Evaluation of an intervention to improve nutrition intakes among elective colorectal surgery patients: a mixed-methods pilot study

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Highlights

- An iKT intervention can improve oral intakes among postoperative colorectal patients
- Time to first oral prescription, delivery and intake improved
- Patients oral intakes for the first two days following surgery improved
- Prescription of free fluids (vs. clear fluids) as first diet type improved
- Patients reported positive experiences with the intervention but suggested improvements

Evaluation of an intervention to improve nutrition intakes among elective colorectal surgery patients: a mixed-methods pilot study

Running title: Effects of a nutrition intervention among colorectal patients

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ABSTRACT

Background: Timely and adequate nutrition after surgery is important. The aim of this study was to evaluate the effects of an intervention, developed using an integrated knowledge translation (iKT) approach, designed to improve oral intake among postoperative colorectal patients.

Methods: A pre/post, mixed-methods pilot study was undertaken at a tertiary teaching hospital in Australia. Patients who had undergone elective colorectal surgery and were admitted to the ward where ten nutrition-related strategies had been implemented were included. Quantitative data, including patient demographics, timing and type of nutrition consumed, and protein and energy intakes were collected pre/post intervention via chart audits, direct observations and verbal clarification. Qualitative data on patients' (n=18) responses to the intervention were collected through one-on-one, semi-structured interviews and analyzed using inductive content analysis.

Results: A total of 64 patients were observed (30 pre- and 34 post-intervention). Significant improvements were seen for the following outcomes (presented as median (IQR), pre- vs. post-intervention): time to first dietary intake (h) (15.7(7.4-22.5) vs. 4.9(3.7-14.2)); patient energy intakes (kJ) on day one (1719(947-2200) vs. 3530(2192-5169)) and day two (2506(1071-3749) vs. 4144(2987-5889)); and patient protein intakes (g) on day one (3.3(1.8-11.2) vs. 30.3(20-45)) and day two (10.8(3.5-29.9) vs. 39.6(30.7-59.0)). Prescription of free fluids as first diet type increased from 13% to 79% pre/post-intervention. There were no significant differences in time to first solid dietary intake (h) (86.1(60.1-104.0) vs. 69.2(46.1-115.5)) and overall proportion of patients who met both their estimated energy and protein requirements while in hospital pre/post-intervention (22% vs. 37%). Patients reported positive experiences with the intervention.

Conclusion: A multifaceted intervention developed using an iKT approach has the potential to improve oral intakes among patients who undergo colorectal surgery. A larger scale trial is required to confirm these findings and assess the impact of the intervention on clinical outcomes and costs.

Key words: Colorectal surgery; early oral feeding; knowledge translation; evidence-based practice; nutrition

Introduction

There is overwhelming evidence to support the reintroduction of liquid and solid foods within 24 hours after colorectal surgery in non-critically ill adult patients. This practice may result in benefits such as reduced morbidity and shorter lengths of stay (1, 2). Further, patients who receive nutrition promptly following surgery have greater potential to meet their energy and

protein needs, reducing their risk of protein-energy malnutrition (PEM) and its associated consequences (3-5). As such, evidence-based guidelines reinforce the timely prescription and delivery of nutrition among non-critically ill, postoperative colorectal patients (6-8).

Despite established guidelines, adopting research findings into clinical practice is often a slow and onerous process (9). Indeed, recent evidence indciates only a minority of colorectal patients recommence nutrition after surgery within timeframes outlined by evidence-based guidelines and meet their nutrition requirements in hospital (10-13). Further, when nutrition is commenced, clear liquid diets are commonly prescribed immediately following surgery, which are grossly inadequate nutritionally, and have little scientific purpose in the context of postoperative nutritional care (14). These practices appear to be influenced by a combination of professional, organizational and patient-related factors (11, 15), which are likely to differ between sites, staff and patients. This indicates a need for multifaceted interventions, designed to address specific factors to improve dietary practices and intakes among patients who have undergone colorectal surgery.

