BMJ Open Gastroenterology

A pilot study to evaluate the feasibility of implementing a split-dose bowel preparation for inpatient colonoscopy: a single-center experience

Dennis Yang[1] Robert Summerlee,[1] Brian Rajca,[1] Jonathan B Williamson,[1] Jennifer LeLaurin,[2] Lasheaka McClellan,[3] Dennis Collins,[1,3] Shahnaz Sultan,[1,2,3]

To cite: Yang D, Summerlee R, Rajca B, *et al*. A pilot study to evaluate the feasibility of implementing a split-dose bowel preparation for inpatient colonoscopy: a single-center experience. *BMJ Open Gastro* 2014;**1**: e000006. doi:10.1136/bmjgast-2014-000006

Received 30 April 2014
Revised 3 August 2014
Accepted 14 August 2014

[1]Division of Gastroenterology and Hepatology, University of Florida, Gainesville, Florida, USA
[2]Center for Chronic Disease Outcomes Research, Minneapolis VA Health Care System, Minneapolis, Minnesota, USA
[3]Gastroenterology Section, Minneapolis VAHS, Minneapolis, Minnesota, USA

Correspondence to
Dr Dennis Yang; dennis.yang@medicine.ufl.edu, dennisj.yang@gmail.com

ABSTRACT

Objectives: Feasibility of using split-dose bowel preparation in an inpatient setting has not been extensively studied. We conducted a single-centre multiphase study to (1) understand the perceived barriers to split-dose administration among nursing and providers, (2) develop and implement a split-dose electronic order set and (3) evaluate the use and impact of split-dose administration on 100 consecutive colonoscopies.

Methods: Nurse/provider interviews were conducted to understand perceived concerns and potential barriers to split-dose preparation. Next, an order set containing specific nursing instructions was developed, disseminated and implemented into the electronic health record as the default order set for inpatient colonoscopies. Finally, 100 consecutive inpatients undergoing colonoscopy were interviewed to determine prep consumption, tolerability and rate of procedural delays due to inadequate preparation.

Results: Survey results indicated perceived concerns about inpatients' ability to tolerate and complete the preparation, insufficient nursing support and complexity of preparation administration. Based on this, prep orders were adjusted to accommodate nursing concerns prior to implementation. 54% of inpatients actually completed the bowel preparation in split doses (SPLIT group); the remainder had the conventional full dose preparation (NON-SPLIT). Less procedural delay and a lower rate of additional laxatives use (13% vs 30.4%) were seen in the SPLIT versus NON-SPLIT group. Split-dose preparation was well tolerated among inpatients.

Conclusions: Split-dose bowel preparation can be implemented for inpatients undergoing colonoscopy. This multiphase study demonstrates the steps used to implement split-dose preparation at our institution and may provide others with strategies that they could use at their institutions.

Summary box

What is already known about this subject?

- Optimal bowel preparation among hospitalised patients remains a challenge.
- Suboptimal bowel preparation results in higher chance of missed pathology and increased costs to the healthcare system.
- Outpatient split-dose bowel preparation has been associated with better quality bowel preparation.

What are the new findings?

- This feasibility trial demonstrated one strategy for implementing split dose bowel prep in an inpatient setting.
- Inpatients who completed the split dose prep underwent more timely colonoscopy (less procedural delays and less additional laxative use).
- The split dose regimen was better tolerated than a non split bowel preparation.
- Larger studies evaluating the efficacy, tolerance, and uptake of split dose bowel preparation in the inpatient setting are needed.

How might this impact on clinical practice?

- We introduce strategies to implement split-dose preparation for colonoscopy among inpatients.
- We highlight the importance of ancillary staff education and training in order to optimise uptake of new strategies and thus effectively disseminate efforts of implementation.

