

The impact of adverse events on health care costs for older adults undergoing nonelective abdominal surgery

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Background: Postoperative complications have been identified as an important and potentially preventable cause of increased hospital costs. While older adults are at increased risk of experiencing complications and other adverse events, very little research has specifically examined how these events impact inpatient costs. We sought to examine the association between postoperative complications, hospital mortality and loss of independence and direct inpatient health care costs in patients 70 years or older who underwent nonelective abdominal surgery.

Methods: We prospectively enrolled consecutive patients 70 years or older who underwent nonelective abdominal surgery between July 1, 2011, and Sept. 30, 2012. Detailed patient-level data were collected regarding demographics, diagnosis, treatment and outcomes. Patient-level resource tracking was used to calculate direct hospital costs (2012 \$CDN). We examined the association between complications, hospital mortality and loss of independence cost using multiple linear regression.

Results: During the study period 212 patients underwent surgery. Overall, 51.9% of patients experienced a nonfatal complication (32.5% minor and 19.4% major), 6.6% died in hospital and 22.6% experienced a loss of independence. On multivariate analysis nonfatal complications ($p < 0.001$), hospital mortality ($p = 0.021$) and loss of independence at discharge ($p < 0.001$) were independently associated with health care costs. These adverse events respectively accounted for 30%, 4% and 10% of the total costs of hospital care.

Conclusion: Adverse events were common after abdominal surgery in older adults and accounted for 44% of overall costs. This represents a substantial opportunity for better patient outcomes and cost savings with quality improvement strategies tailored to the needs of this high-risk surgical population.

Contexte : Les complications postopératoires sont une cause évitable qui contribue grandement aux coûts hospitaliers élevés. Malgré le fait que les personnes âgées courent un risque accru de subir des complications ou des événements indésirables, peu de recherches ont étudié l'incidence de ces éléments sur les coûts d'hospitalisation. Nous nous sommes penchés sur la relation entre les coûts des soins de santé assumés par les malades hospitalisés et les complications postopératoires, la mortalité hospitalière et la perte d'autonomie auprès d'une population de patients de 70 ans et plus ayant subi une intervention chirurgicale abdominale non facultative.

Méthodes : La cohorte prospective a été formée de patients consécutifs âgés de 70 ans et plus ayant subi une intervention chirurgicale abdominale non facultative entre le 1^{er} juillet 2011 et le 30 septembre 2012. Des données détaillées concernant leur profil démographique, leur diagnostic, leur traitement et leurs résultats ont été recueillies. Le calcul des coûts hospitaliers directs est basé sur un suivi des ressources utilisées par les patients (en dollars canadiens, 2012). Au moyen d'une régression linéaire multiple, nous avons analysé la relation entre les complications, la mortalité hospitalière et la perte d'autonomie.

Résultats : Pendant la période à l'étude, 212 patients ont subi une intervention chirurgicale. Parmi eux, 51,9 % ont subi une complication non mortelle (mineure dans 32,5 % des cas; majeure dans 19,4 % des cas), 6,6 % sont décédés à l'hôpital, et 22,6 % ont subi une perte d'autonomie. Une analyse multivariable a permis de conclure que les complications non mortelles ($p < 0,001$), la mortalité hospitalière ($p = 0,021$) et la perte d'autonomie à la sortie de l'hôpital ($p < 0,001$) étaient indépendamment associées aux coûts des soins de santé et qu'elles représentaient respectivement 30 %, 4 % et 10 % des coûts d'hospitalisation totaux.

Conclusion : Les événements indésirables étaient fréquents dans le contexte des interventions chirurgicales abdominales réalisées sur des personnes âgées et représentaient 44 % des coûts totaux. Nous devons saisir cette occasion et nous doter de stratégies d'amélioration de la qualité adaptées aux besoins de cette population, à risque élevé sur le plan chirurgical, afin d'améliorer les résultats pour les patients et de diminuer les coûts.

The Canadian population is aging, and by 2050 the proportion of adults aged 65 and older is expected to double and the proportion aged 80 years and older is expected to triple.¹ These demographic changes may place a considerable financial burden on the health care system as a substantial proportion of the health care budget is allocated to the care of older adults. In 2009, 44% of the total Canadian health care budget was spent on the care of people aged 65 years and older, although they accounted for only 14% of the population.² With health care expenses increasing faster than the gross domestic product,² effective strategies to control costs are needed.