Our team co-developed a multifaceted intervention with knowledge end-users (clinicians at the study site), underpinned by the Knowledge to Action (K2A) framework (9), with the goal of improving postoperative nutrition care practices and intakes among colorectal patients. Seven patient-related and three staff-related strategies were co-designed to address the specific organizational, professional and patient-related factors impacting nutrition intakes at that site. The Medical Research Council's guidance on developing and evaluating complex interventions states that trials are often undermined by problems with acceptability, compliance, recruitment and smaller-than-expected effect sizes (16). It suggests thorough piloting is required to anticipate such issues prior to investing substantial resources into a larger trial, however, this is often neglected (16).

Therefore, this pilot study primarily aimed to assess timing to and type of nutrition used, and patients' energy and protein intakes after surgery, pre/post-intervention, to gain insight into the potential effects of the intervention. Secondary aims included assessing feeding-related outcomes (e.g. vomiting incidence, time to first flatus and bowel motion) pre/post intervention; and exploring patient perceptions of the intervention (i.e. acceptability). This study will provide important data to inform planning for a future trial.

Methods

Study overview and setting

This mixed-method pilot study was conducted in one gastrointestinal ward at a large (750 bed) tertiary teaching hospital located in Queensland, Australia, which performs approximately 200 elective small and large bowel resections each year. The pre- and post-intervention evaluations were undertaken prospectively between June and August 2017, and August and October 2018, respectively. An electronic foodservice system (EFS; Delegate Software, Australia) was in operation at the hospital, whereby nursing staff entered patients' dietary prescriptions into the system and patients ordered their main meals via a bedside patient entertainment system screen (≥3 hours in advance of meal delivery). Patients were delivered a generic meal for the diet they had been allocated if they did not place a meal order. Relevant hospital and university Human Research Ethics Committees (reference numbers: blinded for peer review) approved all study procedures.

Participants

Patients were eligible to participate if they were: (i) were able to provide written informed consent (aged ≥18 years, cognitively intact, and able to communicate in English); and (ii) undergoing an elective colorectal and/or small bowel surgical procedure. Patients who were (i) critically ill or (ii) admitted to the intensive care unit were excluded. Based on the number of bowel resections performed and budgetary constraints, a convenience sample of 30-50 patients was planned to be recruited for each of the pre- and post-intervention groups. In studies that assess intervention efficacy and involve comparison groups, evidence suggests ~30 to 40 participants is reasonable for pilot testing (17). Informed consent was obtained from patients in the surgical preadmission clinic (~1 week prior to their operation) or during the postoperative period. A sub-set of patients enrolled in the post-intervention cohort were invited to participate in interviews, for which they provided additional verbal consent.

Intervention

A multifaceted intervention was co-developed by researchers and knowledge users (clinicians) at the hospital over a 5-month period (February-June 2018). Intervention strategies were aimed at patient, organisational and professional levels. Briefly, patient-related strategies included the delivery of: 1) one Oral Nutrition Supplement (ONS) on Post-operative Day (POD) 0; 2) free fluids prescribed on POD0; 3) High Energy, High Protein (HEHP) diet prescribed on POD1; 4) ONS prescribed three times a day (TDS) from POD1 until discharge; 5) education on meal ordering on or after POD1; 6) nutrition-related

messages delivered by surgeons during ward rounds on POD1 and thereafter; and 7) a nutrition education handout given prior to surgery. Staff-related strategies included the delivery of: 1) nutrition awareness and education sessions to nursing staff and doctors; and 2) a ward orientation (on nutrition) to doctors. Further detail on the theories underpinning the intervention and its process evaluation have been reported previously (citation blinded for peer review). However, for context, a brief description of the intervention strategies and their delivery rates across the implementation period are outlined in Supplementary Material 1.