INTRODUCTION

Optimal bowel preparation for adequate visualisation at the time of colonoscopy among hospitalised patients remains a significant challenge. Inpatients tend to be older, less ambulatory and have more comorbidities than outpatients, which may adversely affect compliance with the bowel regimen and contribute to inadequate bowel cleansing as reflected by several studies that have identified inpatient status as an independent predictor for poor bowel cleansing.[1–3] The risk of failed bowel preparation for hospitalised patients is twofold higher than that of ambulatory outpatients.[4] The

implications of a poor prep include a higher chance of missed pathology, aborted or delayed procedures and the need for a repeat procedure; all of which contribute to patient inconvenience as well as increased costs to the healthcare system.[5–8]

Colon cleansing using a split-dose administration of 4 L polyethylene glycol (PEG) is associated with higher compliance rates, better quality bowel preparations and higher colonoscopy completion rates.[9–11] Despite evidence of improved outcomes with the use of a split-dose PEG solution, the majority of patients who are hospitalised receive the standard full dose (NON-SPLIT) 4 L PEG solution prior to inpatient colonoscopy.[1] The reasons for this discrepancy remain unclear. Recognising this gap between evidence and clinical practice, we performed this multiphase study to evaluate the feasibility of implementing a split-dose bowel prep regimen for inpatient colonoscopy at our institution.

METHODS

Study design

This was a single-centre, prospective observational study conducted at the Malcom Randall VA Medical Center.

Overview

In this multiphase study, the first phase involved surveying nursing staff and providers to identify perceived barriers to administration of a split-dose bowel preparation and their concerns about patient tolerability. In the next phase, with the help of a multidisciplinary team, an intervention to increase adoption of the split-dose bowel regimen was developed, disseminated and implemented. In the third phase of the study, 100 colonoscopies, performed subsequent to implementation of the intervention, were reviewed to determine use of the intervention, as well as patient compliance with the bowel preparation, procedural delays and colonoscopy completion rates. The phases of the study are detailed in figure 1.

Phase A

Study participants

Recruitment

A cross-sectional list of healthcare providers was obtained from the staff listing. All internal medicine (including hospitalists), critical care and general surgery staff were contacted to participate in a one-time electronic survey. A similar survey was also sent electronically to all medical ward nurses for completion. Survey completion was optional and anonymous.

Data collection and analysis

The 13-item survey included structured questions related to bowel preparation, feasibility of split-dose administration and perceptions of patient compliance and tolerability. Responses were on a 1–5 bipolar scale (with a neutral point in the middle and two ends of the scale at opposite positions). The electronic survey could be completed in 5–6 min. Additional free text was allowed for clarification of responses. Descriptive statistics, including frequencies and percentages, were reported.

Phase B

Split-dose bowel preparation order set development

To facilitate uptake and ease of ordering, an electronic 'quick order set' was developed. In a quick order set, series of orders can be grouped together with each order dialogue box having predefined, default values. Launching the order set allows for all of its components to be selected and prepared for electronic signature. This is the fastest way to enter orders and saves the ordering provider from having to enter each order manually.[12] The objective was to develop an order set that contained explicit guidance on timing and volume of laxative administration for the nursing staff. Feedback from the nursing surveys was used to modify the order set prior to incorporation into the electronic health record system and for dissemination. Post implementation, all orders for inpatient colonoscopy were placed using this split-dose quick order set.

Phase C

Study participants

To evaluate the feasibility of implementation of the split-dose bowel preparation, consecutive inpatients scheduled to undergo colonoscopy between October 2012 and April 2013 were approached for study participation until 100 patients were enrolled. Patient interviews were conducted to obtain information regarding bowel preparation consumption, nursing instruction and adverse effects, and colonoscopy outcomes were obtained from chart review.

