

# Evaluation of the effectiveness of an enhanced recovery after surgery program using data from the National Surgical Quality Improvement Program

Louise M. Gresham, BSc, MD  
 Manahil Sadiq, BSc  
 Gillian Gresham, MSc, PhD  
 Maureen McGrath, RN, BScN  
 Kiley Lacelle, MN, BScN  
 Michael Szeto, MD  
 John Trickett, RN, BScN  
 David Schramm, MD  
 Emily Pearsall, MSc  
 Marg McKenzie, RN CCRP  
 Robin McLeod, MD  
 Rebecca C. Auer, MD, MSc

Presented at the 2016 Canadian Surgery Forum, Sept. 8–10, 2016, Toronto, Ont.

Accepted Sept. 17, 2018

## Correspondence to:

R. Auer  
 Ottawa Hospital Research Institute  
 1053 Carling Ave  
 Ottawa ON K1Y 4E9  
 rauer@ohri.ca

DOI: 10.1503/cjs.003518

**Background:** Barriers exist in implementing enhanced recovery after surgery (iERAS), which aims to decrease postoperative complication rates and length of stay, because perioperative care is varied and compliance from a multidisciplinary team is critical to success. The objectives of this project were to evaluate the effectiveness of the National Surgical Quality Improvement Program (NSQIP) database as a tool for the ongoing assessment of outcomes associated with ERAS and to evaluate ERAS as a quality-improvement strategy at a hospital-wide level.

**Methods:** Adult patients who underwent an elective colorectal procedure at The Ottawa Hospital between March 2010 and September 2015 were included. Information on demographic characteristics, functional status, medical background, procedure details and hospital length of stay (LOS) was abstracted from the NSQIP database. We compared data on outcomes (LOS, postoperative complications, unplanned return visits to the emergency department and 30-day mortality) before and after iERAS.

**Results:** We analyzed data for 609 patients (318 [52.2%] colon resection, 291 [47.8%] rectal resection; 190 [31.2%] before iERAS, 419 [68.8%] after iERAS). Significantly more patients were discharged within 5 days of surgery after iERAS than before (43.5% v. 29.1%,  $p < 0.05$ ), and LOS more than 10 days was also reduced (23.7% v. 24.9%,  $p < 0.001$ ). Implementation of ERAS was associated with an absolute reduction of 12% in postoperative complications and a significant reduction in surgical site infections among patients who underwent open procedures ( $p = 0.04$ ).

**Conclusion:** The introduction of an ERAS program for monitoring standardized perioperative care facilitates a data-driven approach to guide implementation of practice guidelines and establish the sustainability of ERAS protocols and data collection processes.

**Contexte :** Il y a des obstacles au déploiement du programme de rétablissement postopératoire rapide ERAS (enhanced recovery after surgery), qui vise à réduire les taux de complications postopératoires et à abréger les séjours hospitaliers, parce que les soins périopératoires sont très diversifiés et que l'observance des équipes multidisciplinaires est cruciale à sa réussite. Les objectifs de ce projet étaient d'évaluer l'efficacité de la base de données NSQIP (National Surgical Quality Improvement Program) comme outil de contrôle continu des résultats du programme ERAS et pour évaluer ce dernier à titre de stratégie d'amélioration de la qualité des soins dans les hôpitaux.

**Méthodes :** Les patients adultes qui ont subi une intervention colorectale non urgente à l'Hôpital d'Ottawa entre mars 2010 et septembre 2015 ont été inclus. Les données démographiques, le statut fonctionnel, les antécédents médicaux, les détails de l'intervention et la durée du séjour hospitalier (DSH) ont été extraits de la base de données NSQIP. Nous avons comparé la DSH, les complications postopératoires, les retours non planifiés aux urgences et la mortalité à 30 j avant et après le déploiement du programme ERAS.

**Résultats :** Nous avons analysé les données sur 609 patients (318 [52,2 %] résection du côlon, 291 [47,8 %] résection rectale; 190 [31,2 %] avant le déploiement du programme ERAS, 419 [68,8 %] après). Un nombre significativement plus élevé de patients ont reçu leur congé dans les 5 jours suivant leur chirurgie après le déploiement du programme ERAS qu'avant (43,5 % c. 29,1 %,  $p < 0,05$ ) et le nombre de DSH supérieurs à 10 jours a aussi diminué (23,7 % c. 24,9 %,  $p < 0,001$ ). Le déploiement du programme ERAS a été associé à une réduction absolue de 12 % des complications postopératoires et à une réduction significative des infections du site opératoire chez les patients soumis à une chirurgie ouverte ( $p = 0,04$ ).

**Conclusion :** L'instauration d'un programme ERAS pour la surveillance des soins périopératoires standardisés facilite une approche axée sur les données pour orienter l'application des lignes directrices de pratique et assurer la viabilité des protocoles ERAS et des processus de collecte de données.

