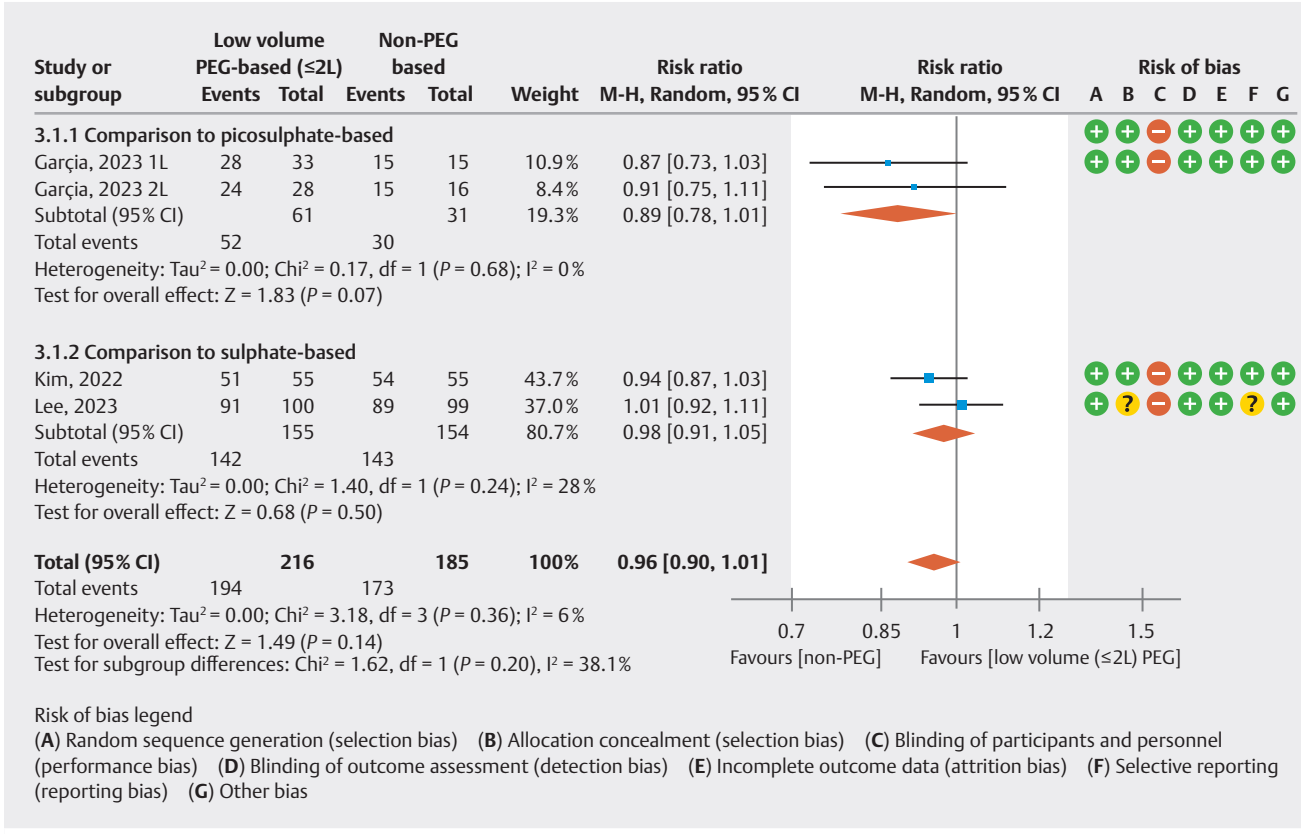
The summary of findings for high- (4 L) vs low- (≤ 2 L) volume PEG preparations and non-PEG vs low- (≤2 L) volume PEG with additives is provided in Supplementary Table 5 and Supplementary Table 6.