Data collection

After completing informed consent, the study team collected basic demographic information including body mass index, comorbid medical conditions, age, gender and prior surgical history. On the morning of colonoscopy, patients were interviewed by one of the investigators (DY, RS, BR, JBW) about completion of the bowel preparation, nursing instructions, quantity and timing of preparation consumption using a standardised patient survey. Patients were asked to report any adverse events or inconveniences (including nausea, vomiting, abdominal bloating/pain, lack of instructions and/or sleep disturbances), identify any obstacles for completing the laxative regimen (including taste, volume, instructions and time of the bowel preparation administration) and, finally, their willingness to repeat the same bowel preparation for future colonoscopies. All colonoscopy procedures were performed by a staff gastroenterologist, or a gastroenterology fellow under the supervision of an attending gastroenterologist. The quality of the bowel preparation was assessed using a standard scale.[13] On the morning of the colonoscopy, patients were

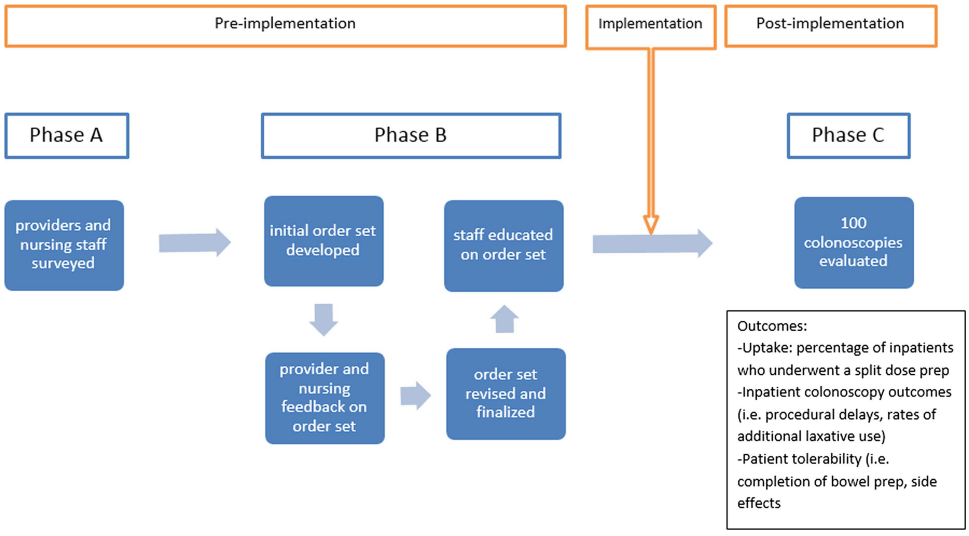

Figure 1 Flow diagram depicting the phases of the study.

interviewed to determine the quantity and timing of bowel laxative consumption and side effects using a standardised patient survey. Additionally, patients were asked to recall what specific instructions they received regarding bowel cleansing.

Study outcomes

'Completion of the bowel preparation' was defined as successful completion of at least three quarters (75%) of the PEG solution. This was evaluated by asking the patient, the nurse and/or the physician if the entire PEG solution (4 L) was consumed and, when applicable, by examining the amount of PEG remaining in the container. 'Colonoscopy completion' was defined as a completed colonoscopy conducted on the scheduled day. If clear liquid stool output void of sediment was not achieved by the time of the scheduled colonoscopy, then the colonoscopy was delayed while additional bowel purgatives were administered. In that situation the procedure was considered 'delayed secondary to suboptimal bowel preparation'. Actual completion of the bowel regimen as a split-dose regimen was measured based on patient and nurse interview on the morning of the procedure by one of the investigators (DY, RS, BR, JBW).

Statistical analyses

All data were entered into an electronic database. The statistical analysis was performed using Statistical Analysis System software (SAS Institute Inc, Cary, North Carolina, USA). A paired t test was used for continuous variables and to compare means between the groups. χ^2/Fisher's exact test was used for categorical variables and proportions in two by two contingency tables. A p value less than 0.05 was considered significant. In some instances, survey item responses were collapsed to ensure adequate numbers in each cell for comparison. When statistical