Data collection

Quantitative

All data was collected over two periods by the lead author; pre-intervention data were collected over 50 consecutive days between June and August 2017, while post-intervention data were collected over a 10-week period between August and October 2018. Direct observation and charts audits were the primary methods used to collect patients' demographic characteristics, medical/nutritional status and dietary data (e.g. timing and type of nutrition, energy and protein intakes, and feeding-related outcomes) for each time period (Supplementary Material 1). Verbal clarification with nurses/patients were used to clarify information if the aforementioned methods were infeasible (e.g. if oral intake occurred after 7pm). Patients' dietary intakes were recorded using visual plate waste observation, from the time they were admitted to the ward after surgery, to the time they reached the study endpoint. Patients reached the study endpoint when they were either discharged from hospital, reached a hospital length of stay of 14 days, or met an exclusion criterion. Nutritional adequacy of food consumed by patients was estimated by: a) recording each patient's dietary intake over each 24-hour period they were enrolled in the study (including main meals, mid meals, ONS and any personal dietary items); b) calculating their total energy and protein intakes for each 24-hour period; and c) comparing nutrition intakes to their individually estimated energy and protein requirements. Estimated energy requirements (EER) and estimated protein requirements (EPR) for each patient were calculated using Australian guidelines (18). One researcher (XX) independently collected all data over both time periods to eliminate inter-rater variability.

Qualitative

Semi-structured interviews, conducted by the lead author, were used to explore patient's responses to the intervention. These interviews were undertaken during the 10 weeks

allocated to collect patient data during the post-intervention evaluation period (Aug–Oct 2018). Interviews were digitally recorded and transcribed verbatim for analysis, with interviews ongoing until data saturation was reached (19).

Data analysis

Quantitative

Observational dietary intake data were analysed by the lead author, a qualified dietitian, using a nutritional analysis software package (Foodworks version 10, Xyris Software, Australia), which contained the energy (kilojoule, kJ) and protein (grams, g) composition of all dietary items provided by the hospital. Estimated total energy and protein consumed by each patient per day, over each complete 24-hour period were calculated. Patients' energy intakes were considered adequate if they met ≥75% of their estimated requirements, which has previously been shown to be sufficient for weight maintenance among hospitalised inpatients (20). The same value was used for protein intake. All quantitative data were entered into SPSS Statistics for Windows version 23.0 (IBM Corp. 2012, Armonk, N.Y., USA). Continuous data were tested for normality using the Shapiro-Wilk test. All continuous data are presented as mean ± standard deviation (SD), or median (interquartile range (IQR)) for non-normally distributed data, while categorical data are described as frequency (percent). Chi-squared tests, Mann Whitney U-tests and independent t-tests were used as appropriate to determine any differences between pre- and post-intervention outcomes. A value of $p \leq 0.05$ was considered a statistically significant difference.

Qualitative

Patient interview data were analysed using content analysis (21). This involved one author (XX) reviewing the transcribed interviews and identifying codes from the data, which were grouped into subcategories, then categories. Analytic rigor and trustworthiness of findings were upheld by a) maintaining memos throughout data analysis to document analytical decisions made, for dependability; and b) conducting regular discussions among the research team regarding emerging categories, for credibility of findings (22).

Results

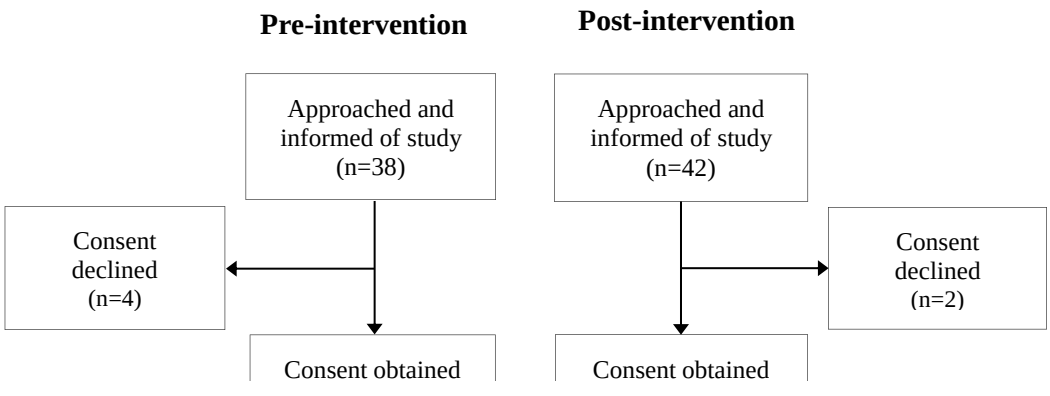

Figure 1. Patient flow diagram

[a]Operation postponed/cancelled (n=5) and ICU transfer (n=1).
[b]Parenteral nutrition commenced (n=2) and death (n=1).
[c]Withdrew from study (n=1), parenteral nutrition commenced (n=1) and break in data collection (n=2).
[d]All dietary intake data collected and analysed from completion of surgery to discharge.