Discussion

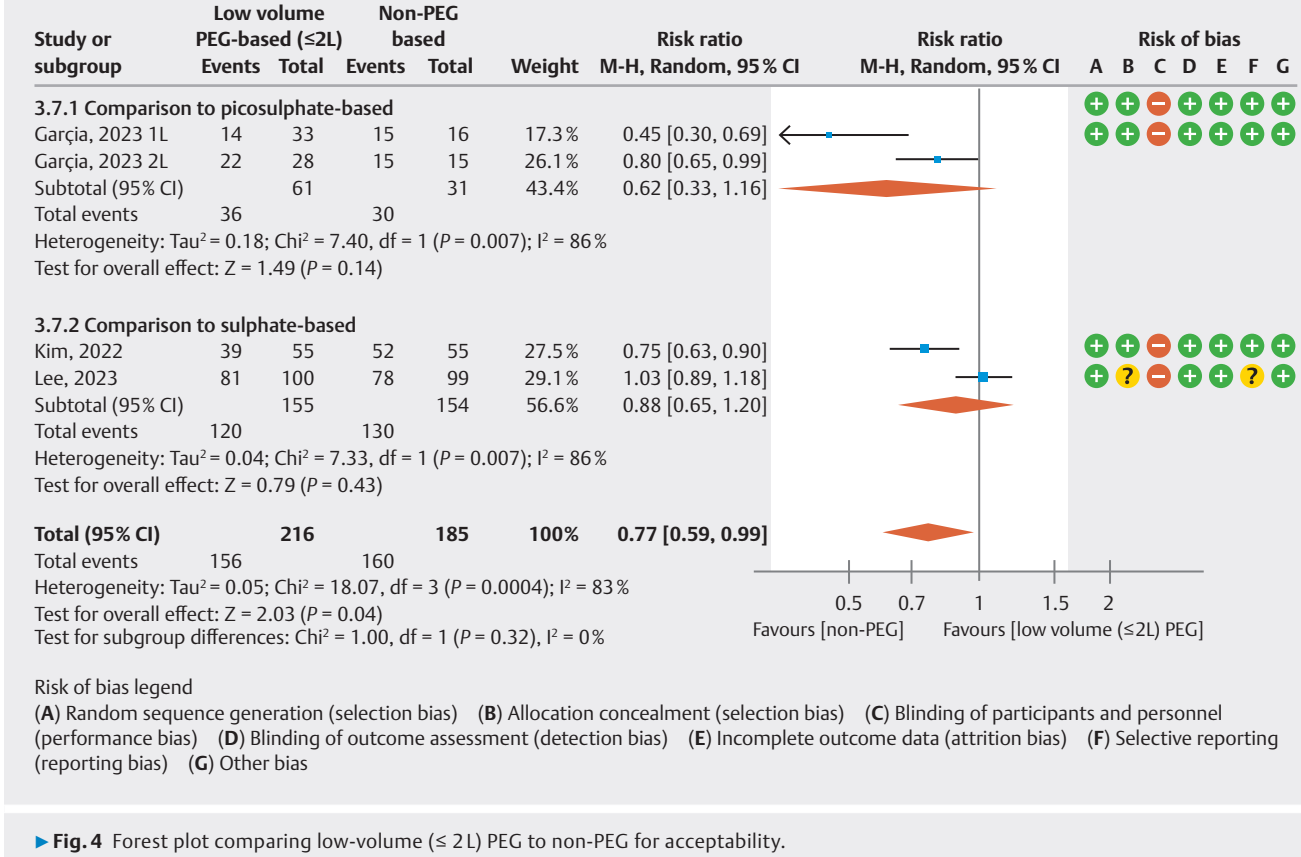
Our analysis demonstrates that low-volume PEG (≤ 2 L) is comparable to high-volume PEG (4 L) for bowel preparation success, with moderate-certainty evidence. Patients strongly preferred low-volume PEG, supported by high-certainty evidence on its acceptability, which could improve adherence to follow-up colonoscopies—an essential aspect of IBD management. This aligns with the objective of providing patient-friendly options without compromising efficacy.