Table 1 Perceived implementation barriers

	Very/somewhat concerned	Neutral	Not very/not at all concerned
Patient will not want to awaken to finish second half of preparation			
Physician/PA	53.6% (30)	25.0% (14)	21.4% (12)
Nursing staff	64.9% (24)	24.3% (9)	10.8% (4)
Patients will have more difficulty following instructions			
Physician/PA	42.9% (24)	25.0% (14)	32.1% (18)
Nursing staff	37.8% (14)	32.4% (12)	29.7% (11)
Instructions too complicated for nurses			
Physician/PA	48.2% (27)	25.0% (14)	26.8% (15)
Nursing staff	13.5% (5)	21.6% (8)	64.9% (24)
Patients will not finish second dose in time			
Physician/PA	69.6% (39)	16.1% (9)	14.3% (8)
Nursing staff	86.5% (32)	8.1% (3)	5.4% (2)
Insufficient nursing support for second dose administration			
Physician/PA	62.5% (35)	25.0% (14)	12.5% (7)
Nursing staff	51.4% (19)	21.6% (8)	27.0% (10)

PA, physician assistant.

Table 2 Perceived patient tolerability and outcome barriers

	Very/somewhat concerned	Neutral	Not very/not at all concerned
More nausea			
Physician/PA	12.5% (7)	41.1% (23)	46.4% (26)
Nursing staff	32.4% (12)	24.3% (9)	43.2% (16)
More vomiting			
Physician/PA	10.7% (6)	41.1% (23)	48.2% (27)
Nursing staff	32.4% (12)	24.3% (9)	43.2% (16)
More abdominal pain			
Physician/PA	7.1% (4)	44.6% (25)	48.2% (27)
Nursing staff	40.5% (15)	16.2% (6)	43.2% (16)
Lower quality bowel prep			
Physician/PA	25.0% (14)	44.6% (25)	48.2% (27)
Nursing staff	51.4% (19)	16.2% (6)	43.2% (16)

PA, physician assistant.

testing was not performed between groups, percentages and frequencies were presented.

RESULTS

Phase A

A total of 65 physicians and 41 nurses completed the electronic survey. Based on survey responses, the most common bowel preparation for an inpatient colonoscopy was Go-Lytely (86.4%). The majority of nurses (80.5%) had never heard of a split-dose bowel regimen. Survey results indicated considerable nursing and provider concern over the feasibility of implementing an inpatient split-dose regimen. Concerns regarding patients' ability to complete the bowel preparation and follow instructions were also reported (with providers expressing slightly more concern than patients). Providers also expressed concern about complexity of nursing instructions (see tables 1 and 2).

Phase B

Taking into account information from the surveys, the study team developed a quick order set for split-dose bowel preparation. The timing of the first and second dose of the preparation was based on nursing concerns over adequate staff for bathroom or commode assistance and minimal overlap of preparation administration with nursing shift changes or medication administration times. The final order set included the following instructions: nursing order to administer first dose of the 4 L PEG solution at 1700 and the second dose at 2400 and nursing to instruct patients to drink 240 mL (8 ounce) increments every 15–20 min for a total of 2 L at each dose (based on nurse feedback). Charge nurses on the

Table 3 Baseline characteristics

	NON-SPLIT* (n=46)	SPLIT† (n=54)	Total (n=100)
Comorbidities, n(%)			
Coronary artery disease	17 (37)	24 (44.4)	41 (41)
Pulmonary disease	29 (63)	25 (46.3)	54 (54)
Hypertension	29 (63)	40 (74.1)	69 (69)
Neurological disease	14 (30.4)	21 (38.9)	35 (35)
Diabetes mellitus	13 (28.3)	20 (37)	33 (33)
Liver disease	3 (6.5)	1 (1.9)	4 (4)
Renal disease	5 (10.9)	9 (16.7)	14 (14)
History of abdominal surgeries	12 (26.1)	14 (25.9)	26 (26)
Chronic narcotic use	13 (28.3)	11 (20.4)	24 (24)
Indication			
Overt GI bleeding	21 (45.7)	22 (40.7)	43 (43)
Occult GI bleeding	4 (8.7)	5 (9.3)	9 (9)
Anaemia	5 (10.9)	7 (13.0)	12 (12)
Weight loss	6 (13.0)	6 (11.1)	12 (12)
History of colorectal polyps	1 (2.1)	6 (11.1)	7 (7)
GI symptoms‡	9 (19.6)	8 (14.8)	17 (17)

*Age 63.7±13.2, BMI 28.0±7.3.
†Age 63.2±14.2, BMI 29.5±7.2.
‡GI symptoms: abdominal pain, nausea, vomiting and or change in bowel habit patterns.
BMI, body mass index; GI, gastrointestinal.

wards, nurse managers and nurse educators were responsible for educating staff about the rationale for and proper usage of the new quick order set (prior to implementation). With IT and pharmacy support, the quick order set was incorporated into the computerised medical record system (CPRS) in October 2012 and became the default order set that was primarily used for all inpatient colonoscopies.