In total, 64 patients (30 pre- and 34 post-intervention) completed the study (i.e. had outcome data collected), as shown in Figure 1. Study processes were deemed feasible, with a recruitment rate of 92.5% (i.e. 74 of 80 patients approached agreed to participate); outcome data collected on 86.5% of recruited patients; and dietary intake analysis conducted on 77.0% of recruited patients. Participant demographics are displayed in Table 1; both groups demonstrated similar demographic profiles with the exception of BMI, which was higher in the post-intervention group. In addition, nine patients in the post-intervention cohort were at deemed at 'nutritional risk' on the malnutrition screening tool (MST).

Timing and type of nutrition

A comparison of feeding parameters (Table 2) indicates that time to first diet prescription, delivery and intake were significantly improved (i.e. lower) post-intervention. Times to first solid diet prescription, delivery and intake were lower (i.e. improved) in the post-intervention group, however these differences were not statistically significant. The type of solid diet

initially prescribed was more varied in the post-intervention cohort, however, significantly more patients in the post-intervention cohort were prescribed a HEHP diet (n=1, 3% pre-intervention *vs.* n=25, 75% post-intervention; χ^2=32.6, p<0.001) and ONS (n=16, 53% pre-intervention *vs.* n=34, 100% post-intervention; χ^2=20.3, p<0.001) during their hospital stay.

Table 1. Demographic and surgical characteristics of patients (pre/post intervention)

	Pre-intervention (n=30)	**Post-intervention (n=34)**	***p* value**
Patient characteristics			
Age, years	61.9±16.9	60.6±13.3	.774
Sex (female)	14 (47%)	12 (35%)	.355
BMI, kg/m^2	25.2(21.9-28.6)	28.4(25.6-31.7)	.011*
Diagnosis			
Malignancy	15 (50%)	24 (71%)	.092
Procedure			.302
Right hemicolectomy	7 (23%)	9 (26%)	
High anterior resection	8 (27%)	10 (29%)	
Hartmann/ileostomy/	4 (13%)	3 (9%)	
Ultra-low resection	0 (0%)	4 (12%)	
Other	11 (33%)	8 (24%	
Surgical information			
Laparoscopic/robotic	20 (67%)	27 (79%)	.249
Anastomosis formed	23 (77%)	24 (71%)	.583
Surgery time, minutes	271±120	277±89	.821
Anaesthesia			
General	28 (93%)	31 (91%)	.748
Postoperative PCA	25 (83%)	28 (82%)	.917
MST score ≥2	-[a]	9 (27%)	-

BMI, body mass index; MST, Malnutrition screening tool; PCA, patient-controlled analgesia.

[a]Data unavailable due inconsistent reporting.

Energy and protein intakes

As seen in Table 3, more patients in the post-intervention group met both their EER and EPR for at least 1 day during their hospital stay; however, this difference was not statistically significant (n=6, 22% pre-intervention *vs*. n=11, 37% post-intervention; χ2= 1.4, P=0.234). Further, more patients in the post-intervention group met their EPR (n=9, 33% pre-intervention *vs*. n=15, 50% post-intervention; χ2=1.6, p=0.203), while more patients in the pre-intervention group met their EER (n=12, 44% pre-intervention *vs.* n=12, 40% post-intervention; χ2=0.12, p=0.734).

Table 2. Comparison of pre- and post-intervention feeding and nutrition parameters.