Among surgical patients, postoperative complications have been identified as an important and potentially preventable cause of increased health care costs.^{3,4} However, very little research has specifically studied this association in older patients.^{5,6} Compared with younger individuals, postoperative adverse events are more common in older adults after abdominal surgery,^{7,8} and some patients are at exceptionally high risk for complications. For example, emergency abdominal surgery in older adults is associated with mortality exceeding that for cardiac procedures and complication rates as high as 50%.⁷⁻¹⁰ This has broad implications given that emergency abdominal surgery is routinely performed in most acute care hospitals and the need for these services is expected to increase with the aging of the general population.^{7,9,11,12}

The increased frequency of complications among older surgical patients is likely an important component of health care costs; however, the magnitude of this association is not well established. Furthermore, other postoperative adverse events, such as perioperative mortality and loss of independence, may also impact the cost of care. A clear understanding of the various factors that contribute to the increased costs among older surgical patients is needed to guide cost containment strategies and resource allocation. The primary purpose of this study was to examine the association between adverse events (postoperative complications, hospital mortality and loss of independence) and direct inpatient health care costs in patients older than 70 years who underwent nonelective abdominal surgery in a tertiary care teaching hospital.

METHODS

We prospectively enrolled all patients aged 70 years and older who were admitted to an acute care surgery service at a tertiary care teaching centre and underwent nonelective abdominal surgery between July 1, 2011, and Sept. 30, 2012. We chose this age group because acuity,

complications and cost increase dramatically in patients older than 70 years.^{2,7} Only patients with intra-abdominal or abdominal wall conditions were included. Patients were excluded if they were admitted for treatment of a complication resulting from a prior elective procedure, or if they were transferred from an outlying hospital, owing to the inability to track resource utilization.

The episode of care used for analysis in this study was from the time of admission to the acute care surgical service until discharge from hospital or 90 days following admission, whichever occurred first. Patients were enrolled within 48 hours of the index admission. At the time of enrolment, one of us (J.G.B. or P.J.B.D.) interviewed and examined each patient, and a comprehensive geriatric assessment (CGA) was completed. The CGA is a validated multidisciplinary diagnostic tool that expands on the standard medical history and physical examination, including aspects of health important for older adults.¹³ It includes an assessment of mobility, activities of daily living, residential status, cognition, mood, self-rated health, strength, sleep and social supports.¹³ The CGA includes a review of systems, a review of medications and medical history. The information from the CGA can be used to calculate a frailty index (FI-CGA).^{14,15} The FI-CGA is calculated by dividing the number of health deficits a patient has accumulated by all measured deficits. Therefore, possible scores range from 0.00 to 1.00 on a continuous scale. For example, mean index scores of 0.22, 0.36 and 0.43 indicate apparent vulnerability, moderate frailty and severe frailty, respectively.¹⁴

We performed a standardized, comprehensive review of the patients' medical records to collect data regarding the following variables: American Society of Anesthesiologists (ASA) classification, operative severity (OS), postoperative complications and resource utilization. The ASA classification¹⁶ was taken from the anesthesiologist's preoperative assessment. We categorized OS on a 3-level ordinal scale: 1) laparoscopic surgery for benign disease, 2) open surgery for benign disease and 3) open or laparoscopic surgery for malignant disease.¹⁷

Hospital complications were categorized by severity using the Clavien–Dindo (CD) classification:¹⁸ nonfatal complications were defined as minor (CD level I and II) and major (CD level III and IV), and fatal complications were categorized as CD level V. Consensus was reached among the investigators when there were discrepancies in grading complications. If a patient experienced more than 1 complication, the most severe was used for analysis. Only deaths that occurred during admission to hospital were included in this analysis, defined here as hospital mortality.

We divided preadmission residential status into 5 categories: living alone, living with others, semi-independent housing, nursing home and inpatient longer than 2 weeks. Residential status at discharge was divided into 6 categories: living alone, living with others, semi-independent housing, nursing home, restorative care (inpatient physiotherapy/occupational therapy) and continued hospitalization. Loss of independence was defined as inability to return to the pre-admission residential status.