Phase C

One hundred and two consecutive inpatients undergoing colonoscopy were approached; only two patients declined to participate (citing disinterest in participation in research studies). Baseline characteristics are summarised in table 3. Despite use of the split-dose order set for all 100 inpatients, a little over a half (54%) of the inpatients consumed the bowel preparation as a split-dose (we refer to these patients as the SPLIT group), the remainder had the 4 L PEG laxative as the conventional non-split bowel regimen (these were referred to as the NON-SPLIT group). Since approximately half of the patients received the preparation as the conventional full dose administration, we chose to use the NON-SPLIT group of patients as an internal control group allowing for comparisons between groups. There were no significant differences between the two groups (SPLIT and NON-SPLIT). The majority of procedures were considered diagnostic colonoscopies. Overt gastrointestinal bleeding was the most frequent indication (43%), followed by gastrointestinal symptoms (17%), such as new onset abdominal pain and/or changes in bowel habits.

Completion of bowel preparation rates are depicted in figure 2. Approximately 97% of patients in the SPLIT group completed the bowel preparation (ie, consumed at least 75% of the PEG solution). Again using the NON-SPLIT group as a control group, we found that a lower percentage of patients in the SPLIT group (13%) required additional laxatives to aid in the cleansing process than the NON-SPLIT group (30.4%). Importantly, inpatient colonoscopy was more commonly delayed due to inadequate bowel preparation in the NON-SPLIT group (32.6%) compared to only 7% in the SPLIT group (p=0.002). Figure 3 depicts the need for additional laxatives and procedural delays in the two groups.

Since survey data indicated nursing concerns about patient tolerability (nausea, vomiting, abdominal pain), our postbowel preparation interviews included assessment of side effects. Overall, the most common patient symptom was nausea (26%) in each group. Abdominal bloating and pain were reported more frequently in the NON-SPLIT group (30% vs 9%). Only one patient in the SPLIT group reported inability to wake up and/or to stay awake as a factor impeding the completion of the split-dose bowel preparation. Among patients in the SPLIT group, 90.7% favoured split-dose administration as their preference for future bowel preparation prior to colonoscopy, suggesting it was well tolerated. To evaluate the process of implementation, patients were explicitly asked about the nursing instructions they received; interestingly, a large percentage in the NON-SPLIT group (38/46, 83%) indicated that they had not received instructions to split the dose.

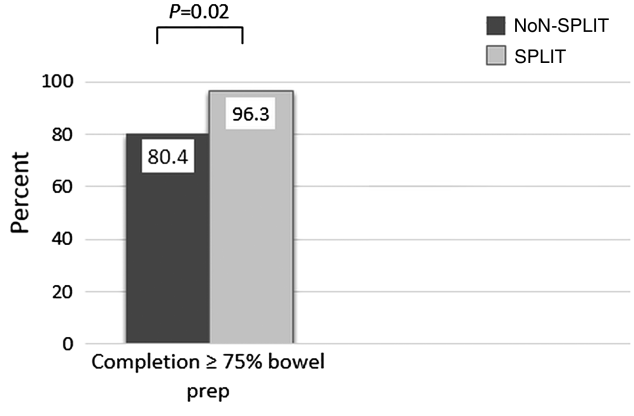

Figure 2 Rates of completion of bowel preparation was significantly higher in the SPLIT group (96.3%).