Enhanced recovery after surgery (ERAS) refers to goal-directed, multimodal perioperative interventions that, when implemented together, aim to decrease perioperative stress, improve pain management, alleviate gastrointestinal dysfunction and minimize postoperative complications.<sup>1-7</sup> Enhanced recovery after surgery programs have also been shown to reduce the surgical patient's length of stay (LOS).<sup>8-11</sup> The benefits of ERAS are well-documented and supported in research settings, and an increasing number of academic and community hospitals across Canada are transitioning to standardizing perioperative care according to ERAS guidelines. However, the process of implementing ERAS programs represents a current weakness in reproducing the outcomes described in the literature. Several barriers are encountered in implementing ERAS programs given that perioperative care is varied and that compliance from a multidisciplinary team is critical to the success of the program.<sup>12</sup> The ongoing assessment of performance and outcomes is therefore critical to the success of ERAS uptake. However, measuring improved outcomes outside the context of a clinical trial is challenging. This emphasizes the value of access to reliable data to guide efforts in the implementation and uptake of ERAS guidelines.

The Council of Academic Hospitals of Ontario funded an ERAS implementation program (iERAS) that was put into practice at 15 academic hospitals in Ontario. The implementation was based on an ERAS guideline developed by the Best Practice in General Surgery Group at the University of Toronto. As part of this initiative, the group develops clinical practice guidelines, which can be accessed by stakeholders and surgeons via a free online platform of knowledge translation for successful implementation of ERAS parameters.<sup>7</sup> The Best Practice in General Surgery Group provides an "off-the-shelf" model to facilitate quality improvement.<sup>13</sup> In other words, the group's ERAS guidelines were created so that they are easily and immediately accessible online and do not require special modifications to be successfully implemented within individual hospitals. The American College of Surgeons (ACS) National Surgical Quality Improvement Program (NSQIP) is another widely recognized quality-improvement program. It is a leading, nationally validated, risk-adjusted database containing information on surgical outcome measures that can be collected for all surgical cases.<sup>14</sup> The NSQIP collects surgical data on 135 clinical variables, including preoperative risk factors, intraoperative variables, and 30-day postoperative mortality and morbidity outcomes for patients undergoing major surgical procedures.<sup>15</sup> Participating sites can track surgical complications through the ACS NSQIP database to evaluate the quality of their surgical programs and use collected data to measurably improve surgical outcomes.<sup>16-18</sup> The ACS NSQIP database is therefore a useful tool for data collection, monitoring and analysis for quality improvement of surgical outcomes.

The NSQIP is currently implemented in 61 hospitals across Canada, with 28 of these in Ontario.

Given the increasing uptake of iERAS in hospitals across Ontario, we questioned whether the ACS NSQIP database offers potential as an accessible, reliable and comprehensive tool to monitor and evaluate various outcomes in the setting of iERAS. The primary objective of the present study was to compare postoperative outcomes including LOS and complications for patients undergoing elective colorectal procedures before and after iERAS using surgical outcome data collected in the ACS NSQIP. Secondary objectives included showing the feasibility of the use of the ACS NSQIP and identifying challenges and opportunities associated with iERAS.

## METHODS

### *Study design*

This study was an observational quality-improvement project conducted at The Ottawa Hospital (TOH). The hospital has been participating in the ACS NSQIP since 2010, with 100% of data on colorectal cases collected since March 2014. A total of 934 patients are included in the data set through September 2015. Preoperative through 30-day postoperative data are collected and entered online on the Web-based ACS NSQIP platform on an ongoing basis.

### *Setting*

The design of the present study capitalized on the participation of TOH Department of General Surgery with both ERAS guidelines and the ACS NSQIP database. The ACS NSQIP database was introduced to TOH campuses in March 2010. As part of the iERAS initiative funded by the Council of Academic Hospitals of Ontario, TOH implemented a hospital-wide ERAS program beginning in September 2013 for all patients undergoing colorectal surgery. The interventions outlined in the council's ERAS clinical pathway for colorectal surgery include preoperative information and counselling, reduced fasting duration, mechanical bowel preparation, prevention of surgical site infection, thromboprophylaxis, intraoperative fluid management, avoidance of prophylactic abdominal drains, avoidance of prophylactic nasogastric tubes, early mobilization, postoperative fluid management, early enteral feeding, use of chewing gum to reduce postoperative ileus and multimodal pain control (e.g., thoracic epidural anesthesia, lidocaine infusion, nonsteroidal anti-inflammatory drugs, acetaminophen and gabapentin). These guidelines are summarized in detail in Supplementary Table S1, Appendix 1 (available at [canjsurg.ca/003518-a1](http://canjsurg.ca/003518-a1)). Data for this study reflect the period of introduction of the ACS NSQIP database, in March 2010, and a 2-year period after iERAS, collected with the ACS NSQIP database from September 2013 to September 2015.