Cost calculation

Direct costs were calculated from the perspective of the hospital (payer). We estimated costs by tracking resource utilization and multiplying by the cost of each resource. For patients who remained in hospital for more than 90 days, the costs incurred after 90 days were truncated. Since health care costs are typically high right-skewed,¹⁹ we truncated costs to limit the influence of outliers and avoid severely skewed data. To limit measurement bias, we used only the costs from the index hospitalization; the costs of readmission at outlying hospitals were excluded owing to the potential bias and complexity of estimating costs incurred in other institutions. All costs were calculated in 2012 Canadian dollars.

The majority of unit cost estimates were based on an exact count. When this was not feasible, cost estimates were based on time intervals. We counted the exact number of resources used in each of the following categories: diagnostic imaging, laboratory investigations, nonoperative interventional procedures, blood products, consultations, physician fees, antibiotics, anticoagulants and operative disposables. These counts were double-checked for errors in extraction or transcription.

Cost estimates for hospital beds and the operating room were assigned based on units of time rather than the number of resources used. Bed costs for ward, intermediate and intensive care were assigned on a daily basis. Bed costs included direct supplies and staff compensation. Operating room facility costs were assigned using a base rate (for preoperative nursing, the patient attendant, the anesthesia technician, anesthesia supplies and postanesthetic care unit nursing) and an hourly rate (for intraoperative nursing). Medication costs for analgesics and antiemetics outside of the operating room as well as intensive care infusions were assigned on a daily basis. We calculated daily averages for these medications by performing an exact count of medication dosages for the first 25 patients and applying these to subsequent patients. The subset of patients that we used to calculate the costs of medications did not differ significantly from the study population in terms of age, sex, body mass index, ASA classification, frailty index, Charlson comorbidity score, OS or length of stay in hospital. Sources for unit cost estimates are listed in Appendix 1, available at canjsurg.ca.

The cost of unnecessary patient days was also estimated. The number of unnecessary days in hospital was defined as the difference between the actual discharge date and the date when health care providers documented in the chart that the patient was medically ready to leave hospital. Unnecessary days in the intermediate care unit (IMCU) or intensive care unit (ICU) were defined as the difference between the date that the patient was declassified and the date that they actually left the IMCU or ICU. We estimated the excess cost of unnecessary days on the ward by multiplying the number of patient days by the ward bed costs. We estimated the excess cost for unnecessary IMCU and ICU patient days using the difference between IMCU or ICU bed costs and costs at the next lower level of care.

Statistical analysis

Univariate differences in cost were compared using non-parametric tests (Wilcoxon rank-sum test or Kruskal-Wallis test). To assess the multivariate association between cost and postoperative complications, loss of independence and hospital mortality, we performed a multiple linear regression, controlling for age, ASA, OS and FI-CGA. These factors have been associated with health care costs in previous research.^{4,20-24}

Even after truncating the data, the data continued to be right-skewed. The cost data were logarithmically transformed to adjust for the skewness. Log-transforming the data improved the fit diagnostics of the models, demonstrated by more homogeneous, random residuals plots. Additionally, the R^2 value of the cost model increased from 0.3554 to 0.5735 with log-transformation of cost data, indicating better fit to the regression line. We calculated adjusted median costs by exponentiating the least squares means of the log-transformed total costs using general linear models.

The increase in cost associated with each level of an ordinal factor was calculated by exponentiating the β coefficient (e.g., x unit increase in complication severity results in \exp [coefficient] increase in cost).^{19,25} We calculated the costs attributable to adverse events (most severe postoperative complication, hospital mortality and loss of independence) using a regression-based approach.²⁶

RESULTS

During the 15-month study period 212 patients underwent nonelective abdominal surgery and formed the study cohort (Fig. 1). Patient characteristics are summarized in Table 1. The median length of stay was 8.0 (interquartile range [IQR] 4.0–16.5) days. The length of stay was truncated for 7 (3.3%) patients in the study. Eighty-eight percent of patient-days in hospital were spent in a ward bed, 7% were in the IMCU and 5% were in the ICU. Overall, 110 (51.9%) patients experienced a least 1 nonfatal complication. Of these, 69 (32.5%) experienced a minor complication and

41 (19.4%) a major complication. The 3 most common complications are listed by grade for all patients in Table 2. See Appendix 1 for a complete list of complications, using the most severe complication experienced by each patient. Hospital mortality was 6.6%. Of the 14 patients who died, 12 died from complications directly related to their surgeries. The remaining 2 patients died from a combination of pre-existing comorbidities and progression of the presenting disease. Major complications were more common among the patients who died in hospital than among patients who survived (43% v. 18%, $p = 0.033$). Patients who died in hospital were more likely than those who survived to require admission to the ICU (93% v. 17%, $p < 0.001$), where they spent a median of 2.0 (range 0–16) days.