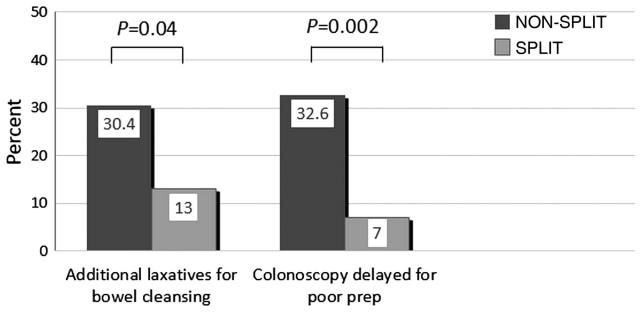

Figure 3 Suboptimal bowel preparation and colonoscopy delay. Lower rates of additional laxative use and less procedural delay among the SPLIT group.

DISCUSSION

Despite evidence demonstrating the superiority of split dosing for bowel cleansing, there has been reluctance in uniformly adopting this strategy for inpatient colonoscopy. Hospitalised patients represent a challenging population in which to achieve adequate bowel preparation, due to immobility, narcotic use and worse overall health. In this study, we demonstrate reasonable success with implementing split-dose administration of the 4 L bowel prep for hospitalised patients undergoing colonoscopy, which was the primary focus of our feasibility study.

Feasibility studies on implementation are focused on the extent, likelihood and manner in which an intervention can be fully implemented, often in an uncontrolled design,[14] taking into account the contexts, settings and cultures that might translate the intervention into practice. Keeping this in mind, we incorporated several steps in our multiphase study including: (1) evaluating

perceived barriers to implementation of a split dosing preparation; (2) adapting the intervention to maximise nursing uptake; (3) engaging stakeholders upfront to maximise buy-in; (4) working with a multidisciplinary team of nurse managers, nurse educators, pharmacy and IT support; and (5) measuring outcomes related to the intervention to demonstrate its success.

One of the key steps in implementing a split-dose bowel preparation for inpatients related to engaging and working with nursing staff, as they played a significant role in ensuring that the intervention would be successful. To maximise uptake, we adapted the intervention for the nurses in our clinical setting. We adjusted the administration of the split-dose regimen to a time more suitable for the nursing staff (first dose at 17:00 and second dose at midnight) in response to concerns of interference with nursing shift changes, charting and medication administration, insufficient staff and perceived concerns about patients' ability to complete the second dose prior to colonoscopy. Additionally, we relied on nurse educators to help disseminate information about the importance and value of split-dose preparations. Furthermore, we also used patient interviews to evaluate inpatients' ability to complete the split-dose preparation and assessed patient tolerability as this was a concern expressed by nurses and providers and a potential barrier to its implementation.

Despite these measures, 46% of inpatients did not receive the split-dose bowel preparation (as instructed in the quick order set). One of the contributing factors may have been the lack of information or education provided by the nurses: 94% in the SPLIT group reported receiving instruction about split dosing whereas only 17% in the NON-SPLIT group reported receiving instruction. This information, however, was based on patient reports and subject to recall bias as well as reporting bias. To overcome this limitation, we could have provided more repeated efforts at nursing education emphasising the value of the split-dose preparation. Additionally, providing nurse feedback with preliminary results from our colonoscopy interviews may also have helped increase uptake as our results showed decreased procedural delays and higher rates of preparation completion. Another explanation could be that nurses did not adopt the split-dose strategy because they questioned its clinical utility. This is consistent with diffusion of innovation theories, which describe a predictable process of adoption based on individuals' level of readiness to accept new ideas.[15]