### Patient selection

Given that all the patients were treated according to the standard of care at TOH as well as the minimal risk to patient confidentiality, this study was considered a quality-improvement project under the Ottawa Health Science Network Research Ethics Board, which approved the study protocol to be conducted with waived consent. All adult (age  $\geq 18$  yr) patients who underwent an elective colorectal procedure (e.g., left or right hemicolectomy, total colectomy, sigmoid colon resection, segmental colon resection) between March 2010 and September 2015 were included. Patients who had an emergency admission and surgery were excluded, given that they were unable to benefit from the preoperative teaching and preparation components central to the ERAS program. Patients who underwent pelvic exenteration were also excluded, on the basis that this surgery involves extensive multivisceral resection and recovery may not be comparable to that with other procedures. Given that transanal excision is often performed as a day procedure, patients who underwent this procedure were also excluded from analysis.

### Data sources and outcome variables

Patients were identified through the institution's Performance Metrics (Health Records). Information on the included patients' demographic characteristics, functional status, medical background, procedure details and hospital stay was abstracted from the ACS NSQIP database. We defined duration of hospital LOS as the total number of days spent in hospital from the surgery date until the discharge date. All categories were defined by ACS NSQIP standard definitions. We defined the occurrence of complications as a patient's having experienced any of the complications recorded by the ACS NSQIP (Supplementary Table S2, Appendix 1). We recorded postoperative outcomes based on ACS NSQIP category, including LOS, postoperative complications (number and severity), unplanned return visits to the emergency department and 30-day mortality rate.

At the outset of iERAS, we targeted an "ideal" LOS of 5 days or less.<sup>18</sup> We also noted that patients staying more than 10 days were more likely than those with shorter stays to experience complications or have social issues limiting the ability to be discharged home, as has been previously reported.<sup>19</sup> For this reason, we identified 3 categories for LOS: 1–5 days (ideal), 6–10 days and more than 10 days ("extended"). Our objective was to increase the number of patients discharged within 5 days.

### Statistical analysis

We used descriptive statistics to describe the demographic, preoperative and operative characteristics of the study population. We used 2-sample *t* tests to examine differences in the means for continuous variables comparing the pre- and post-

iERAS periods, and analyzed for outcomes pertaining to open procedures only and iERAS. We used additional comparisons, including  $\chi^2$  tests, Wilcoxon rank-sum tests and analysis of variance with post-hoc Tukey honestly significant difference testing, as appropriate. We fit multiple logistic regression models to evaluate the association between iERAS and clinical outcomes, adjusted for potential confounding factors. We calculated the outcomes involving postoperative complications for all types of laparoscopic procedures only. All analyses were carried out with Stata v.15 (StataCorp).

## RESULTS

A total of 934 colorectal cases were collected between March 2010 and September 2015, of which 325 were excluded (300 with emergency admission and surgery, 22 with pelvic exenteration and 3 with transanal excision). The remaining 609 cases (318 [52.2%] colon resection and 291 [47.8%] rectal resection) were included in the data set for analysis. A total of 190 patients (31.2%) underwent resection before iERAS, and 419 (68.8%) had resection during or after iERAS. There were no significant differences in baseline demographic or clinical characteristics between the 2 cohorts except for mean surgery duration, which was longer in the post-iERAS group than in the pre-iERAS group (309.0 min v. 281.8 min,  $p = 0.008$ ) (Table 1).

### Hospital length of stay

The observed distribution across all LOS categories was significantly different between patients who underwent surgery before and after iERAS ( $p = 0.001$ ) (Fig. 1). A median LOS of 7 days (interquartile range 5–10 d) was observed before iERAS, compared to 6 days (interquartile range 4–10 d) during or after iERAS ( $p = 0.048$ ) (Supplementary Fig. S1, Appendix 1). The proportion of patients discharged between 6 and 10 days was significantly reduced after iERAS (32.8% v. 46.0%,  $p < 0.001$ ), and the proportion of patients discharged within 5 days of surgery was significantly increased (43.5% v. 29.1%,  $p < 0.05$ ). Length of stay of more than 10 days was also significantly reduced (23.7% v. 24.9%,  $p < 0.001$ ). After adjustment for complications, age and sex, ERAS status was associated with reduced odds for LOS 6–10 days (odds ratio 0.44, 95% confidence interval 1.52–3.77) and more than 10 days (odds ratio 0.16, 95% confidence interval 4.53–12.31) compared to the target reference LOS of less than 6 days. Similar findings were reflected for open surgical procedures only (Fig. 1, B), where there was an increase in the proportion of patients discharged within 5 days, from 13.8% in the pre-ERAS group to 32.9% in the post-ERAS group, ( $p < 0.001$ ). Similarly, the proportion of patients discharged between 6 and 10 days was reduced, from 53.7% before iERAS to 39.8% after iERAS ( $p < 0.001$ ).

Postoperative complications

The distribution of complication rates is shown in Table 2. There was a significant absolute reduction of 12% in the proportion of patients in the overall cohort with postoperative complications after iERAS compared to before iERAS ( $p = 0.004$ ) (Fig. 2, A). Similarly, there was a significant absolute reduction of 10% in the proportion of patients who underwent open procedures and had postoperative surgical site infections after iERAS compared to before

iERAS (24.8% v. 34.7%,  $p = 0.04$ ) (Fig. 2, B). There was no difference in postoperative urinary tract infections before iERAS versus after iERAS among patients who underwent open procedures. Among patients who underwent laparoscopic procedures, there was no statistically significant differences in postoperative complications before iERAS versus after iERAS (Fig. 2, C). A multivariable regression model evaluating outcomes among patients who underwent open procedures showed an absolute reduction of 12% in postoperative complications in the post-iERAS group compared to the pre-iERAS group ( $p < 0.001$ ).

**Table 1. Baseline demographic and clinical characteristics of patients who underwent colorectal surgery before and after implementation of the enhanced recovery after surgery program**

Characteristic	No. (%) of patients*		p value
	Pre-ERAS n = 190	Post-ERAS n = 419	
<b>Demographic characteristics</b>			
Age, yr, mean ± SD	63.8 ± 14.9	64.0 ± 15.0	0.9
Male sex	102 (53.7)	239 (57.0)	0.5
<b>Preoperative measures</b>			
Body mass index, mean ± SD	27.9 ± 5.9	28.6 ± 5.9	0.2
Functional status			
Independent	186 (97.9)	404 (96.4)	0.5
Partially dependent	4 (2.1)	13 (3.1)	
Totally dependent	0 (0.0)	2 (0.5)	
Diabetes			
Insulin-dependent	11 (5.8)	17 (4.1)	0.4
Non-insulin-dependent	26 (13.7)	47 (11.2)	
None	153 (80.5)	355 (84.7)	
Congestive heart failure	0 (0.0)	8 (1.9)	0.06
Hypertension	92 (48.4)	198 (47.2)	0.8
Smoker	33 (17.4)	68 (16.2)	0.7
Dyspnea on moderate exertion	13 (6.8)	34 (8.1)	0.5
Disseminated cancer	18 (9.5)	54 (12.9)	0.2
Chronic obstructive pulmonary disease	8 (4.2)	24 (5.7)	0.4
Dialysis	1 (0.5)	3 (0.7)	0.8
Recent steroid use	13 (6.8)	31 (7.4)	0.8
<b>Operative characteristics</b>			
ASA classification			0.2
II	54 (28.4)	87 (20.8)	
III	121 (63.7)	296 (70.6)	
IV	15 (7.9)	35 (8.4)	
V	0 (0.0)	1 (0.2)	
Type of surgery			
Colon	96 (50.5)	222 (53.0)	0.6
Rectal	94 (49.5)	197 (47.0)	
Procedure			
Laparoscopic	66 (34.7)	129 (30.8)	0.3
Open	124 (65.3)	290 (69.2)	
Creation of stoma	56 (29.5)	107 (25.5)	0.3
Duration of surgery, min, mean ± SD	281.8 ± 104.3	309.0 ± 122.8	0.008

ASA = American Society of Anesthesiologists; ERAS = enhanced recovery after surgery; SD = standard deviation.  
\*Except where noted otherwise.

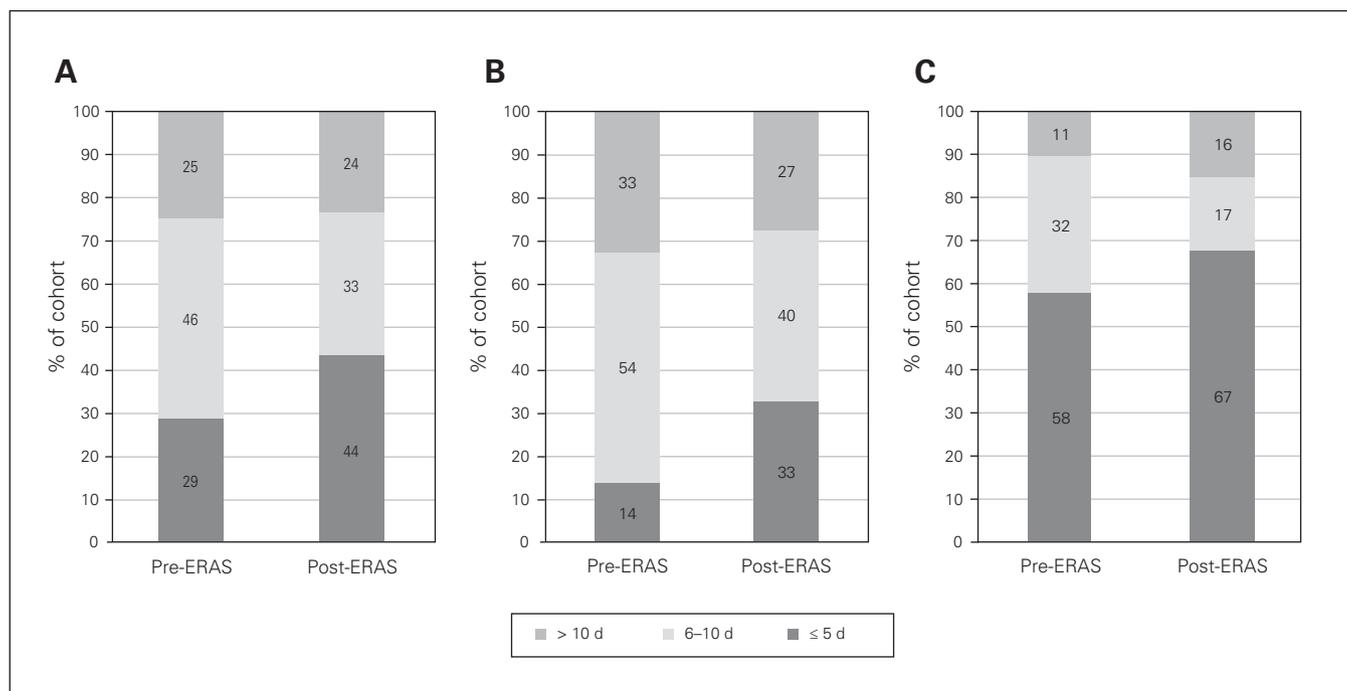
Return visits to emergency department and death