Outcomes	**Pre-intervention**	**Post-intervention**	***p* value**

	(n=30[c])	(n=34[c])	
Timing of nutrition (h)			
First diet prescription[a]	6.0 (3.0-19.6)	3.1 (2.1-3.9)	.001*
First diet delivery	13.8 (6.4-21.5)	4.7 (3.3-12.8)	.002*
First diet intake	15.7 (7.4-22.5)	4.9 (3.7-14.2)	.001*
First solid diet prescription	86.8 (62.5-112.3)[d]	67.1 (42.2-109.5)	.272
First solid diet delivery	86.1 (58.6-105.3)[d]	69.1 (47.2-115.5)	.523
First solid diet intake	86.1 (60.1-104)[d]	69.2 (46.1-115.5)	.523
Free fluids prescribed POD0[b]	4 (13%)	27 (79%)	<0.001*
Nutrition (any type) intake ≤6h	5 (17%)	20 (59%)	<0.001*
Nutrition (any type) intake ≤24h	24 (80%)	32 (94%)	0.088
Solid oral intake ≤24h	4 (13%)	1 (3%)	0.093
Solid diet first prescribed			
Full	23 (85%)[d]	7 (21%)[e]	-
HEHP	0	6 (18%)[e]	-
HPSO	0	9 (27%)[e]	-
Soft	2 (7.5%)[d]	11 (33%)[e]	-
Low fibre	2 (7.5%)[d]	0	-
Feeding related outcomes			
Had NGT inserted PO[f]	4 (15%)[d]	6 (18%)	.635
Vomiting incidence ≤24h PO	3 (10%)	6 (18%)	.483
Vomiting incidence overall	12 (44%)	15 (44%)	.739
Diet downgrade	5 (19%)[d]	13 (39%)[e]	.031*
Day of first flatus	2 (2-3)	1 (1-2)	.001*
Day of first bowel movement	3 (2-4)	3 (3-4.3)	.565
LOS (d)	7.5±2.7[d]	8.2±3.2	.762

D, day; h, hours; LOS, length of stay; PO, postoperatively.
[a]Taken as the time a diet was first entered into the hospitals food service system.
[b] In place of clear fluids or nil-by-mouth orders
[c]Except where else indicated; [d]n=27; [e]n=33.
[f]Inserted after initiating oral intake if patients were being quired for ileus or to alleviate patient discomfort.

Statistically significant increases in total energy and protein intakes, and consequently the proportion of EER and EPR met, were observed in the post-intervention group on study days 1 and 2 only (Table 3). In the post-intervention group, consumption of ONS was greatest during the first 2 days after surgery, where 64% (range: 0%-100% for energy and protein) and 49% (range: 0%-95% for energy and 0%-94% for protein) of total energy and protein consumed were derived from ONS on study days 1 and 2, respectively.

Table 3. Percentage of EER and EPR met

Outcome	Day	Pre-intervention	Post-intervention	*p* value
% of estimated energy requirements met	1	8.5 (3.3-16.1)	35.5 (23.6-51.3)	.000*
	2	16.8 (11.1-29.0)	42.8 (30.9-61.1)	.004*
	3	26.1 (11.6-45.6)	33.4 (20.0-53.1)	.910
	4	36.0 (18.0-63.5)	37.0 (15.7-46.3)	.128
	5	47.0 (28.7-66.2)	39.3 (18.9-52.1)	.025*
% of estimated protein	1	3.5 (1.3-9.1)	29.7 (22.7-46.3)	.000*

requirements met	2	8.9 (3.1-28.6)	43.0 (32.2-58.5)	.000*
	3	27.7 (3.9-51.9)	27.6 (22.4-43.0)	.932
	4	25.5 (6.1-48.2)	32.1 (15.1-48.7)	.445
	5	39.6 (25.4-56.7)	42.5 (20.5-55.1)	.062
Total energy (kJ) consumed	1	1719 (947-2200)	3530(2192-5169)	.000*
	2	2506 (1071-3749)	4144(2987-5889)	.000*
	3	3230 (1626-5714)	3295 (2166-4632)	.113
	4	4428 (2498-5958)	3870 (1569-4518)	.879
	5	4862 (3043-6647)	3753 (1770-5472)	.681
Total protein (g) consumed	1	3.3 (1.8-11.2)	30.3 (20-45)	.000*
	2	10.8 (3.5-29.9)	39.6 (30.7-59.0)	.000*
	3	24.1 (4.0-55.1)	27.7 (21.1-41.2)	.190
	4	24.8 (7.4-56.9)	32.5 (12.8-45)	.678
	5	43.6 (23.9-50.9)	38.3 (16.9-58.9)	.953
Energy consumed via ONS[a]	1	-	2289 (1526-3052)	-
	2	-	2689 (1007-3052)	-
	3	-	1526 (0-2910)	-
	4	-	1206 (191-2966)	-
	5	-	763 (0-3052)	-
Protein consumed via ONS[a]	1	-	22.2 (13.0-26.0)	-
	2	-	26.0 (9.8-32.7)	-
	3	-	17.1 (0-32.5)	-
	4	-	16.3 (2.2-29.9)	-
	5	-	10.7 (0-34.0)	-