Though our rate of uptake was modest, we demonstrated that among inpatients who did have the split bowel prep, there were fewer procedural delays, decreased use of additional laxatives to ensure complete clean-out as well as high-bowel preparation completion rates. The majority of inpatient colonoscopies in our cohort were performed for evaluation (and/or therapy) of GI bleeding or GI symptoms and timely colonoscopy was important for clinical decision-making and management in these patients. Adverse effects were similar across groups. Among the SPLIT group, patient adherence with the nocturnal dose was not an obstacle for bowel cleansing (only 1/56 patients could not wake up or remain awake to complete split-dose regimen). Moreover, the vast majority of inpatients expressed willingness to repeat the split-dose regimen for future colonoscopies. While our results appear to be in line with other reports indicating patient willingness to awaken during the night to complete a split-dose bowel preparation when educated about the benefits of split-dosing,[16–21] these studies primarily involved outpatients. Thus, future studies in the inpatient setting are needed to corroborate our preliminary findings, to establish the optimal time interval between the end of purgative administration and colonoscopy to achieve an adequate bowel preparation, and to further determine how changes in split-dosing scheduling may affect patient and provider receptivity.

There are several limitations of our study. This was an uncontrolled, single centre study with a small number of patients, which limited our ability to make comparisons between the SPLIT-group and NON-SPLIT group. Also, despite explicit nursing orders regarding timing of preparation administration, there was variability in the actual administration of the two doses as well as the variability in the exact timing of colonoscopy, which could have impacted our findings. A limitation with respect to our dissemination efforts included reliance on nurse educators and charge nurses to provide education to the nurses; this was neither standardised nor monitored, thus leading to variability in how the importance of split-dose was communicated and perhaps affecting uptake. However, this direct communication by nursing may also have been an important factor influencing uptake and early adoption among nursing staff that did demonstrate uptake. Furthermore, while a patient survey following bowel preparation was obtained to assess tolerability and acceptability of split-dosing, a postintervention survey was not obtained from the nursing staff and/or providers. This may have been a valuable tool to help identify any potential barriers for split-dose bowel preparation implementation. Another limitation is that this study utilised an intervention (quick order set) that was specific for the VA hospital's electronic health record, and may not be available nor generalisable in other settings. However, we hope that the strategy and multistep process that we employed (not the specific intervention) may be of value to other individuals or institutions that are planning to implement a split-dose regimen for their inpatient colonoscopies.

At our institution, this was the first attempt to implement a process for split-dose bowel preparation among hospitalised patients. While there have been studies evaluating the implementation of split dosing for outpatient colonoscopy, we found only one other study (presented in abstract form) that reported on outcomes associated with split-dose bowel preparation for inpatient

colonoscopy, however, no data on implementation was provided.[22]

In conclusion, there is a lack of data on the optimal bowel preparation for inpatients undergoing colonoscopy. Overall, this multiphase study demonstrated one strategy for implementing split-dose bowel preparation for inpatient colonoscopy with reasonable success and suggests that split-dose bowel preparation may be better tolerated among inpatients. Based on our results, we emphasise the importance of ancillary staff education and training in order to optimise uptake of new strategies and thus effectively disseminate efforts of implementation. Larger studies evaluating the efficacy and tolerance of split dose bowel preparation as well as strategies for implementing a split dose bowel prep among inpatients are needed.

Contributors DY and JBW performed the literature search. DY, RS, BR, SS and DC were involved in the design of the study and survey questionnaire. DY, RS, BR, JL and LM were involved in data and statistical analyses. DY, RS and BR wrote the first draft of the manuscript. SS provided critical appraisal of the manuscript. All authors were involved with the critical revision of the final manuscript.

Funding This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors. Dr. Sultan is supported by a VA Health Services Research and Development (HSR&D) Career Development Award. The findings and conclusions in this document are those of the authors and do not necessarily represent the views of the Department of Veterans Affairs.

Competing interests None.

Ethics approval Institution's Review Board at the University of Florida and the Research and Development Committee at the Malcom Randall VA Medical Center in Gainesville, Florida.

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement No additional data are available.