There was no significant difference in the number of unplanned return visits to the emergency department after hospital discharge between the pre-iERAS and post-iERAS periods ( $p = 0.2$ ) (Table 2). Thirty-day mortality was also similar between the 2 periods ( $p = 0.5$ ).

DISCUSSION

Using ACS NSQIP data, we compared surgical outcome rates before and following implementation of a provincially standardized ERAS program and found a significant reduction in LOS among patients who underwent elective colorectal surgery, with improved overall morbidity when ERAS guidelines were followed. The proportion of patients with LOS of 6-10 days before iERAS was shifted to LOS of 5 days or less in the post-iERAS period. The implementation of ERAS made little impact on patients requiring a LOS beyond 10 days after either open or laparoscopic colorectal surgery. Importantly, we found that there was no significant increase in the number of unplanned return visits to the emergency department related to the reduced LOS in the post-iERAS period.

The implementation of ERAS protocols is widely credited for reducing hospital LOS after colorectal surgery.<sup>3,5,7,20-22</sup> Consistent with previous reports,<sup>23-25</sup> we observed that, following iERAS, there was an increase in the proportion of patients discharged within 5 days. Although we have attributed the shift toward an earlier discharge to the ERAS program, there are other factors that may have been responsible, at least in part, for this finding, including a shift in the procedures performed or in the demographic characteristics of the patients seen. However, there were no significant differences in body mass index, functional status, preoperative comorbidities or ASA class between our pre- and post-ERAS cohorts. Moreover, the proportion of patients who underwent rectal (as opposed to colon) surgery, had a laparoscopic procedure and recovered with a new ostomy was similar between the 2 periods (34.7% pre-ERAS and 30.8% post-ERAS). Interestingly, the observed reduction in LOS was reflected in patients who underwent open procedures but not laparoscopic procedures. This may



**Fig. 1.** Hospital length of stay among patients who underwent colorectal surgery before and after implementation of the enhanced recovery after surgery (ERAS) program. (A) Entire cohort. (B) Patients who had open procedures. (C) Patients who had laparoscopic procedures.

suggest that TOH had already been carrying out practices consistent with enhanced recovery, whereas ERAS protocols had more of an impact in standardizing perioperative approaches in open surgical procedures. Given that all the colorectal surgeons at TOH perform both open and laparoscopic procedures, it is unlikely that the observed differences observed are a reflection only of specific surgeons' preferred approach to perioperative care.

