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Risk factors for non-clinical prolonged lengths of stay after elective colorectal surgery

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Identification of reasons and causative factors for prolonged lengths of stay (LOS) after elective colorectal surgery in patients with uneventful postoperative recovery. A prospectively maintained database of colorectal cancer (CRC) patients between 2019 and 2021 was reviewed. Peri-operative parameters were evaluated to identify risk factors for prolonged LOS. Uneventful postoperative recovery was defined as Clavien-Dindo (CD) Complication Grade 0. 181 patients had uneventful postoperative recovery. 30 (16.7%) patients had delayed discharge, the underlying reasons were ongoing physiotherapy assessment for discharge (*N* = 11), caregiver training for stoma/drain (*N* = 6), family/patient confidence and or pending community placement for continuation of postoperative rehabilitation (*N* = 14). Factors such as pre-operative status of activity of daily living (ADL) and community ambulance, stoma creation, and high dependency (HD) ward admission were independently associated with delayed discharge. Multiple factors accounted for delayed discharge in in patients after elective surgery for CRC. Pre-operative identification and intervention to some of these factors might pave the way to reduce the overall length of hospitalization.

Keywords Colorectal surgery, Risk factors, Prolonged hospitalization

Background

Colorectal cancer (CRC) is one of the commonest cancers worldwide and surgery remains the mainstay of treatment in non-metastatic colorectal cancer[1]. Over the past decade, adopting a laparoscopic approach has superseded the traditional open approach as the standard of care in colorectal resection due to more favourable peri- and post-operative complication rates, as well as lower length of stay (LOS)[2 3 4]. Enhanced recovery after surgery (ERAS) has also been widely adopted, which are pre-, peri- and post-operative care protocols that use a multimodal evidence-based framework for better post-operative care outcomes[5 6 7]. Together, these have improved various surgical outcomes following elective laparoscopic colectomies[8].

Most CRC patients undergoing elective laparoscopic colectomy also do not develop severe post-operative complications, with only about 10–12% classified as Clavien-Dindo (CD) grade 3 and above[9 10]. However, literature has suggested the possibility of mismatch between clinical fitness for discharge and actual date of discharge[11 12 13 14]. Maessen and colleagues, for example, found that 87% of ERAS patients in their study were not discharged on the day that clinical discharge criteria were met[15].

Within the local context, Singapore has been experiencing a "bed crunch" due to the combination of a rapidly ageing population, rising rates of patients with complex conditions preventing discharge, and increasing incidence of cancer cases[16 17]. This echoes the situation found in other developed healthcare systems including the UK and Australia[18 19]. Since 2019, the Singapore Ministry of Health has also been promoting Value Driven Care/Outcomes (VDC/VDO) in all tertiary public hospitals[20]. The objective of VDC is to pursue the most cost-effective treatment modalities and pathways while still maintaining a high quality of care delivery[21 22], and one of the largest contributing factors to high healthcare costs within the VDC framework has undoubtedly been hospitalisation.

Moreover, prolonged LOS has a negative impact not just on healthcare costs and workflow, but also on patients themselves due to concomitant issues such as hospital-associated nosocomial risks and deconditioning[23 24]. The objective of this study was therefore to identify causative medical and sociodemographic factors leading to

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prolonged LOS despite no post-operative morbidity, in a retrospective cohort of CRC patients who underwent elective laparoscopic surgery.

Method

A prospectively maintained cohort database was reviewed. We included all colorectal cancer patients who underwent elective laparoscopic colorectal resection between 2019 and 2021 in a single Asian tertiary colorectal centre (i.e., National University Hospital, Singapore).

Data extracted was categorized into demographic, pre-, peri- and post-operative data. Demographical data extracted were age, gender, and ethnicity. The collected pre-operative data included body weight, body mass index (BMI), pre-existing co-morbidities, American Society of Anesthesiologists[25] (ASA) physical status grade, as well as pre-surgical biochemical results (i.e., haemoglobin levels (g/dL), total white blood cell count ($x10^9$/L), urea levels (mmol/L), sodium levels (mmol/L), potassium levels (mmol/L), albumin levels (g/dL), creatinine levels (mmol/L) and haematocrit levels (%). The collected peri-operative data included, estimated blood loss (EBL) (ml), duration of surgery (minutes), type of procedure (i.e. colon or rectum), stoma creation and intra-operative opioid use. We also collected post-operative data, including patient-controlled analgesia (PCA) use, post-operative opioid use, surgical high dependency (SHD) ward admissions, length of stay (LOS), community ambulance status as well as status of activities of daily living (ADL).

We defined uneventful postoperative recovery as patients with CD complication grade 0. Those with CD grade 1 or above complications were categorised as post-operative clinical complication group. Delayed discharge was defined as a total LOS of more than 5 days, derived from a review of the median and mean LOS amongst the seven public hospitals in Singapore, which is aligned with the VDC guidance from the Ministry of Health for colectomies[26–27]. Frequencies, proportions, and bivariate analyses were used to draw comparisons between CD-0 patients with delayed discharge versus patients with no delayed discharge. LOS was defined as the total length of stay including day of operation. Chi-square test and independent samples t-test was utilized for categorical and continuous parameters respectively. Forward logistic regression was also performed to identify contributors of delayed discharge amongst patients with uneventful postoperative recovery.

Patient-reported outcome measures (PROM) were not captured as the information was not routinely included in our national electronic medical records as part of usual clinical care.

Results

Patients' demographics

A total of 386 patients were identified in the prospective database. A total of 181 patients had uneventful postoperative recovery and formed the study group 151 (83.4%) patients had no delayed discharge and the remaining 30 (16.7%) had delayed discharge despite uneventful postoperative recovery. Table 1 highlights the comparisons in demographic characteristics between patients with no delay discharge and delayed discharged.

The reasons for delayed discharge in the uneventful postoperative recovery cohort ($N=30$) was classified into five categories, namely: prolonged inpatient physiotherapy/occupational therapy for fitness for safe discharge ($N=11$), patient and or family members lack of confidence for home despite suitable for discharge ($N=7$), awaiting step-down care ($N=6$), extra sessions for caregiver training for drain/stoma care ($N=6$) and ongoing social worker review for community placement planning ($N=1$) (Fig. 1).

Pre-Operative parameters

Table 2 highlights the difference in the peri-operative outcomes between patients with no delay discharge and delayed discharged. Compared to patients with no delayed discharge, patients with delayed discharge group had significantly higher urea levels (4.72 [4.39–5.04, 95% CI] Vs 5.83 (5.16–6.51, 95% CI), $p=0.005$) and lower albumin levels (38.6 (37.70-39.49, 95% CI) Vs 35.48 (33.50-37.46, 95% CI), $p=0.02$) pre-operatively. However, albumin was omitted from subsequent analyses because only a total of 100 (55.2%) patients had their pre-operative albumin levels reported.

		No Delayed Discharged ($N=151$)	Delayed Discharge ($N=30$)	p-value
Age	Mean, 95% CI	63.83 (61.94–65.71)	68.01 (64.54–71.60)	0.064
Gender, N (%)	Male	78 (51.66)	20 (66.67)	
	Female	73 (48.34)	10 (33.33)	0.132
Race, N (%)	Chinese	112 (74.17)	25 (83.33)	
	Others	39 (25.83)	5 (16.67)	0.356
BMI, Kg/M^2	Mean, 95% CI	24.50 (23.74–25.26)	25.05 (22.92–27.17)	0.578
Comorbidities, N (%)	No	42 (27.81)	5 (16.67)	
	Yes	109 (72.19)	25 (83.33)	0.258
ASA, N (%)	I	5 (3.31)	2 (6.67)	
	II	111 (73.51)	16 (53.33)	
	III	35 (23.18)	12 (25.53)	0.062

Table 1. Baseline characteristics of uneventful postoperative recovery patients with delayed and no delayed discharges.

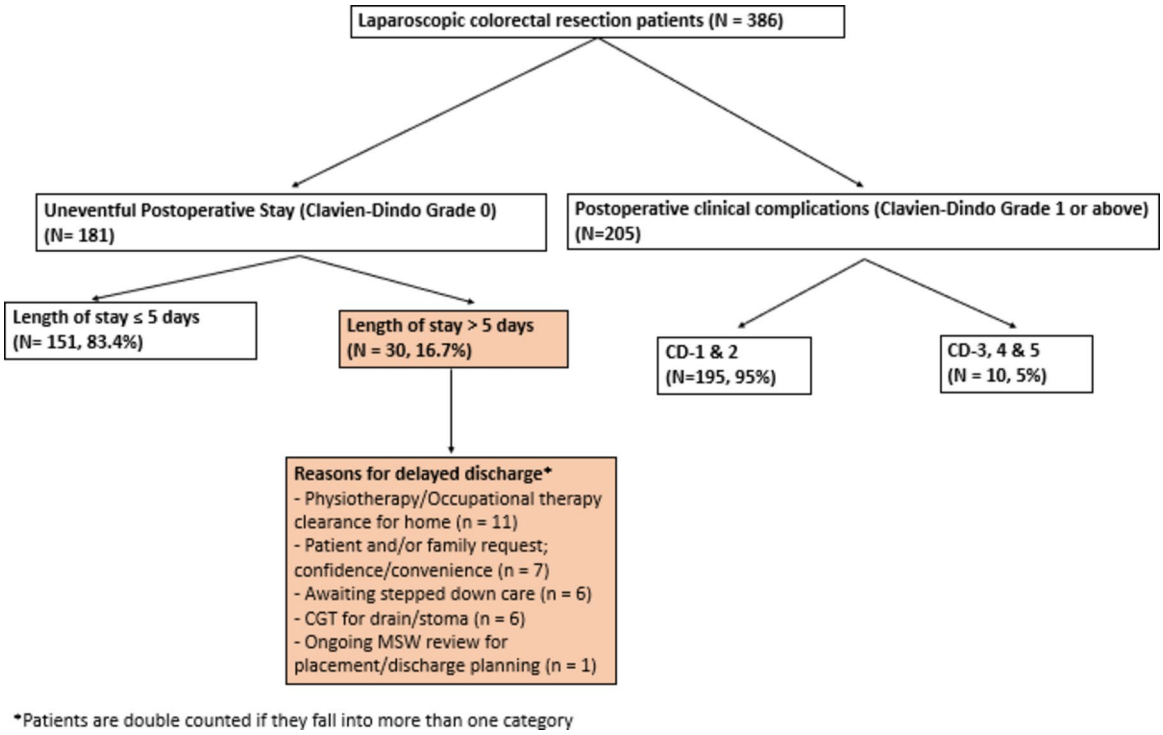

Fig. 1. Elective Laparoscopic Colorectal resection outcomes and LOS in patients with uneventful postoperative recovery.

		No Delayed Discharged ($N=151$)	Delayed Discharge ($N=30$)	p-value
Haemoglobin levels, g/dL	Mean, 95% CI	12.86 (12.27–13.46)	11.77 (11.07–12.46)	0.114
Total white blood cell count, x109/L	Mean, 95% CI	7.06 (6.69–7.43)	7.03 (6.04–8.02)	0.951
Urea levels, mmol/L	Mean, 95% CI	4.72 (4.39–5.04)	5.83 (5.16–6.51)	0.005
Sodium levels, mmol/L	Mean, 95% CI	139.43 (139.00-139.86)	139.03 (138.26–139.80)	0.438
Potassium levels, mmol/L	Mean, 95% CI	4.06 (3.97–4.15)	4.06 (3.93–4.20)	0.977
Albumin levels, g/dL	Mean, 95% CI	38.60 (37.70-39.49)	35.48 (33.50-37.46)	0.002
Creatinine levels, mmol/L	Mean, 95% CI	82.67 (66.64–98.70)	91.77 (69.80-113.73)	0.628
Haematocrit levels, %	Mean, 95% CI	37.96 (37.07–38.86)	37.13 (34.33–39.94)	0.483

Table 2. Comparison of pre-operative parameters of uneventful postoperative recovery patients with no delayed and delayed discharges.

Intra- and Post-Operative parameters

Table 3 compared the intra- and post-operative parameters between the two groups. Patients with delayed discharge reasons had significantly higher average EBL (80 (66.92–93.81, 95% CI) Vs 146 (75.34-217.66, 95% CI), $p=0.003$) and longer surgery duration (228 (214.03-241.95, 95% CI) Vs 298 (214.03-241.95,, 95% CI), $p<0.001$). There were also statistically significant associations between these two groups with stoma creation ($X^2(1, 181)=9.37$, $p=0.002$) SHD admission ($X^2(1, 181)=31.10$, $p<0.001$), ADL status ($X^2(1, 173)=5.43$, $p=0.02$) and community ambulance ($X^2(1, 166)=10.75$, $p=0.001$).

To understand the factors that contributed to prolonged hospitalisation despite uneventful postoperative recovery, a forward logistic regression analysis was conducted, regressing delayed discharge (Y/N) on relevant patients' demographics, pre-operative parameters, intra- and post-operative parameters (Table 4 and Supplementary Table 1). The model was statistically significant ($F(10, 157)=39.49$, $p<0.001$, adjusted $R^2=0.268$).

The logistic regression suggests that delayed discharge in patients with uneventful postoperative recovery was significantly associated with SHD admission (OR = 5.162, SE = 3.050, 95% confidence interval (CI)= [1.621, 16.433], $z=2.78$, $p=0.005$).

Discussion

The objective of the current study was to evaluate factors for prolonged hospitalization after elective laparoscopic colorectal resection in patients with uneventful postoperative stay. The factors we identified can be broadly

		No Delayed Discharged (*N* = 151)	Delayed Discharge (*N* = 30)	*p*-value
Estimated Blood Loss, ml	Mean, 95% CI	80.36 (66.92–93.81)	146.50 (75.34-217.66)	0.003
Duration of Surgery, Min	Mean, 95% CI	228.00 (214.03-241.95)	298.03 (257.97–338.10)	< 0.001
Type of Procedure, N (%)	Colon	60 (39.74)	10 (33.33)	
	Rectum	91 (60.26)	20 (66.67)	0.511
Stoma Creation, N (%)	No	142 (94.04)	23 (76.67)	
	Yes	9 (5.96)	7 (23.33)	0.002
Intra IV Opioid, N (%)	No	6 (4.14)	0 (0.00)	
	Yes	139 (95.86)	29 (100.00)	0.591
PCA, N (%)	No	80 (52.98)	14 (46.67)	
	Yes	71 (47.02)	16 (53.33)	0.554
SHD Admission, N (%)	No	127 (84.11)	11 (36.67)	
	Yes	24 (15.89)	19 (63.33)	< 0.001
ADL, N (%)	No	10 (6.94)	6 (20.69)	
	Yes	134 (93.06)	23 (79.31)	0.020
Community Ambulant, N (%)	No	12 (8.76)	9 (31.03)	
	Yes	125 (91.24)	20 (68.97)	0.001

Table 3. Comparison of intra- and post-operative parameters among uneventful postoperative recovery patients with no delayed discharged and delayed discharge.

Variable	OR	Std. Err	z	*P*>|z|	*95% CI OR*	
					Lower	Upper
Demographics						
Sex	0.57	0.323	− 0.99	0.322	0.188	1.733
Age	0.995	0.026	− 0.18	0.854	0.945	1.048
BMI	0.926	0.049	− 1.46	0.145	0.826	1.027
Pre-operative parameters						
Urea levels	1.199	0.125	1.74	0.082	0.977	1.472
Intra-operative parameters						
Estimated Blood Loss	1.001	0.002	0.37	0.709	0.996	1.006
Duration of surgery	1.006	0.003	1.94	0.052	1	1.013
Stoma Creation (Y/N)	0.914	0.721	-0.11	0.909	1.621	4.289
Post-operative parameters						
SHD admission (Y/N)	5.162	3.05	2.78	0.005	1.621	16.433
ADL Independent (Y/N)	,622	0.695	-0.43	0.671	0.0696	5.557
Community ambulant (Y/N)	0.212	0.209	-1.57	0.115	0.0309	1.461

Table 4. Delayed discharge (Y/N) regressed on relevant patients' characteristics and parameters

classified into complexity of the surgery, stoma-related care, insufficient social support, frailty, and doctor/patient choice[28]. Recent meta-analysis of RCTs by Sauro and colleagues found that implementation of ERAS guidelines has been consistently effective at reducing LOS and post-operative complication rate[29]. Similarly, some of these factors have also been shown in existing literature to contribute to the delayed discharges from hospital despite the implementation of ERAS programmes in colorectal surgery[30]. Promisingly, this group of patients can potentially be identified pre-operatively to allow for early education, prehabilitation and placement allocation, and in so doing decrease post-operative LOS[31], which can reduce the economical healthcare burden incurred by preventable prolonged hospitalisation.

In our previous work, we found that admission to SHD was independently associated with prolonged LOS[32]. In fact, admission to SHD did not result in earlier detection or treatment of surgical complications but may have instead resulted in delay in initiation of physiotherapy and diet, leading on to delays in mobility and discharge. Thus, we proposed a review of the necessity of SHD admission following elective colorectal surgery[33]. With lessons gleaned from the COVID pandemic, continuous monitoring is now possible from wearable electronic devices and wireless technology, which may mean that these "higher-risk" patients may be safely transferred to the general ward after surgery, which may reduce their LOS[34].

The need for post-operative rehabilitation and patients with a poor social set-up also required longer hospital stays despite being medically fit to be discharged earlier. This is likely also pertinent to other patients going for abdominal surgery in an ageing population. Some of these patients underwent therapy in the tertiary hospital

setting, while others required application to a stepdown facility (e.g., community hospital) for a longer-term rehabilitation programme. The delay in the initiation and eventual transit to the various rehabilitation facility added considerable time to LOS despite the absence of any post-operative morbidity. It may be intuitive to assume that the family members could have taken a bigger role in the post-operative care of these patients. If the patient is an elderly, the spouse is likely to be of similar age and hence may not be fit or able to assist the patient. In addition, with birth rates hitting record lows across many countries worldwide, these patients may be single and have no one to take care of them after surgery. In addition, even if they do have children, it is not uncommon that they would be working adults and also have children of their own to take care of. Hence, transiting to a step-down facility or hiring a domestic helper are common solutions. The process of hiring a domestic helper and to train them to be competent in caring for the patients will also take considerable time. Many of these issues are often not obvious until after the patients have undergone the surgeries.

In our institution patient are clinically assessed for frailty by our dedicated ERAS nurse during pre-operative outpatient encounter. While frailty is increasingly emphasized as an important factor associated with surgical outcomes amongst colorectal cancer patients, routine prehabilitation amongst these frail patients has not been shown to confer any additional benefit[35]. This can be due to poor adherence rate, and time constraints faced to sufficiently provide the required anabolic stimulus to counteract surgery-related morbidity[36]. Moreover, most patients are not keen to delay any definitive treatment to their cancers which they believe would be more detrimental than to get "stronger" for the surgery. Future studies evaluating the role of prehabilitation ought to first establish a consensus on both the diagnostic criteria for frailty and the prehabilitation protocol[37]. Based on the current study results, we propose a multidisciplinary and tailored approach with geriatricians, medical social workers, physiotherapist, and occupational therapist to identify and assess a select group of patients pre-operatively based on age, frailty index, presence of a dedicated caregiver and functional status. This allows for assessment of their suitability for early rehabilitation, caregiver training and stepdown facility application[38].

Lastly, stoma formation is a known cause for delayed discharge following colorectal surgery[39]. This was evident in the current study despite the absence of stoma-related complications in the uneventful postoperative recovery patient cohort. In our institutional patient undergoing elective stoma creation as part of colorectal resection will undergo mechanical and oral antibiotics bowel preparation (MOABP) and undergo pre-operative outpatient education on stoma indication, function and post-operative stoma care with our dedicated stoma nurse[40]. In the immediate post-operative phase, our stoma nurse will review our patients and reinforce any shortfalls in patient or caregiver stoma care abilities. This suggests that post-operative stoma education and caregiver training is often time consuming[41] and prolongs hospital stay unnecessarily in patients that are otherwise medically fit to be discharged. Such delays can be even more apparent in patients with surgeries performed later in the week due to the absence of ostomy education over the weekend. This was also demonstrated by Rashidi and colleagues in which Friday ostomy surgeries had the longest LOS duration[42]. There is increasing evidence to support the conduct of stoma education in the pre-operative setting[43], and it should be incorporated into existing ERAS pathways in colorectal surgery.

Limitations

There are several limitations in our study. It is a retrospective study with risk of confounding bias as delayed discharge is likely to be multi-factorial. Important contributors to LOS such as sociodemographic and psychosocial factors were unable to be acquired due to the limitations of the retrospective design of this study. Potential future studies to consider a prospective cohort approach which would allow for stratified analyses based on patient grouping using social economic status and level of baseline social support.

Our results are also based on our local and regional practice, as well as prevailing institutional polices. Pre-existing patient expectations, cost and access to care could vary across institutions and countries, thus our findings may not be fully representative of other healthcare systems. Future retrospective and prospective studies should seek to use larger, multicentre cohorts to validate the findings that we have identified.

Another limitation is that patient-reported outcome measures (PROM) were not administered as part of standard care in this cohort – given that our findings highlight the possible contribution of social factors to delayed discharge, it would have been helpful to understand whether LOS could be associated with poorer quality of life scores (which could in turn allow for allied healthcare professionals to "predict" patients with poorer post-operative social support).

Conclusions

This study has shown that non-clinical reasons remain a significant contributor to delayed discharge in a proportion of our cohort of patients with no postoperative complications. The main factors include stoma-related care, insufficient social support, frailty, and doctor/patient choice. Pre-operative identification of patients at risk of delayed discharge and implementing patient-specific optimization in the pre-operative setting should be looked at future studies to reduce unnecessary prolonged LOS in patients with no postoperative complications. From a broader perspective, our study also highlights the increasingly pertinent need to incorporate non-clinical patient characteristics in assessing patients' post-operative outcomes – a lesson that could be applied beyond colorectal surgery.

Ultimately, we feel that institutions aligned with VDC should work to reduce LOS as this is beneficial to all parties involved (patients and caregivers, healthcare professionals, and institutional administrators). Such initiatives can work as complementary concurrent alternatives to other programmes such as the hospital-at-home concept, which allows patients to receive the same standard of care as a general ward from the comfort of their own home. In an ideal future, it would not be far-fetched to imagine a risk-stratified post-operative framework in which the lowest risk patients with no complications can be discharged early, while patients with

minor complications can receive ward care at home, leaving precious hospital beds to those in need of intensive monitoring and urgent intervention.

Data availability

The data that support the findings of this study are not openly available due to reasons of patient data privacy, and are available from the corresponding author (Ker Kan Tan) upon reasonable request.

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References

1. Dekker, E., Tanis, P. J., Vleugels, J. L. A., Kasi, P. M. & Wallace, M. B. Colorectal cancer. Lancet. 394(10207):1467–1480. (2019). https://doi.org/10.1016/S0140-6736(19)32319-0. PMID: 31631858.
2. Feroci, F. et al. Laparoscopic surgery improves postoperative outcomes in high-risk patients with colorectal cancer. *Surg. Endosc.* **27** (4), 1130–1137. https://doi.org/10.1007/s00464-012-2559-y (2013). Epub 2012 Oct 6. PMID: 23052534.
3. Keller, D. S., de Paula, T. R., Qiu, J. & Kiran, R. P. The trends in adoption, outcomes, and costs of laparoscopic surgery for colorectal Cancer in the elderly population. *J. Gastrointest. Surg.* **25** (3), 766–774. https://doi.org/10.1007/s11605-020-04517-6 (2021). Epub 2020 May 18. PMID: 32424686.
4. Biondi, A. et al. Laparoscopic-assisted versus open surgery for colorectal cancer: short- and long-term outcomes comparison. *J. Laparoendosc Adv. Surg. Tech. A.* **23** (1), 1–7. https://doi.org/10.1089/lap.2012.0276 (2013). Epub 2012 Sep 24. PMID: 23004676; PMCID: PMC3698686.
5. Seow-En, I. et al. Results of a colorectal enhanced recovery after surgery (ERAS) programme and a qualitative analysis of healthcare workers' perspectives. *Asian J. Surg.* **44** (1), 307–312 (2021). Epub 2020 Aug 27. PMID: 32863145.
6. Hong, J., de Roulet, A., Foglia, C., Saldinger, P. & Chao, S. Y. Outcomes of a colorectal enhanced recovery after surgery protocol modified for a diverse and urban community. *J. Surg. Res.* **286**, 74–84. https://doi.org/10.1016/j.jss.2022.12.044 (2023).
7. Ban, K. A., Berian, J. R. & Ko, C. Y. Does implementation of enhanced recovery after surgery (ERAS) protocols in colorectal surgery improve patient outcomes?? *Clin. Colon Rectal Surg.* **32** (2), 109–113. https://doi.org/10.1055/s-0038-1676475 (2019).
8. Spinelli, A. et al. Reduced duration of stay after elective colorectal surgery during the peak phase of COVID-19 pandemic: A positive effect of infection risk awareness? *Surgery* **170** (2), 558–562 (2021). Epub 2020 Dec 23. PMID: 33714617; PMCID: PMC7757347.
9. Wang, Y., Liu, Y., Han, G., Yi, B. & Zhu, S. The severity of postoperative complications after robotic versus laparoscopic surgery for rectal cancer: A systematic review, meta-analysis and meta-regression. *PLoS One.* **15** (10), e0239909. https://doi.org/10.1371/journal.pone.0239909 (2020). PMID: 33002066; PMCID: PMC7529204.
10. Division of Colorectal Surgery in Singapore: National University Hospital. April (2024). Available at: https://www.nuh.com.sg/ourservices/Specialties/Surgery/Pages/Colorectal-Surgery.aspx (Accessed: 07.
11. Fiore, J. F. Jr, Faragher, I. G., Bialocerkowski, A., Browning, L. & Denehy, L. Time to readiness for discharge is a valid and reliable measure of short-term recovery after colorectal surgery. World J Surg. 37(12):2927-34. (2013). https://doi.org/10.1007/s00268-013-2208-1. PMID: 24101012.
12. Gustafsson, U. O. et al. Guidelines for perioperative care in elective colonic surgery: enhanced recovery after surgery (ERAS(R)) society recommendations. *Clin. Nutr.* **31** (6), 783–800 (2012).
13. Tweed, T. T. T. et al. Reducing hospital stay for colorectal surgery in ERAS setting by means of perioperative patient education of expected day of discharge. *Int. J. Colorectal Dis.* **36** (7), 1535–1542. https://doi.org/10.1007/s00384-021-03948-0 (2021). Epub 2021 May 11. PMID: 33977333; PMCID: PMC8195902.
14. Kenneth Lim. Singapore's Public Hospital Bed Crunch: Are Radical Solutions needed? CNA. Available at: https://www.channelnewsasia.com/cna-insider/singapore-public-hospital-bed-crunch-waiting-time-radical-solutions-3943586 (Accessed: 07 April 2024).
15. Maessen, J. M., Dejong, C. H., Kessels, A. G., von Meyenfeldt, M. F. & Enhanced Recovery After Surgery (ERAS) Group. Length of stay: an inappropriate readout of the success of enhanced recovery programs. *World J. Surg.* **32** (6), 971–975. https://doi.org/10.1007/s00268-007-9404-9 (2008).
16. News highlights, Ministry of Health. April (2024). Available at: https://www.moh.gov.sg/news-highlights/details/update-on-efforts-to-alleviate-shortage-of-hospital-beds-and-nursing-staff-in-public-hospitals (Accessed: 07.
17. Khalik, S. Bed crunch at singapore hospitals: Some patients are stuck in emergency departments, The Straits Times. (2022). Available at: https://www.straitstimes.com/singapore/bed-crunch-at-singapore-hospitals-some-patients-are-stuck-in-emergency-departments (Accessed: 07 April 2024).
18. England rushes to discharge hospital patients to ease bed-blocking crisis | reuters. Available at: https://www.reuters.com/world/uk/england-rushes-discharge-hospital-patients-ease-bed-blocking-crisis-2023-01-09/ (Accessed: 07 April 2024).
19. Australians in hospital emergency departments waiting days for Ward Beds as health system overwhelmed. The Guardian. (2022a). Available at: https://www.theguardian.com/australia-news/2022/jun/01/australians-in-hospital-emergency-departments-waiting-days-for-ward-beds-as-health-system-overwhelmed#:~:text=Australians%20face%20ballooning%20waits%20from,beds%20to%20admit%20new%20patients (Accessed: 07 April 2024).
20. Angelina, E. et al. Transforming value driven care structure in Singapore General Hospital [Poster]. 2022 ICHOM. Boston, USA. https://conference.ichom.org/wp-content/uploads/2022/11/2096.pdf
21. Value-based Healthcare Journey. National University Health System. Available at: https://www.nuhs.edu.sg/About-NUHS/nuhs-value-based-healthcare/Pages/Value-Based-Healthcare-Journey.aspx (Accessed: 07 April 2024).
22. Better patient experience and outcomes as value-driven care expands across SingHealth. Singapore General Hospital. April (2024). Available at: https://www.sgh.com.sg/news/tomorrows-medicine/better-patient-experience-and-outcomes-as-value-driven-care-expands-across-singhealth (Accessed: 07.
23. Jia, H. et al. Impact of Healthcare-Associated infections on length of stay: A study in 68 hospitals in China. *Biomed. Res. Int.* 2019;2019:2590563. Published 2019 Apr 18. https://doi.org/10.1155/2019/2590563
24. Smith, T. O., Sreekanta, A., Walkeden, S., Penhale, B. & Hanson, S. Interventions for reducing hospital-associated deconditioning: A systematic review and meta-analysis. *Arch. Gerontol. Geriatr.* **90**, 104176. https://doi.org/10.1016/j.archger.2020.104176 (2020 Sep-Oct). Epub 2020 Jul 6. PMID: 32652367.
25. Mayhew, D., Mendonca, V. & Murthy, B. V. S. A review of ASA physical status - historical perspectives and modern developments. *Anaesthesia* **74** (3), 373–379. https://doi.org/10.1111/anae.14569 (2019). Epub 2019 Jan 15. PMID: 30648259.
26. Lim, E. K. Value-Driven Care – The role of Allied Healthcare Professionals. Singapore Allied Health Conference 8-9th March 2021. Singapore (2021).
27. Tan, I. E. H. et al. Cost avoidance achieved through Value-Driven care practices. *Singap. Healthc. Manage.* (2024). 13–15 August 2024. Singapore.
28. Celio, D. A. et al. ERAS, length of stay and private insurance: a retrospective study. *Int. J. Colorectal Dis.* **34** (11), 1865–1870. https://doi.org/10.1007/s00384-019-03391-2 (2019). Epub 2019 Oct 8. PMID: 31595311.

29. Sauro, K. M. et al. Enhanced recovery after surgery guidelines and hospital length of stay, readmission, complications, and mortality: A Meta-Analysis of randomized clinical trials. *JAMA Netw. Open.* **7** (6), e2417310. https://doi.org/10.1001/jamanetworkopen.2024.17310 (2024).
30. Slieker, J. C., Clerc, D., Hahnloser, D., Demartines, N. & Hübner, M. Prospective evaluation of discharge trends after colorectal surgery within an enhanced recovery after surgery pathway. *Dig. Surg.* **34** (4), 298–304 (2017). Epub 2016 Dec 10. PMID: 27941346.
31. Faiz, O. et al. Hospital stay amongst patients undergoing major elective colorectal surgery: predicting prolonged stay and readmissions in NHS hospitals. Colorectal Dis. 13(7):816 – 22. doi: 10.1111/j.1463-1318.2010.02277.x. Epub 2010 Apr 5. PMID: 20402737. (2011).
32. Tan, J. K. H. et al. Surgical high dependency admissions after elective laparoscopic colorectal resections: is it truly necessary?? *J. Intensive Care Med.* **39** (2), 153–158 (2024). Epub 2023 Aug 15. PMID: 37583284.
33. Tan, J. K. H. et al. Surgical high dependency admissions after elective laparoscopic colorectal resections: is it truly necessary?? *J. Intensive Care Med.* **39** (2), 153–158. https://doi.org/10.1177/08850666231194258 (2024).
34. Leenen, J. P. L., Ardesch, V. & Patijn, G. Remote home monitoring of continuous vital sign measurements by wearables in patients discharged after colorectal surgery: observational feasibility study. *JMIR Perioper Med.* **6**, e45113. https://doi.org/10.2196/45113 (2023). PMID: 37145849; PMCID: PMC10199380.
35. Gloor, S. et al. Prehabilitation in patients undergoing colorectal surgery fails to confer reduction in overall morbidity: results of a single-center, blinded, randomized controlled trial. *Langenbecks Arch. Surg.* **407** (3), 897–907. https://doi.org/10.1007/s00423-022-02449-0 (2022). Epub 2022 Jan 27. PMID: 35084526.
36. Bousquet-Dion, G. et al. Evaluation ofsupervised multimodal prehabilitation programme in cancer patients undergoing colorectal resection: a randomized control trial. *Acta Oncol.* **57**(6), 849–859. https://doi.org/10.1080/0284186X.2017.1423180 (2018).
37. Maeda, H., Takahashi, M., Seo, S. & Hanazaki, K. Frailty and colorectal surgery: review and concept of Cancer frailty. *J. Clin. Med.* **12** (15), 5041. https://doi.org/10.3390/jcm12155041 (2023). PMID: 37568445; PMCID: PMC10419357.
38. Ljungqvist, O., Scott, M. & Fearon, K. C. Enhanced Recovery After Surgery: A Review. JAMA Surg. 152(3):292–298. (2017). https://doi.org/10.1001/jamasurg.2016.4952. PMID: 28097305.
39. Reddy, K. M. et al. Postoperative stay following colorectal surgery: a study of factors associated with prolonged hospital stay. *Ann. R Coll. Surg. Engl.* **85** (2), 111–114. https://doi.org/10.1308/003588403321219894 (2003). PMID: 12648342; PMCID: PMC1963727.
40. Chan, D. K. H., Ang, J. J., Tan, J. K. H. & Chia, D. K. A. Age is an independent risk factor for increased morbidity in elective colorectal cancer surgery despite an ERAS protocol. *Langenbeck's Archives Surg.* **405** (5), 673–689. https://doi.org/10.1007/s00423-020-01930-y (2020).
41. Younis, J. et al. Focused preoperative patient stoma education, prior to ileostomy formation after anterior resection, contributes to a reduction in delayed discharge within the enhanced recovery programme. *Int. J. Colorectal Dis.* **27** (1), 43–47. https://doi.org/10.1007/s00384-011-1252-2 (2012). Epub 2011 Jun 10. PMID: 21660418.
42. Rashidi, L., Long, K., Hawkins, M., Menon, R. & Bellevue, O. Stoma creation: does onset of ostomy care education delay hospital length of stay? *Am. J. Surg.* **211** (5), 954–957. https://doi.org/10.1016/j.amjsurg.2016.01.019 (2016). Epub 2016 Mar 10. PMID: 27046795.
43. Chaudhri, S., Brown, L., Hassan, I. & Horgan, A. F. Preoperative intensive, community-based vs. traditional stoma education: a randomized, controlled trial. Dis Colon Rectum. 48(3):504-9. (2005). https://doi.org/10.1007/s10350-004-0897-0. PMID: 15768181.

Author contributions

XG wrote the first draft of the manuscript. XG, JKHT, and KKT conceived of the methods. All authors assisted with analysis of the data. XG, JKHT and DKHC assisted with editing drafts of the manuscript. KKT provided overall supervision for the project.

Declarations

Competing interests

The authors declare that they have no conflicts of interests.

Research involving human participants and informed consent

This article does not contain any studies with human participants performed by any of the authors. The present research was approved by the National Healthcare Group's Domain Specific Review Board (NHG DSRB Ref: 2022/00564) in accordance with the principles of the Declaration of Helsinki. The need for informed consent was waived by the ethics board as the study only consisted of retrospective analysis of deidentified data that did not require patient interaction.

Additional information

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