REFERENCES

1. Ness RM, Manam R, Hoen H, *et al*. Predictors of inadequate bowel preparation for colonoscopy. *Am J Gastroenterol* 2001;96:1797–802.
2. Chung YW, Han DS, Park KH, *et al*. Patient factors predictive of inadequate bowel preparation using polyethylene glycol: a prospective study in Korea. *J Clin Gastroenterol* 2009;43:448–52.
3. Lebwohl B, Wang TC, Neugut AI. Socioeconomic and other predictors of colonoscopy preparation quality. *Dig Dis Sci* 2010;55:2014–20.
4. Chorey N, Chadad B, Segal N, *et al*. Preparation for colonoscopy in hospitalized patients. *Dig Dis Sci* 2007;52:835–9.
5. Froehlich F, Wietlisbach V, Gonvers JJ, *et al*. 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.
6. Harewood GC, Sharma VK, de Garmo P. Impact of colonoscopy preparation quality on detection of suspected colonic neoplasia. *Gastrointest Endosc* 2003;58:76–9.
7. Rex DK, Imperiale TF, Latinovich DR, *et al*. Impact of bowel preparation on efficiency and cost of colonoscopy. *Am J Gastroenterol* 2002;97:1696–700.
8. Rex DK, Petrini JL, Baron TH, *et al*. Quality indicators of colonoscopy. *Am J Gastroenterol* 2006;101:873–85.
9. Enestvedt BK, Tofani C, Laine LA, *et al*. 4-liter split-dose polyethylene glycol is superior to other bowel preparations, based on systematic review and meta-analysis. *Clin Gastroenterol Hepatol* 2012;10:1225–31.
10. Kilgore TW, Abdinoor AA, Szary NM, *et al*. Bowel preparation with split-dose polyethylene glycol before colonoscopy: a meta-analysis of randomized controlled trials. *Gastrointest Endosc* 2011;73:1240–5.
11. Rex DK, Johnson DA, Anderson JC, *et al*. American College of Gastroenterology guidelines for colorectal cancer screening 2009 [corrected]. *Am J Gastroenterol* 2009;104:739–50.
12. Payne TH, Hoey PJ, Nichol P, *et al*. Preparation and use of preconstructed orders, order sets, and order menus in a computerized provider order entry system. *J Am Med Inform Assoc* 2003;10:322–9.
13. Lai EJ, Calderwood AH, Doros G, *et al*. The Boston Bowel Preparation Scale: a valid and reliable instrument for colonoscopy-oriented research. *Gastrointest Endosc* 2009;69:620–5.
14. Bowen DJ, Kreuter M, Spring B, *et al*. How we design feasibility studies. *Am J Prev Med* 2009;36:452–7.
15. Rogers EM. *Diffusion of innovations*. Free Press: New York, 1983.
16. Ell C, Fischbach W, Bronisch HJ, *et al*. Randomized trial of low-volume PEG solution versus standard PEG + electroytes for bowel cleansing before colonoscopy. *Am J Gastroenterol* 2008;103:883–93.
17. Unger RZ, Amstutz SP, Seo DH, *et al*. Willingness to undergo split-dose bowel preparation for colonoscopy and compliance with split-dose instructions. *Dig Dis Sci* 2010;55:2030–4.
18. Henry PO, Jenkins JT, Diament RH. The impact of poor bowel preparation on colonoscopy: a prospective single center study of 10,571 colonoscopies. *Colorectal Dis* 2007;9:745–8.
19. Park SS, Sinn DH, Kim YH, *et al*. Efficacy and tolerability of split-dose magnesium citrate: low-volume (2 Liters) polyethylene glycol vs. single- or split-dose polyethylene glycol bowel preparation for morning colonoscopy. *Am J Gastroenterol* 2010;105:1319–26.
20. Golub RW, Kerner BA, Wise WE, *et al*. Colonoscopic bowel preparations-which one? A blinded, prospective, randomized trial. *Dis Colon Rectum* 1995;38:594–9.
21. Marshall JB, Pineda JJ, Barthel JS, *et al*. Prospective, randomized trial comparing sodium phophate solution with polyethylene glycol-electrolyte lavage for colonoscopy preparation. *Gastrointest Endosc* 1993;39:631–4.
22. Lim R, Barkatullah S, Soudagar AS, *et al*. A randomized trial of standard vs. split-dose polyethylene glycol electrolyte (PEG-E) bowel preparation for inpatient colonoscopy. *Am J Gastroenterol* 2009;104(Suppl):S169.