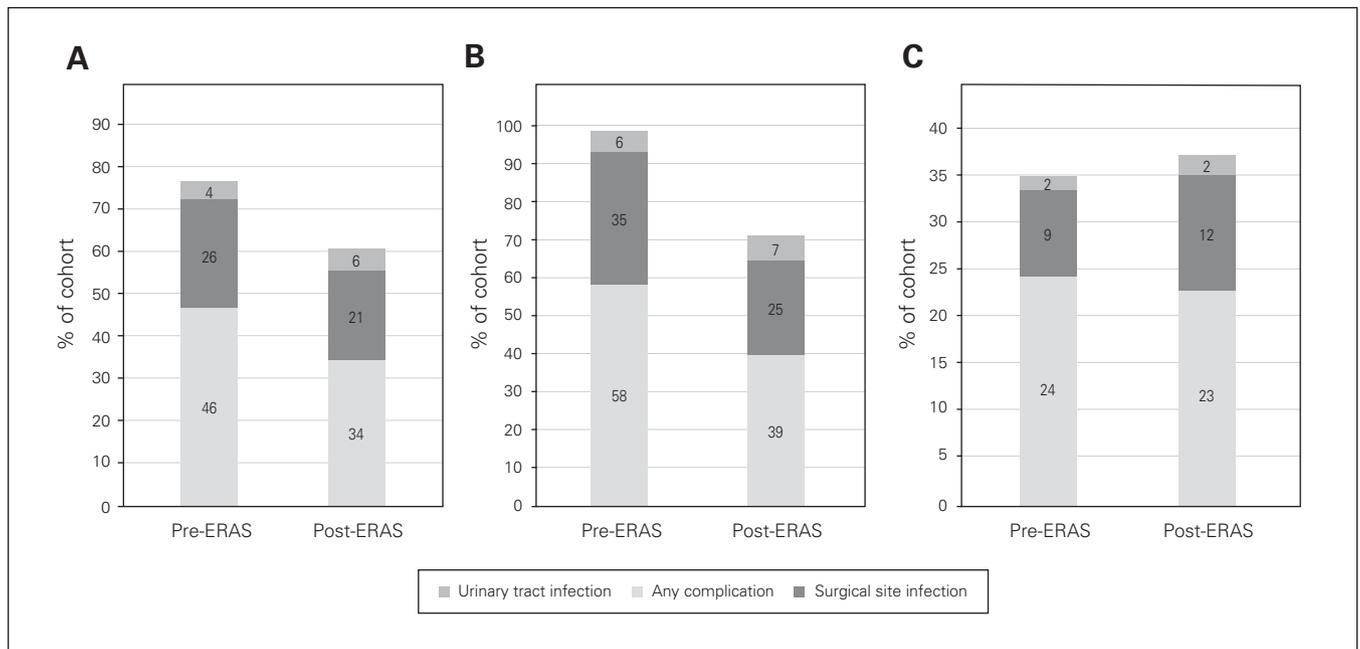
An important observation in this analysis, as well as a primary goal of the ERAS program, was a reduction in rates of surgical site infection among patients undergoing colorectal surgery. Surgical site infections are a common complication after surgical procedures and are associated with increased morbidity and health care costs.<sup>26</sup> We found that iERAS was successful in decreasing surgical site infection rates for open procedures. However, the observed reduction was modest, and this is an area that still warrants quality initiatives to achieve desired outcomes.

One unexpected finding in our study was an increased mean duration of surgery of roughly 30 minutes after iERAS. This may be explained by several changes in operating room protocols that were implemented concomitantly with the transition to ERAS, such as preoperative briefing periods, completion of 3-part checklists and closing tray protocols, all of which may have contributed to the increase seen in operating room time. There are several enhanced recovery programs, such as ERAS, that exist and share common elements including patient education and

**Table 2.** Postoperative outcomes before and after implementation of the enhanced recovery after surgery program

Outcome	% of patients		p value
	Pre-ERAS	Post-ERAS	
<b>All procedures (open and laparoscopic)</b>			
Complications			
Any	46.3	34.1	0.004
Surgical site infection	25.8	21.0	0.2
Urinary tract infection	4.2	5.5	0.5
No. of unplanned return visits to emergency department			0.2
1	2.6	6.4	
2	0.5	0.2	
3	0.0	0.2	
30-day mortality, %	3.7	2.6	0.5
<b>Open procedures only (n = 414)</b>			
Any complication	58.1	39.3	< 0.001
Surgical site infection	34.7	24.8	0.04
Urinary tract infection	5.7	6.9	0.6
<b>Laparoscopic procedures only (n = 195)</b>			
Any complication	24.2	22.5	0.8
Surgical site infection	9.1	12.4	0.5
Urinary tract infection	1.5	2.3	0.7

ERAS = enhanced recovery after surgery.



**Fig. 2.** Postoperative complication rates before and after implementation of the enhanced recovery after surgery (ERAS) program. (A) Entire cohort. (B) Patients who underwent open procedures. (C) Patients who underwent laparoscopic procedures.

preoperative planning, preoperative carbohydrate loading, improved analgesic techniques to reduce the physical stress of the operation, early oral feeding and mobilization.<sup>23,27,28</sup>

Before ERAS, information regarding outcomes related to implementation of enhanced recovery programs was limited. Inconsistencies within this research area have also been observed as a result of inadequate data quality and insufficient data quantity.<sup>29</sup> This highlights the importance of using an effective and accurate tool to monitor outcomes following the implementation of an ERAS program. Our methodology shows the effectiveness of off-the-shelf, evidence-based perioperative protocols. The protocols for iERAS used for this quality-improvement project at TOH are multidisciplinary, easily accessible (available at [www.bestpracticeinsurgery.ca/guidelines/general-surgery](http://www.bestpracticeinsurgery.ca/guidelines/general-surgery)), cost-effective and modifiable based on specific hospital preferences or standards.

Finally, our findings support the utility and effectiveness of the ACS NSQIP as a data collection tool for improved surgical outcomes.<sup>10,30-32</sup> Furthermore, the NSQIP has been adopted by many hospitals across Canada.<sup>18</sup> However, it is important to note that data collected via the NSQIP are only as good as their source of documentation. To address this limitation, we recently introduced an ERAS-NSQIP module to supplement outcome data with compliance data as a method to assess adherence with ERAS. The goal of this module is to track compliance with ERAS guidelines (Supplementary Table S1, Appendix 1) in order to further identify barriers and target potential areas for improvement. We believe that this module is promising to see further improvements in perioperative care. At the same time, however, through the current project, we

have realized that quality-improvement efforts such as ERAS rely heavily on point-of-care documentation by engaged members of the team, often nursing. Engagement of our nurses in the development of documentation requirements has been paramount in improving accurate recording of compliance with ERAS metrics. The ERAS-NSQIP platform is a highly valuable tool for implementing and measuring more innovative improvements in perioperative care quality with continuous audit and feedback.

## CONCLUSION

Evidence-based approaches to perioperative care should improve the value of delivery of health care services in Ontario by increasing quality while reducing costs. Improved collection and reporting of how enhanced recovery programs are implemented, resourced and experienced are an important component in the success of these programs. Continuous reassessment of surgical outcomes and collection of process quality indicators is an important step in determining implementation gaps and identifying practice changes that require ongoing support. The introduction of an ERAS-NSQIP module for monitoring standardized perioperative care facilitates a data-driven approach to inform implementation teams where best to focus their efforts and to address barriers to the uptake of and compliance with implementation, in hopes of establishing the sustainability of ERAS protocols and data collection processes. There are several ERAS guidelines and implementation tools available online that are easily adapted to local practices, and their impact can be efficiently monitored through the ACS NSQIP.<sup>33,34</sup>

**Affiliations:** From the Faculty of Medicine, University of Ottawa, Ottawa, Ont. (L.M. Gresham, Schramm, Auer, Sadiq, Szeto); the Johns Hopkins Bloomberg School of Public Health, Baltimore, Md. (G. Gresham); The Ottawa Hospital, Ottawa, Ont. (McGrath, Lacelle, Trickett); the University of Toronto, Toronto, Ont. (Pearsall, McLeod); and Mount Sinai Hospital, Toronto, Ont. (McKenzie).

**Competing interests:** None declared.

**Contributors:** J. Trickett, E. Pearsall, M. McKenzie, R. McLeod and R. Auer designed the study. M. Sadiq, M. McGrath, K. Lacelle, M. Szeto, J. Trickett, D. Schramm, E. Pearsall, R. McLeod and R. Auer acquired the data, which L. Gresham, M. Sadiq, G. Gresham, E. Pearsall and R. Auer analyzed. M. Sadiq and R. Auer wrote the article, which all authors reviewed and approved for publication.