The comparison between non-PEG-based and PEG-based preparations suggests similar efficacy in bowel cleansing with moderate-certainty evidence. These findings are particularly relevant for patients who struggle with the volume or taste of PEG solutions. In a discrete choice experiment, patients favored a bowel prep option of 0.3 L of laxative with 2 L of clear liquid versus 1 to 4 L of laxative.[7]

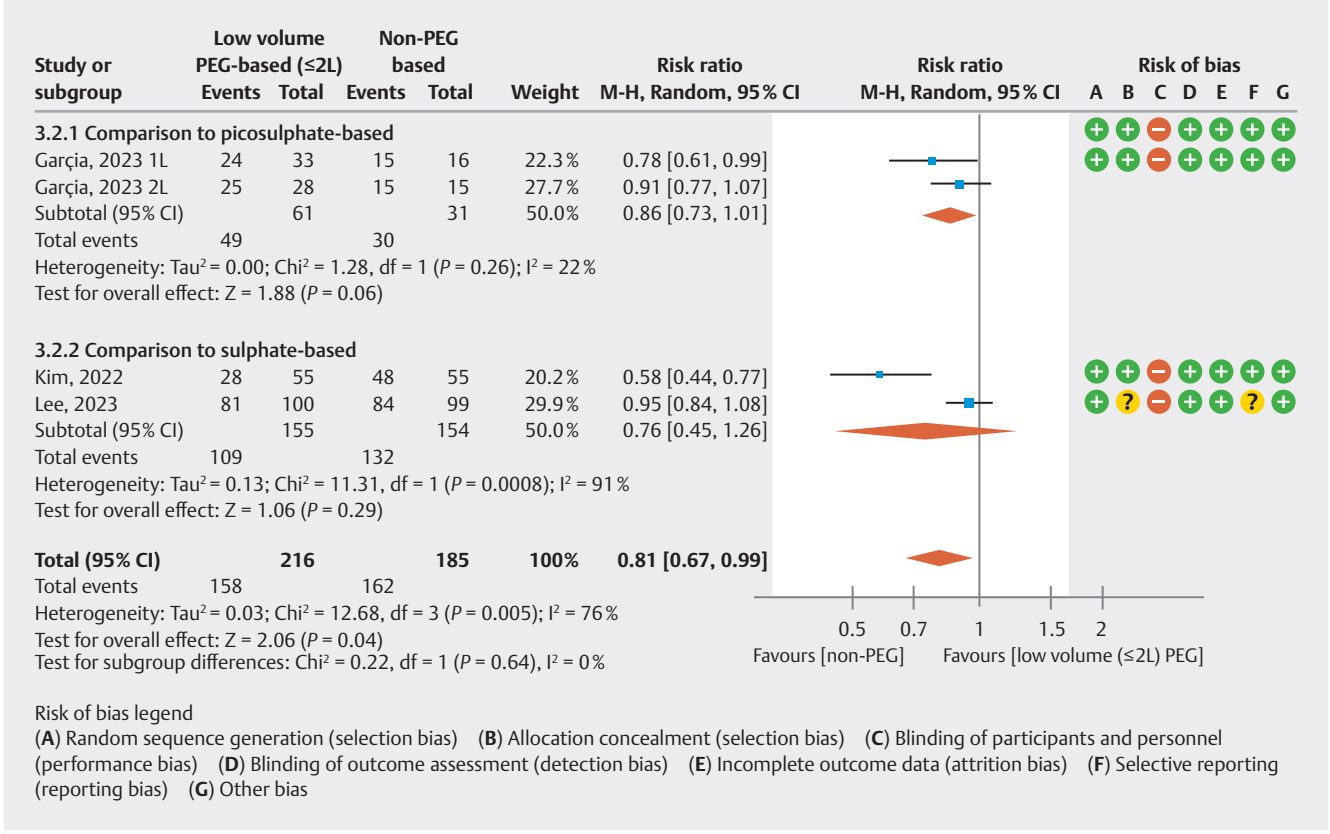
Adequate bowel preparation is critical for high-quality colonoscopy and IBD surveillance, as it directly impacts diagnostic accuracy, dysplasia detection, adherence to follow-up, and post-colonoscopy CRC (PCCRC) risk [25, 26]. A recent case-control study identified inadequate bowel preparation, defined as a BBPS < 6, as independently associated with PCCRC in IBD patients (OR 5.9; 95% CI 11.1–31.4) [27]. Furthermore, use of dye-based chromoendoscopy has been shown to enhance detection of dysplastic lesions in IBD, making proper bowel preparation even more critical for optimal visualization [28]. Poor preparation is associated with missed lesions and a higher PCCRC risk, emphasizing the importance of personalized regimens that balance efficacy and patient acceptability [26].



▶ **Fig. 3** Forest plot comparing low-volume (≤ 2 L) PEG to non-PEG for bowel preparation success.



▶ **Fig. 4** Forest plot comparing low-volume (≤ 2 L) PEG to non-PEG for acceptability.



▶ **Fig. 5** Forest plot comparing low-volume (≤ 2 L) PEG to non-PEG for tolerability.

Low-volume PEG appears more acceptable and tolerable to patients compared to high-volume PEG. Reduced volume likely decreases adverse effects like nausea and vomiting, while flavouring agents improve palatability [9, 29]. However, evidence comparing low-volume PEG with non-PEG preparations remains of low-certainty for tolerability and acceptability. Differences in volume, flavouring agents, and data capture methods to report on outcomes complicate direct comparisons. Further research is needed to determine the superiority of non-PEG preparations.

Emerging ultra-low-volume PEG preparations (1 L) show promise but require more data in IBD populations. Retrospective data on 1 L PEG from 1779 outpatient colonoscopies reported higher preparation adequacy (adjusted OR 2.30, 95% CI 1.67–3.16, $P < 0.001$) compared with 2 L PEG and SP, though tolerability and acceptability data were not specified. [30] A single-center RCT in non-IBD patients found 1 L PEG noninferior to 2 L PEG for bowel cleansing (BBPS: 92.5% vs 90.8%) with similar tolerability and acceptability [31]. The study by Rueda Garcia et al. (2023) included in this review found that 1 L PEG had comparable efficacy to 2 L PEG in IBD patients, but lower tolerability and acceptability [22]. Concerns about the ascorbate content in 1 L PEG, which may impact taste and adherence, highlight the need for further research in IBD populations.

Non-PEG alternatives raise concerns about potential disease flares or electrolyte imbalances, particularly in active IBD, but our review found limited evidence of these risks. Reporting inconsistencies precluded meta-analysis of flare-up outcomes. A large French study found PEG-2 L and SP were more effective and better tolerated than PEG-4 L, with minimal adverse events and no increase in disease flares [32]. This supports the broader use of low-volume preparations in clinical practice for IBD patients.

Subgroup analyses showed picosulphate- and sulphate-based preparations were comparable to low-volume PEG in effectiveness, tolerability, and willingness to repeat. These findings suggest that alternatives to low-volume PEG could expand options for IBD patients beyond current ESGE guidelines [8]. The safety profile of different preparations, although inconsistently reported across studies, did not reveal significant concerns. No abnormal electrolyte levels were reported post-bowel preparation in either PEG or non-PEG groups.

Current guidelines emphasize the importance of split-dose preparation with same-day bowel preparation as an acceptable alternative to split dosing for patients undergoing same-day colonoscopy [8]. Although our study did not specifically compare split-dose versus same-day dosing, previous research has shown that split dosing generally improves bowel preparation quality and patient tolerability [33]. Future studies should aim to evaluate the efficacy, acceptability and tolerability of split dosing vs same-day dosing specifically in the IBD population.

There were also lack of data between differences in the performance of different bowel preparations for patients with UC and CD to conduct a subgroup analysis based on disease subtype.

Our study has several strengths, including its comprehensive search strategy, focus on RCTs, and the use of GRADE methodology to assess evidence certainty. However, limitations include the heterogeneity in outcome reporting across studies and the relatively small number of trials for some comparisons.

Our findings align with those of Chatterjee et al., who also found no significant differences in the effectiveness of various bowel preparations for IBD [34]. Although they conducted an NMA, we opted for pairwise meta-analyses due to sparse data and significant heterogeneity, which undermines key NMA assumptions. Low-volume PEG regimens in included RCTs varied in their adjuncts, such as ascorbic acid (osmotic agent) and bisacodyl (stimulant laxative), reflecting commercial formulations. Given the sparse data and lack of head-to-head trials in IBD populations, separating these regimens for an NMA would have further fragmented the analysis and reduced interpretability. Pairwise analyses enabled pragmatic, clinically actionable comparisons (high- vs. low-volume and PEG- vs. non-PEG-based regimens), consistent with other systematic reviews grouping clinically comparable preparations [35].

Limitations related to heterogeneity and evidence synthesis should be acknowledged. While this systematic review is based on the current version of the GRADE process to align with most international guidelines, there are some aspects of this approach that deserve further consideration. The GRADE- and Cochrane-based approach uses I^2 to assess heterogeneity between studies; however, I^2 depends on sample size and can be misleading. A more clinically relevant alternative measure could be the degree of between-study variability, measured by τ^2 [36].

As a consequence of assessment of heterogeneity, this meta-analysis was conducted using random-effects models. In contrast to fixed-effect models, which estimate a common effect, random-effects models estimate an average effect. The variability of effects represented by this average may have implications for the clinical interpretation of the results. Adding a prediction interval in forest plots can help describe this variability [37], but the current Cochrane Handbook does not routinely endorse this approach. Therefore, we followed an approach that uses I^2 alongside visual interpretation and, most importantly, clinical consideration of the causes of heterogeneity, which we believe together form a holistic approach.

The studies in this review showed significant variability in outcome definitions and reporting, particularly for bowel preparation success, tolerability, and acceptability. Various scales like OBPS, BBPS, and HCS were used, contributing to the heterogeneity in meta-analysis. Tolerability (completion of the regimen) and acceptability (willingness to repeat) were assessed through both objective measures and patient-reported questionnaires, adding to the variability and heterogeneity. To enhance comparability and reliability, future studies need standardized outcome definitions, validated scales, and comprehensive data reporting. Many included trials excluded patients with more severe or complex disease phenotypes, such as those with active flares, strictures, fistulas, or known or suspected colitis-associated neoplasia. These exclusions may limit applicability of the findings to patients with advanced or complicated IBD, who may have different tolerability profiles or bowel preparation requirements.

In summary, future research should prioritize head-to-head comparisons of low-volume PEG-including ultra-low-volume PEG- and non-PEG regimens in IBD populations using standardized, validated outcome measures for efficacy, tolerability and acceptability. Studies should assess the impact of split dosing in IBD patients, explore differential efficacy in UC vs CD including more diverse IBD populations and conduct long-term studies to evaluate the relationship between bowel preparation quality, dysplasia detection and CRC risk. Standardized patient-reported experience measures and consistent safety reporting are particularly needed in bowel preparation research for IBD patients to facilitate robust comparisons and improve evidence quality in future meta-analyses.

Conclusions

This systematic review supports use of low-volume PEG-based and non-PEG-based preparations as effective alternatives to high-volume PEG for IBD patients, with moderate- to high-certainty evidence on comparable success and better acceptability. These findings suggest that current ESGE guidelines could be expanded to include these options, offering greater flexibility in patient bowel preparation choices.

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Data availability statement

The data that support the findings of this study are available upon reasonable request.

Contributors' Statement

GBN and MG contributed equally to the study's conception and design. GBN performed abstract and full-text screening, acted as the second reviewer for data collection, supported data analysis and interpretation, and led the drafting and revisions of the manuscript. MG led the literature search, supervised data analysis and interpretation, supported the critical revision of the manuscript, and equally supervised the project.VS supported the study's conception and design, contributed equally to the literature search, and supported data collection, data analysis, interpretation, drafting, and revising the manuscript. AT performed abstract and full-text screening, acted as the first reviewer for data collection, and supported data analysis and interpretation. SD, MV, and AW supported drafting and critical revision of the manuscript.The British Society of Gastroenterology Colorectal IBD Surveillance Guideline Development Group supported the drafting and critical revision of the manuscript. JEE contributed equally to the study's conception and design, supported drafting and critical revision of the manuscript, and equally supervised the project. MG and JEE act as the guarantors for this work.

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The views expressed are those of the authors and not necessarily those of the National Health Service, the NIHR or the Department of Health.
SD acknowledges funding from NHS Lothian RD.

Conflict of Interest

The authors declare that they have no conflict of interest.

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