EER, estimated energy requirements; EPR, estimated protein requirements; g, grams; kJ, kilojoules; ONS, oral nutrition supplement.
Note: all data presented as median (interquartile range [IQR]).
*Significantly different.
[a]Less than half the pre-intervention cohort were prescribed and consequently consumed ONS, thus, only data for the post-intervention cohort is presented.

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Feeding-related outcomes

A comparison of feeding-related outcomes

pre- and post-intervention are outlined in Table 2. Vomiting incidence was higher in the first 24 hours after surgery among the post-intervention cohort, but not between groups overall. NGT insertion remained unchanged from pre- to post-intervention, while diet downgrades were greater post-intervention (n=5, 19% pre-intervention *vs.* n=15, 39% post-intervention; χ^2=5.2, p=0.031). No significant differences were observed in time to first flatus or bowel motion, or in LOS between groups. Fewer patients were seen by a dietitian post-intervention (n=8, 27% pre-intervention *vs.* n=3, 9% post-intervention).

Patients' responses to the intervention

Eighteen patients (53% of the post-intervention cohort) participated in interviews. In general, participants responded positively to questions about their experiences of the intervention components (Table 4). An unintended consequence of the study was that the evaluator acted as a reminder for patients to eat/drink more. Patients described a range of personal and

hospital-related barriers to eating, including low appetite, nausea, bloating, repetitious meal options and unpalatable or unsuitable meal options (e.g. curries and other spicy dishes).

Table 4. Patients' responses to and experiences with intervention components 1

(1) Receiving nutrition-related messages improved attitudes and behaviours towards nutrition
Patients' attitudes and behaviours towards nutrition, particularly to ONS, were positively influenced during daily ward rounds, when doctors encouraged nutrition consumption and when nursing staff reiterated the benefits of ONS upon its delivery. "*The doctors did say those drinks were good for me.*" (P11, F, 64y).
(2) Desiring more specific nutrition advice around eating and drinking postoperatively
Many patients desired more specific, personalised advice around eating and drinking after surgery. Many patients thought receiving information after surgery would be beneficial, such as on foods to preference or avoid and diets/meals available at the hospital, facilitating patients' capacity to make informed nutrition decisions. "*What the patients want, I think, is more suggestions or guidance from the hospital… we are not nutrition experts, we don't know what to eat after surgery*." (P28, M, 36y).
(3) Varying views on the utility of the nutrition handout in the preoperative setting
While many patients appreciated the nutrition handout being available, not all participants welcomed this information in the preoperative setting, when priorities were focused elsewhere (e.g. anaesthetic information and the surgery itself). "*I don't think I took a great deal out of that one because I wasn't really concentrating on nutrition. I was more scared of reading about the anaesthetic side effects.*" (P06, F, 39y).
(4) Trusting the hospital to provide appropriate foods and uncertainty around selecting dietary options
Many patients assumed the hospital was selecting and delivering meals to help with their recovery. Some (who were aware of the menu selection option) believed it was in their best interest to allow the food service system to auto-select their meals, particularly while on the fluid diet, as they were uncertain of the 'right' foods to choose to optimise recovery/manage their symptoms. "*If I was ordering, I feel I would have ordered things that I should not have had*." (P05, M, 53y).
(5) Appreciating early fluids but varied readiness for solids
Overall, the majority of patients appreciated receiving free fluids on POD0. However, patients' responses regarding their readiness to eat solids were mixed; several patients were willing to try solid foods earlier than prescribed, while others preferred to hold off commencing solids. *"I was happy with the [fluid] diet [on POD0]… [While] the [solid] food was quite nice when it came [on POD2], I was not ready for it. My mind and my stomach were not talking."* (P17, M, 53y).
(6) Associating ONS with negative or positive experiences/outcomes