## References

1. Scott MJ, Baldini G, Fearon KCH, et al. Enhanced Recovery After Surgery (ERAS) for gastrointestinal surgery, part 1: pathophysiological considerations. *Acta Anaesthesiol Scand* 2015;59:1212-39.
2. Rawlinson A, Kang P, Evans J, et al. A systematic review of enhanced recovery protocols in colorectal surgery. *Ann R Coll Surg Engl* 2011;93:583-8.
3. Melnyk M, Casey RG, Black P, et al. Enhanced recovery after surgery (ERAS) protocols: Time to change practice? *Can Urol Assoc J* 2011;5:342-8.
4. Khoo CK, Vickery CJ, Forsyth N, et al. A prospective randomized controlled trial of multimodal perioperative management protocol in patients undergoing elective colorectal resection for cancer. *Ann Surg* 2007;245:867-72.
5. Eskicioglu C, Forbes SS, Aarts MA, et al. Enhanced recovery after surgery (ERAS) programs for patients having colorectal surgery: a meta-analysis of randomized trials. *J Gastrointest Surg* 2009;13:2321-9.
6. Spanjersberg WR, Reurings J, Keus F, et al. Fast track surgery versus conventional recovery strategies for colorectal surgery. *Cochrane Database Syst Rev* 2011;(2):CD007635.
7. McLeod RS, Aarts MA, Chung F, et al. Development of an enhanced recovery after surgery guideline and implementation strategy based on the knowledge-to-action cycle. *Ann Surg* 2015;262:1016-25.
8. Stephen AE, Berger DL. Shortened length of stay and hospital cost reduction with implementation of an accelerated clinical care pathway after elective colon resection. *Surgery* 2003;133:277-82.
9. Braga M, Vignali A, Gianotti L, et al. Laparoscopic versus open colorectal surgery: a randomized trial on short-term outcome. *Ann Surg* 2002;236:759-66.
10. Lacy AM, Garcia-Valdecasas JC, Delgado S, et al. Laparoscopy-assisted colectomy versus open colectomy for treatment of non-metastatic colon cancer: a randomised trial. *Lancet* 2002;359:2224-9.
11. Rawlinson A, Kang P, Evans J, et al. A systematic review of enhanced recovery protocols in colorectal surgery. *Ann R Coll Surg Engl* 2011;93:583-8.
12. Lyon A, Solomon MJ, Harrison JD. A qualitative study assessing the barriers to implementation of enhanced recovery after surgery. *World J Surg* 2014;38:1374-80.
13. Best Practice in Surgery guidelines. Enhanced recovery after surgery. Toronto: University of Toronto Department of Surgery; 2017. Available: <http://bestpracticeinsurgery.ca/guidelines/all/enhanced-recovery-after-surgery/> (accessed 2019 Mar. 5).
14. About ACS NSQIP. Chicago: American College of Surgeons; 1996-2017. Available: <https://www.facs.org/quality-programs/acs-nsqip/about> (accessed 2017 May 18).
15. Ko C. ACS NSQIP conference and semiannual report overview. American College of Surgeons NSQIP National Conference; 2009 July 19-21; San Diego.
16. Schramm DR, Worthington JR, Kitts JB. Implementation of an integrated peri-operative quality management program at The Ottawa Hospital. *Healthcare Management Forum* 2011;24(1 Suppl):S34-40.
17. Fuchshuber PR, Greif W, Tidwell CR, et al. The power of the National Surgical Quality Improvement Program — achieving a zero pneumonia rate in general surgery patients. *Perm J* 2012;16:39-45.
18. Aravani A, Samy EF, Thomas JD, et al. A retrospective observational study of length of stay in hospital after colorectal cancer surgery in England (1998-2010). *Medicine (Baltimore)* 2016;95:e5064.
19. Ricciardi R, Roberts PL, Read TE, et al. Which adverse events are associated with mortality and prolonged length of stay following colorectal surgery? *J Gastrointest Surg* 2013;17:1485-93.
20. Chambers D, Paton F, Wilson P, et al. An overview and methodological assessment of systematic reviews and meta-analyses of enhanced recovery programmes in colorectal surgery. *BMJ Open* 2014;4:e005014.
21. Kehlet H, Wilmore DW. Multimodal strategies to improve surgical outcome. *Am J Surg* 2002;183:630-41.
22. Sturm L, Cameron AL. *Fast-track surgery and enhanced recovery after surgery (ERAS) programs*. ASERNIP-S report 74. Adelaide (Australia): ASERNIP-S; 2009.
23. Thiele RH, Rea KM, Turrentine FE, et al. Standardization of care: impact of an enhanced recovery protocol on length of stay, complications, and direct costs after colorectal surgery. *J Am Coll Surg* 2015;220:430-43.
24. Miller TE, Thacker JK, White WD, et al.; Enhanced Recovery Study Group. Reduced length of hospital stay in colorectal surgery after implementation of an enhanced recovery protocol. *Anesth Analg* 2014;118:1052-61.
25. Bray MS, Appel AL, Kallies KJ, et al. Implementation of an Enhanced Recovery After Surgery program for colorectal surgery at a community teaching hospital. *WJG* 2017;116:22-6.
26. Keenan JE, Speicher PJ, Thacker JKM, et al. The preventive surgical site infection bundle in colorectal surgery: an effective approach to surgical site infection reduction and health care cost savings. *JAMA Surg* 2014;149:1045-52.
27. Martin TD, Lorenz T, Ferraro J, et al. Newly implemented enhanced recovery pathway positively impacts hospital length of stay. *Surg Endosc* 2016;30:4019-28.
28. Miller TE, Roche AM, Mythen M. Fluid management and goal-directed therapy as an adjunct to Enhanced Recovery After Surgery (ERAS). *Can J Anaesth* 2015;62:158-68.
29. Zhuang CL, Ye XZ, Zhang XD, et al. Enhanced recovery after surgery programs versus traditional care for colorectal surgery: a meta-analysis of randomized controlled trials. *Dis Colon Rectum* 2013;56:667-78.
30. Paton F, Chambers D, Wilson P, et al. Effectiveness and implementation of enhanced recovery after surgery programmes: a rapid evidence synthesis. *BMJ Open* 2014;4:e005015.
31. Cohen ME, Ko CY, Bilimoria KY, et al. Optimizing ACS NSQIP modeling for evaluation of surgical quality and risk: patient risk adjustment, procedure mix adjustment, shrinkage adjustment, and surgical focus. *J Am Coll Surg* 2013;217:336-46.
32. Sellers MM, Reinke CE, Kreider S, et al. American College of Surgeons NSQIP: quality in-training initiative pilot study. *J Am Coll Surg* 2013;217:827-32.
33. Best Practice in Surgery guidelines. General surgery. Toronto: University of Toronto Department of Surgery. Available: [www.bestpracticeinsurgery.ca/guidelines/general-surgery](http://www.bestpracticeinsurgery.ca/guidelines/general-surgery) (accessed 2017 May 18).
34. ERAS/Guidelines/List of guidelines. Stockholm: ERAS Society; 2016. Available: <http://erasociety.org/guidelines/list-of-guidelines/> (accessed 2017 May 18).