Table 3 shows preadmission and discharge residential status for the study cohort. Overall, 22.6% of patients experienced a loss of independence. Patients who had a loss of independence at discharge spent a longer time in hospital (median stay 19.0 d v. 6.5 d, $p < 0.001$) and had a higher number of unnecessary days in hospital (median 1.5 d v. 0.0 d, $p < 0.001$) than patients who returned to their pre-admission residential status.

The median total direct hospital costs were \$9166 per patient (range \$1993–\$104 403). Hospital costs for the entire cohort of 212 patients totaled \$3 378 132 (for a breakdown of mean, median and total direct hospital costs by category, see Appendix 1). The severity of complications was associated with increased health care costs (Table 4). The median

cost of care was also significantly greater for patients who died in hospital and for those who experienced a loss of independence (Table 4). Forty-seven (22.2%) patients stayed in hospital at least 1 day that was medically unnecessary. The total number of medically unnecessary days for all patients in ward, IMCU and ICU beds were 386 (12%), 12 (< 1%) and 8 (< 1%), respectively. Unnecessary days in ward, IMCU and ICU beds accounted for estimated costs of \$170 226 (5.0%), \$3708 (0.1%) and \$10 800 (0.3%), respectively.

On multivariate analysis, age was not independently associated with costs ($p = 0.28$), whereas ASA score ($p = 0.001$), OS ($p < 0.001$), frailty index ($p < 0.001$), complication severity ($p < 0.001$), loss of independence ($p < 0.001$) and hospital mortality ($p = 0.021$) were significantly associated with health care resource utilization. The costs attributable to experiencing a complication, hospital mortality or loss of independence are listed in Table 5. Each increasing level of the Clavien–Dindo classification of complications was associated with a 28% increase in total health care costs. Hospital mortality was associated with a 50% increase in costs, and a loss of independence was associated with a 46% increase.

DISCUSSION

In the present study, postoperative complications, hospital mortality and loss of independence collectively accounted for 44% of direct inpatient health care costs among older adults who underwent nonelective abdominal surgery.

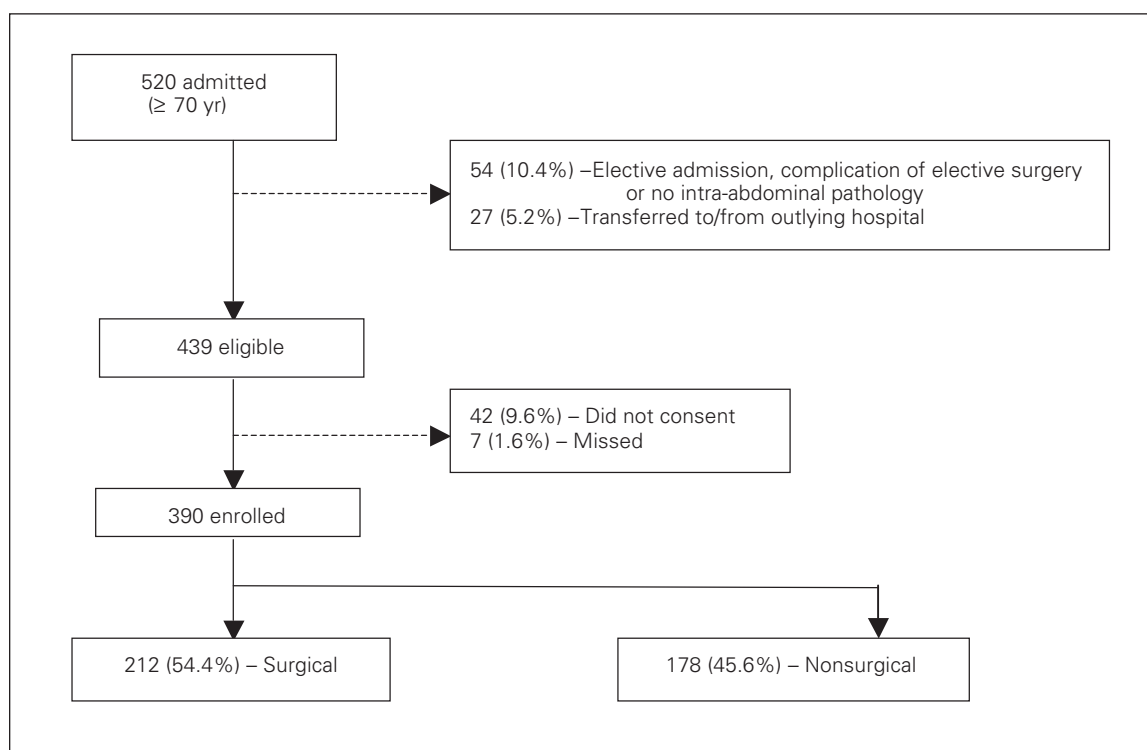


Fig. 1. Recruitment and selection of elderly patients (age ≥ 70 yr) admitted to the acute care surgery service between July 1, 2011 and Sept. 30, 2012.

While the finding that postoperative complications are associated with increased costs is not new, this study was unique in that it focused specifically on high-risk older adults and used detailed patient-level data. This allowed us to control for relevant patient factors and to accurately categorize complications.¹⁸ Furthermore, costs were calculated by counting resources, which is the most accurate method, but is uncommonly performed. Patient age was not associated with costs, suggesting that other factors, such as comorbidities and performance status (included in the frailty index and ASA class), might play a more important role in predicting resource utilization in older surgical patients. Increasing frailty was associated with costs, and this is consistent with the findings of previous studies that have reported an association between frailty and various outcomes in older surgical patients.^{22,27}

Nonfatal complications occurred in more than 50% of patients and accounted for 30% of the overall costs. Recognition of the high costs and poor outcomes associated with complications has led to quality improvement initiatives, such as the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP). While some studies have reported a decrease in morbidity and mortality associated with NSQIP participation,^{28,29} others have failed

to demonstrate any improvements.^{30,31} Osborne and colleagues³⁰ specifically compared outcomes between older adult surgical patients who were treated at NSQIP hospitals and those who were not, and reported that there was no difference in morbidity, mortality or costs.

While quality reporting systems like NSQIP are important, quality improvement requires specific interventions. Additionally, quality improvement is unlikely to be successful with a one size fits all approach. Research has suggested that older patients are more likely to experience cardiac, pulmonary and urologic complications, falls and adverse drug events than younger patients.^{7,9,24,32-34} Accordingly, interventions to improve outcomes and reduce costs need to be tailored to the population at risk. For example, several surgical and anesthetic strategies have been described to reduce pulmonary complications in older adults;^{35,36} these were the most common life-threatening complications (grade IV) in the present study and were associated with a 274% increase in costs. Other complications that were common in the patient population that could also be modified were delirium and urinary tract infections. These also represent potential areas for cost reduction. Whether or not these interventions or other quality improvement initiatives will be both successful and cost-effective will require careful evaluation.

Postoperative mortality is an inherent risk associated with emergency surgical care of older adults. Previous research has reported that acute care hospital admissions at the end of life contribute to increased costs of death.³⁷ However, very little research has specifically examined the impact of death

Table 1. Characteristics of 212 patients aged 70 years and older who underwent nonelective abdominal surgery

Characteristic	No. (%)*
Age, median [range], yr	78 [70-97]
Female sex	112 (52.8)
Frailty index at admission, median [range]	0.3 [0.16-0.51]
ASA classification	
I	5 (2.4)
II	82 (38.7)
III	99 (46.7)
IV	22 (10.4)
V	4 (1.9)
Operative severity	
Grade 1	77 (36.3)
Grade 2	108 (50.9)
Grade 3	27 (12.7)
Common diagnoses	
Biliary tract disease	62 (29.2)
Small bowel obstruction	59 (27.8)
Large bowel obstruction (malignant)	18 (8.5)
Incarcerated hernia without obstruction	18 (8.5)
Colitis (including diverticulitis)	15 (7.1)
Appendicitis	7 (3.3)
Common procedures	
Cholecystectomy	59 (27.8)
Segmental colon resection	39 (18.4)
Hernia without bowel resection	27 (12.7)
Lysis of adhesions	22 (10.4)
Small bowel resection	11 (5.2)
Hernia repair with bowel resection	9 (4.2)
Appendectomy	7 (3.3)

ASA = American Society of Anesthesiologists.
*Unless indicated otherwise.

Table 2. Three most common hospital complications among patients aged 70 years and older who underwent nonelective abdominal surgery

Clavien-Dindo classification; description	Complication*	No. (%)
Grade I		
Any deviation from the normal postoperative course, without specific intervention	Delirium	12 (35)
	Wound infection	6 (18)
	Ileus	4 (12)
Grade II		
Requiring specific pharmacological intervention	Urinary tract infection	10 (29)
	Atrial fibrillation	8 (24)
	Pneumonia	6 (18)
Grade III		
Requiring surgical, endoscopic or radiological intervention	Dehiscence	2 (17)
	Postoperative bleeding	2 (17)
	Urinary tract infection	2 (17)
Grade IV		
Life-threatening complication involving organ dysfunction	Respiratory failure	16 (64)
	Acute renal failure	2 (8)
	Pneumonia	2 (8)
Grade V		
Complication resulting in death	Intra-abdominal sepsis	4 (33)
	Pneumonia	2 (17)
	Ischemic bowel	2 (17)

*Includes only the most severe complication experienced by each patient.

on inpatient costs, which accounted for 4% of overall costs in the present study. Ideally, aggressive and expensive interventions, like surgery, should be avoided when they are likely to be futile. The ability of health care providers to predict death before surgery is inadequate.^{38,39} Decisions to withhold care at the time of presentation may be appropriate for only a small proportion of older adults with advanced frailty or severe comorbidities. Research is needed to develop strategies, such as time-limited trials of care,⁴⁰ to minimize the occurrence of high-cost inpatient deaths. These will help patients, families and physicians make sound decisions regarding appropriateness of care and resource utilization.

Hospitalization and treatment of older adults can result in a functional decline and loss of independence. This has important implications not only for patients, but also for their families and the health care system in general.⁴¹ While nursing home care has been associated with increased costs compared with home- or community-based care, the influence of a loss of independence on inpatient health care costs has not been described.^{42,43} A change in residential status at discharge in the present study was associated with significantly more medically unnecessary days in hospital and

increased costs. This suggests that time spent in hospital waiting for appropriate institutional or community-based discharge care contributed, at least in part, to these costs. This emphasizes the need for adequate rehabilitation and nursing home resources to meet the future demand for such facilities. A chronic shortage of nursing home beds has been a problem in both Canada and the United Kingdom.^{44,45} Changing demographics may place increasing pressure on beds in acute care facilities.

Limitations

Several limitations associated with this study should be considered. While the sample size was small in contrast to other investigations of a similar nature, it allowed for collection of detailed information regarding the patients, complications and resource utilization. In addition, we excluded patients transferred from outlying hospitals (5.2%) owing to inability to access cost data. Patients are typically transferred from other hospitals if they require a subspecialty surgeon or if they require intensive care that is not available at the referring hospital. Since these situations represent

Table 3. Preadmission and discharge residential status for patients aged 70 years and older who underwent nonelective abdominal surgery

Preadmission residential status	Discharge destination; no. (%)							Total no.
	Living alone	Living with others	Semi-independent housing	Nursing home	Restorative care	Continued hospitalization	Deceased	
Living alone	31 (53)	12 (20)*	1 (2)*	2 (3)*	5 (8)*	5 (8)*	3 (5)	59
Living with others	3 (2)	103 (76)	—	—	14 (10)*	4 (3)*	11 (8)	135
Semi-independent housing	—	—	6 (60)	2 (20)*	1 (10)*	1 (10)*	—	10
Nursing home	—	—	—	6 (86)	1 (14)*	—	—	7
Inpatient > 2 wk	—	—	—	—	1 (100)	—	—	1

*Change in residential status where available care was increased, representing a loss of independence.

Table 4. Univariate comparison of costs (2012 \$CDN) between patients aged 70 years and older who did and did not experience an adverse event after undergoing nonelective abdominal surgery

Adverse event*	No. (%)	Hospital costs, median (IQR) [range], \$CDN	p value
Death			
No	198 (93)	7926 (5043–17 880) [1993–104 403]	< 0.001†
Yes	14 (7)	21 224 (13 815–41 355) [11 079–97 568]	—
Clavien–Dindo complication			
None	102 (48)	6030 (4010–9570) [1993–37 036]	< 0.001‡
Grade I	34 (16)	9459 (6554–16 126) [2975–47 407]	—
Grade II	35 (17)	17 366 (16 605–23 456) [3513–78 080]	—
Grade III	12 (6)	16 151 (11 028–19 566) [5973–54 253]	—
Grade IV	29 (14)	30 660 (16 810–66 427) [9497–104 403]	—
Loss of independence			
No	164 (77)	7248 (4851–15 611) [1993–97 568]	< 0.001†
Yes	48 (23)	19 872 (9674–32 452) [3753–104 403]	—

IQR = Interquartile range.
 *The most severe complication experienced by each patient was used in this analysis.
 †Wilcoxon rank-sum test.
 ‡Kruskal–Wallis test.

more severe cases, the study population was likely typical of patients who would be seen for emergency abdominal surgery in most acute care hospitals. Readmission to hospital has been associated with increased health care costs but was not included in this study to avoid a measurement bias associated with inability to track costs at outside institutions. Overall, only 3.8% of patients were readmitted within 6 months for reasons related to their initial hospital stays. Finally, our results may not be applicable to care settings outside of Canada given the differences in practice patterns and costs. Although health care costs in the United States are higher than those in other countries,⁴⁶ research suggests that proportionate cost associations appear to be similar across different health care systems.⁴⁷

CONCLUSION

Adverse events were common among older patients who underwent nonelective abdominal surgery and accounted for 44% of inpatient health care costs. This represents a substantial opportunity for better patient outcomes and cost savings. Given the substantial costs attributable to adverse events, savings may be possible with effective quality improvement programs even if large implementation costs are required. Developing such programs tailored to the needs of high-risk surgical populations should be a priority for clinicians and policy-makers.

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Table 5. Adjusted and attributable costs (2012 \$CDN) associated with hospital mortality, complication severity and loss of independence among patients aged 70 years and older who underwent nonelective abdominal surgery

Adverse events	No. (%)	Adjusted costs, median (IQR)*	Attributable costs, median (IQR)†	p value‡	Total attributable costs for all patients (%)†
Hospital death					
No	198 (93)	9924 (9179–10 730)	—	0.021	135 043 (4)
Yes	14 (7)	14 866 (10 713–20 629)	7535 (5156–14 003)		
Complication severity§					
None	102 (48)	7745 (6893–8702)	—	< 0.001	1 016 668 (30)
Grade I	34 (16)	8858 (7283–10 772)	2364 (1959–3521)		
Grade II	35 (17)	12 838 (10 625–15 512)	5800 (3911–7390)		
Grade III	12 (6)	13 851 (10 079–19 034)	8692 (6268–12 294)		
Grade IV	29 (14)	21 230 (17 115–26 334)	19 092 (14 302–23 641)		
Loss of independence					
No	164 (77)	9353 (8572–10 205)	—	< 0.001	343 155 (10)
Yes	48 (23)	13 691 (11 534–16 251)	6090 (3809–9284)		

ASA = American Society of Anesthesiologists; IQR = interquartile range; OS = operative severity.

*Adjusted for age, ASA classification, frailty Index based on a comprehensive geriatric assessment and OS.

†Estimated based on predicted values using multiple linear regression (log costs = age + ASA classification + frailty index based on a comprehensive geriatric assessment + OS + Clavien–Dindo classification + change in residential status + in-hospital mortality).

‡Multiple linear regression adjusting for age, ASA classification, frailty index based on a comprehensive geriatric assessment, OS, Clavien–Dindo classification, loss of independence, and in-hospital mortality.

§The most severe complication experienced by each patient was used in this analysis.

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