Most patients were accepting of ONS, irrespective of palatability, if they believed consuming the drinks would support their recovery. However, ONS consumption was hindered when patients associated it with adverse outcomes related to poor tolerance (e.g. bloating, vomiting, nausea) or negative past experiences with similar drinks (e.g. previous admissions, weight loss programs). "*I think it is just an acquired taste... [But] I think they were of benefit for me… especially if I wasn't eating properly, I think it just helped*." (P18, M, 54y).
(7) Acknowledging ONS flavour fatigue and taste preferences are barriers to continued consumption
ONS flavour fatigue was commonly acknowledged by patients, irrespective of palatability or their perceptions of benefits derived from consuming ONS. "*I didn't mind them, but because of the amount I was getting, I was sort of getting over it.*" (P05, M, 53y).

F, female; M, male; NGT, nasogastric tube; ONS, oral nutrition supplement; y, years of age.

Discussion

This study describes quantitative and qualitative findings following the implementation of a multifaceted intervention designed to improve nutrition practices and intakes among patients undergoing elective colorectal surgery. Significant improvements were noted in the access to nutrition in the immediate stages of recovery after surgery, and most patients reported positive experiences with intervention components. However, not all feeding parameters demonstrated improvements following the intervention. Study processes were deemed feasible, with recruitment over 90% and sufficient outcome and dietary intake data collected on 87% and 77% of recruited patients, respectively.

The tailored, complex intervention evaluated in this study resulted in patients meeting higher proportions of their EER and EPR for the first two days following surgery. This favourable outcome was likely the result of several intervention successes. Firstly, patients had improved access to nutrition in the immediate stages of recovery (via earlier diet prescription and delivery), which contributed to earlier nutrition intakes after surgery (15.7h pre-intervention vs. 4.9h post-intervention). The higher prescription of free fluids (in place of clear fluids or nil-by-mouth orders) provided patients with a wider selection of nutrient-dense fluids from POD0 onwards, which, along with increased prescription and encouragement of ONS, resulted in a suite of changes that increased energy and protein intakes by 2-3-fold in the initial 48 hours following surgery. Previous work has reported similar outcomes when ONS are routinely used after surgery (23). Automating the prescription of ONS (and HEHP diets) for postoperative patients who rarely meet their nutritional requirements while in hospital

could streamline nutrition care and staff workflow, considering improvements in nutrition delivery and intake in the current study occurred despite fewer dietetic reviews post-intervention, thus freeing up dietitians to spend their time with patients who need more individualised care.

The intervention failed to alter dietary intakes beyond the initial 48 hours following surgery, with over half of patients eating inadequately to meet their estimated energy and protein requirements for the duration of their hospital stay. The short-term nature of this result is likely a consequence of two concurrent factors. Firstly, most patients reduced their ONS consumption (often due to reduced palatability over time) by POD3. This was critical, as the provision of ONS in the initial phase provided the primary source of nutrition (49% and 64% of total energy and protein consumed, respectively). Secondly, patients' intakes in the pre-intervention cohort increased by POD3, reducing the likelihood of seeing an intervention effect during our pilot study. The potential for ONS to acutely increase energy and protein intakes immediately after surgery (POD0-POD3) has been previously demonstrated (23), as has reduced consumption of ONS due to repeated exposure (24). Hence, it appears that while ONS is effective for increasing nutritional intakes immediately after surgery, other strategies are required to sustain these improvements beyond 48 hours. These strategies are important to consider, as poor oral intake remains a problem for the majority of patients for many days following colorectal surgery. Nevertheless, given the importance of protein intake on convalescence (25), the significantly higher nutritional intakes during the first 48hrs after surgery from pre- to post-intervention are clinically meaningful and would likely result in implications for patients and hospitals (8).

Overall, patient responses to the intervention were positive, but they also provided feedback and suggestions that may be useful in intervention refinement for a larger trial. For example, while patients appreciated receiving nutrition-related messages from doctors during ward rounds, many desired more specific, personalised feedback around eating and drinking after surgery. This is in agreement with previous research suggesting that patients value nutrition information that is tailored to them specifically and aligns with a patient-centred care approach (26, 27). Patients in this study and in previous research (28) have indicated that the provision of nutrition education materials preoperatively is challenging, as patients are preoccupied with processing other information (e.g. relating to their upcoming surgery). A more acceptable approach could be to briefly discuss nutrition expectations with patients

prior to surgery, then provide specific resources (e.g. outlining foods to preference or avoid and diet types/foods available within the hospital) after surgery, when this information is pertinent. Patients reported trusting the hospital to provide appropriate meals, and were wary of self-selecting foods, which is in agreement with previous work (27), demonstrating that some patients rely on HCPs to make informed decisions for them. However, shared decision making has important implications and in the context of postoperative nutrition care, could be achieved through surgeons prescribing an unrestricted diet from POD1 and guiding patients to the best option given their needs.

An unintended consequence of earlier nutrition intakes observed in the post-intervention cohort was a higher incidence of vomiting during the first 24 hours after surgery (18% post- vs. 10% pre-intervention). EOF has been previously associated with a higher incidence of vomiting (29). Strategies to prevent this may involve reducing food volume (e.g. by prioritising nutrient-dense foods/fluids) and slowing eating (e.g. by encouraging small mouthfuls) among patients in the first 24 hours after surgery, while ensuring timely administration of antiemetics and use of multimodal opioid-sparing analgesia. Other unexpected outcomes included fewer patients being prescribed solids on POD1, greater use of soft diets and more frequent diet downgrades among the post-intervention group, despite patients experiencing first flatus significantly earlier. It appeared doctors were delaying upgrading patients to solids due outdated beliefs and may have been using a soft diet as an additional step as they believed they were progressing diets faster than before, and therefore required a 'testing' phase (reference citied for peer review). However, these approaches are not evidence-based and restrict the types of foods patients can order from the hospital foodservice. The reasoning behind the higher proportion of diet downgrades is less clear but may relate to the higher incidence of vomiting seen during the first 24 hours after surgery, which was not statistically significant, but could be considered clinically meaningful. These findings reiterate the importance of educating all staff on the unit regarding the evidence-based practice changes implemented in this study, and the need for monitoring of adherence to intervention strategies in the early stages of implementation, to troubleshoot problems and reassure staff.

This investigation has a number of limitations. Firstly, static equations were used to estimate energy and protein requirements, resulting in values that may not reflect an individual's actual requirements. However, estimating nutrition requirements were done in accordance

with the study hospital's (and the state of Queensland's) standard practice. Secondly, due to the pre/post study design, the changes observed in patients' nutrition intakes cannot be assumed to be a direct result of the intervention. However, process data (outlined in Supplementary Material 2 and described in detail elsewhere [(citation blinded for peer review)]) indicates successful implementation of several strategies, which the improved nutrition intakes may at least in part be attributed to. Further, patient responses suggested that the presence of researchers involved in data collection may have influenced patients' intakes by acting as a reminder for them to eat and/or drink. While this was an unintended consequence of the study, it highlights the potential for staff employing a proactive approach to nutrition to possibly moderate patients' eating/drinking behaviours. Lastly, due to the amount of data collected, this study was labour and resource intensive. Therefore, future research should prioritise collecting data on the most clinically meaningful measures for this type of intervention, being time to first diet intake, time to first solid diet intake and adequacy of nutrition intake for the first five days after surgery.

Conclusion

This pilot study has indicated that a multifaceted intervention targeting patient and staff factors relating to nutrition is likely to be effective in improving nutrition care practices and patients' nutritional intakes in the immediate period following elective colorectal surgery. Importantly, this study has also shown that the methods used to recruit patients and evaluate the intervention were feasible, justifying the next step to a larger trial. Patient responses, secondary outcome data (e.g. vomiting incidence) and lack of an interventional effect after 48 hours post-surgery indicate some areas in which the intervention could be improved. With minor refinements, a larger scale trial of the intervention is warranted to evaluate its effects on patient and hospital outcomes.

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Authorship

All authors contributed to study design and conception; MR contributed to data collection; MR contributed to data analysis; and all authors contributed to data interpretation and drafting, reviewing and approving the final version of the manuscript.

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Declaration of interests

☒ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☐The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:
