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ARTICLE

Readmissions after radical nephrectomy in a national cohort

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ABSTRACT

Objective: To analyze the factors and costs associated with 30-day readmissions for patients undergoing radical nephrectomy.

Materials and Methods: We used the 2014 Nationwide Readmission Database to identify adults who underwent radical nephrectomy for renal cancer, stratified by surgical approach. We determined patient factors associated with readmission rates, diagnoses, and costs using multivariate logistic regression.

Results: Among 19,523 individuals, the 30-day readmission rate was 7.7% ($n = 1{,}506$). On multivariate regression, odds of readmission were significantly increased with age ≥75 in those who underwent open nephrectomy (OR: 1.35; 95%CI: 1.03–1.78). Subjects with a Charlson comorbidity score ≥3 had significantly higher rates of readmission regardless of surgical approach (Open RN – OR: 1.85; 95%CI: 1.33–2.56; Lap RN – OR: 1.99; 95%CI 1.10–3.59; Robotic RN – OR: 2.18; 95%CI: 1.23–3.86). Common reasons for readmission were gastrointestinal, cardiovascular, urinary tract infections, and wound complications across all surgical approaches. The mean cost per readmission was as high as 126% ($20,357) of the mean index admission cost.

Conclusion: One in 13 adults undergoing radical nephrectomy is readmitted within 30 days of discharge. Associated readmission cost is up to 1.26 times the cost of index admission. Our findings may inform efforts aiming to reduce hospital readmissions and curtail healthcare costs.

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Radical nephrectomy; hospital readmission; national readmission database; postoperative outcomes; kidney; cost

Introduction

The Affordable Care Act aimed to improve health care outcomes while minimizing costs [1]. In 2012, this policy incorporated the Hospital Readmissions Reduction Program to align payment with quality by reducing reimbursement to hospitals with excess rates of hospital readmissions outside the calculated standard deviation [2,3]. This program targets readmissions after hospitalizations for conditions such as acute myocardial infarction or heart failure and uses 30-day post-discharge readmission rates to assess the quality of care and overall hospital performance. Most recently, surgical interventions such as hip and knee replacement were added to the program [2]. Although currently not included, urologic surgical procedures are expected to join this growing list.

Radical nephrectomy remains the standard of care for patients with renal tumors not amenable to partial nephrectomy [4,5]. However, few studies have focused on hospital readmission after radical nephrectomy, and the current literature fails to detail the reasons for readmission, associated costs, and 30-day post-discharge follow-up [6–8].

We sought to evaluate a large cohort of patients undergoing radical nephrectomy stratified by surgical approach to analyze the rates and risk factors for readmission.

Materials and methods

Data source and study population

We utilized data from the 2014 Nationwide Readmissions Database (NRD). The NRD captures all-payer hospital inpatient stays developed as part of the Healthcare Cost and Utilization Project (HCUP) by the Agency for Healthcare Research and Quality. The NRD samples data from 22 states, accounts for nearly 50% of all US hospitalizations, and contains information on patient demographics, comorbidities, hospital characteristics, and admission characteristics. It is a publicly available, de-identified database, and institutional review board approval was obtained at our institution.

We identified hospital discharges for patients ≥18 years old who underwent radical nephrectomy for renal cancer in 2014 using the *International Classification of Disease, 9th revision* (ICD-9) codes. Patients were stratified by surgical approach: open, laparoscopic, and robotic. We excluded patients who died during the index admission, patients with out-of-state residence due to potential loss of follow-up, patients who underwent an emergent radical nephrectomy, and those who were discharged in December because of inadequate follow-up time. We also excluded patients with a

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high disease burden undergoing concomitant procedures such as splenectomy, liver resection, pancreas resection, bowel, or colon resection, or thrombectomy with vascular reconstruction.

Study variables

We analyzed patient characteristics including age, sex, primary payer, median household income, and comorbidity. Comorbidity was graded using the Charlson Comorbidity Index score as implemented by Deyo et al. [9,10] excluding ICD-9 codes for the index cancer diagnosis from the solid tumor category. Admission characteristics included discharge destination and prolonged length of hospital stay (LOS) defined as greater than the median length of stay of initial admission. Hospital characteristics included size and teaching status. Hospital size was categorized using bed number in addition to the region the particular hospital is located. Insurance was broken down into Medicaid, Medicare, private and other. Medicare is a federally sponsored health insurance for Americans 65 years of age and older as well as certain young people with disabilities (Euro). A complete breakdown can be found in the NRD Description of Data Elements.

Outcomes measures

The primary outcome of interest was 30-day all-cause readmission stratified by surgical approach: open, laparoscopic, and robotic. We defined readmission as admission to the same (index) or different (non-index) hospital within 30 days of discharge from the index hospitalization [2]. Readmissions within 24 h of discharge were excluded, as these could have been hospital transfers.

For patients who had multiple readmissions within 30 days, only the first readmission was included. Readmission diagnoses were classified into 1 of 6 groups: gastrointestinal, renal/genitourinary, respiratory, cardiovascular (cardiac, venous thromboembolism (VTE), stroke), wound-related (surgical site infection, dehiscence, fistula, bleeding/hematoma), and sepsis/septicemia. Causes for readmission were classified as ICU-level complications based on Clavien-Dindo stage IV morbidity, which was derived from ICD-9 codes previously described for major urological procedures [11].

Secondary outcomes of interest included patient admission and hospital-level risk factors for readmission as well as readmission costs. Inpatient costs were converted from Nationwide Readmissions Database charges using the hospital-specific cost-to-charge ratios provided by the Nationwide Readmissions Database and adjusted for inflation to 2014 dollars using the medical component of the consumer price index [12].

Statistical analysis

Descriptive statistics were performed, and the data is presented as the median [interquartile range]. Chi-square testing for categorical variables was performed to identify variables that increased the odds of readmission within 30-days based on the surgical approach. To identify independent predictors of readmission, variables significantly associated with readmission ($p < 0.2$) were included in the multivariate model. We generated national estimates using survey weights from the Nationwide Readmissions Database. Statistical significance was indicated by p values <0.05. Statistical analyses were performed using STATA 14 (StataCorp, College Station, TX, USA).

Results

Study population

We identified 27,118 patients who underwent radical nephrectomy for renal cancer. After excluding patients who died during the index admission ($n = 203$), had out-of-state residence ($n = 2,195$), received urgent or emergent radical nephrectomy ($n = 2,447$), had high disease burden ($n = 911$), procedures performed in December ($n = 1,839$), our final cohort included 19,523 patients. Majority of the patients were male (64%) and under the age of 75 (79%). Most operations were performed at teaching hospitals (74%). The 30-day readmission rate was 7.7% ($n = 1,506$).

Incidence, timing, and causes of readmission

In total, 1,506 patients were readmitted, 928 after open (7%), 218 after laparoscopic (8%), and 360 after robotic (9%) nephrectomy. Twenty-nine percent of all readmissions were to a non-index hospital. The median time to readmission was 10 (4–18), 8 (4–17), and 9 (5–17) days for open, laparoscopic, and robotic nephrectomy, respectively ($p > 0.05$). Median LOS for the index procedure was 4 (3–5), 3 (2–4), and 3 (2–4) days and readmission was 4 (2–7), 4 (2–7), and 3 (2–6) days for open, laparoscopic, and robotic surgery, respectively ($p > 0.05$).

GI complications were the most common reason for readmission in open, laparoscopic, and robotic approaches, 20%, 28%, and 23%, respectively. The most common GI-related causes of readmission for the open and laparoscopic approaches were intestinal obstruction (5% and 8%, respectively), while the most common cause was other digestive disorders (7%) in the robotic approach. *Clostridium Difficile* accounted for 2% of readmission causes in both open and robotic approaches and 4% in the laparoscopic approach. Cardiovascular diagnoses were the second most common readmission diagnosis in open (14%) and laparoscopic (19%) surgery, which included CVD (9%), VTE (4%), and stroke (1%) for open and CVD (11%) and VTE (9%) for laparoscopic surgery. Wound-related complications (14%) in open and (10%) in laparoscopic included surgical site infection (6%) and (6%), bleeding/hematoma (3%) and (2%), and dehiscence (3%) and (2%), respectively. Renal/genitourinary (11%) and (16%) readmission diagnoses for open and laparoscopic surgical approaches were the fourth and third most common causes, respectively. Cardiovascular readmission causes after robotic surgery (11%) ranked fourth, including cardiac (7%), VTE (3%), and stroke (1%), while

Table 1. Cause of readmission of US adults readmitted after radical nephrectomy in 2014.

Variable	Open	Laparoscopic	Robotic	p-Value
Not readmitted	11,857 (93)	2,437 (92)	3722 (91)	0.15
Readmitted	928 (7)	218 (8)	360 (9)	
Causes				
Gastrointestinal	188 (20)	61 (28)	81 (23)	0.33
C-difficile	17 (2)	9 (4)	6 (2)	0.34
Other obstruction	43 (5)	21 (10)	8 (2)	0.07
Ileus	1 (0)	1 (1)	6 (2)	0.09
Cardiovascular	137 (14)	42 (19)	39 (11)	0.33
CVD	88 (9)	23 (11)	24 (7)	0.61
VTE	36 (4)	19 (9)	11 (3)	0.23
Stroke	11 (1)	—	3 (1)	0.53
Genitourinary	107 (11)	35 (16)	42 (12)	0.52
Pyelonephritis	9 (1)	—	—	0.43
UTI, NOS	17 (2)	5.0 (2)	19 (6)	0.06
Wound related	129 (14)	22 (10)	40 (12)	0.65
SSI	60 (6)	12 (6)	13 (4)	0.53
Dehiscence	30 (3)	5 (2)	4 (1)	0.52
Bleeding	31 (3)	4 (2)	23 (7)	0.28
Respiratory	71 (8)	5 (3)	28 (8)	0.18
Sepsis	66 (7)	9 (4)	25 (7)	0.61
Readmission timing	Mean	Mean	CI	p-Value
Open vs. laparoscopic	11.7	10.6	−0.72 to 3.0	0.23
Open vs. robotic	11.7	11.1	−1.2 to 2.4	0.52
Laparoscopic vs robotic	10.6	11.1	−2.8 to 1.7	0.64

CVD: cardiovascular disease; VTE: venous thromboembolism; UTI, NOS: urinary tract infection, not otherwise specified; SSI: surgical site infection; CI: confidence interval.

renal/genitourinary diagnosis (12%) and wound-related complications (12%) were second and third most common, respectively (Table 1). The proportion of readmissions attributed to Clavien-Dindo IV (ICU-level) complications was similar for open (5%), laparoscopic (6%), and robotic (4%) approaches.

Risk factors and costs of readmission

Readmitted patients were more likely to have significant differences in all studied variables except for gender, median household income, teaching hospital status, and hospital size (Table 2). After controlling for other covariates, significant clinical predictors of increased odds of readmission in those who underwent open nephrectomy included age ≥75 years, Medicare insurance, Charlson score of 2, Charlson score of ≥3, discharge home with care, LOS above the median, and transfusion. In those who underwent a laparoscopic nephrectomy, increased odds of readmission were seen in Medicare patients, Medicaid patients, and those with a Charlson score of 2 and ≥3. Lastly, increased odds of readmission in the robotic nephrectomy group were only seen in those with a Charlson score of 1 or ≥3 (Table 3).

The total aggregate costs of 30-day readmissions were $30.7 million. The mean cost per readmission after open

Table 2. Baseline characteristics of American adults readmitted after radical nephrectomy in 2014.

Variable	Total patients n = 19,523 (%)	Open RN n = 12,785 (%)	Lap RN n = 2,655 (%)	Robotic RN n = 4,083 (%)	Readmitted vs not readmitted patients: Open p-value	Lap p-value	Robotic p-value
Readmissions	1,506 (8)	928 (7)	218 (8)	360 (9)			
Male	12,460 (64)	8,344 (65)	1,520 (57)	2,596 (64)	0.73	0.69	0.39
Age (years)							
<75	15,388 (79)	10,222 (80)	2,088 (79)	3,078 (75)	<0.001	0.08	0.006
≥75	4,136 (21)	2,563 (20)	569 (21)	1,004 (25)			
Payer							
Private	7,175 (37)	4,857 (38)	891 (34)	1,427 (35)	<0.001	0.02	0.01
Medicare	10,230 (53)	6,478 (51)	1,451 (55)	2,301 (57)			
Medicaid	1,272 (7)	871 (7)	173 (7)	228 (6)			
Other	824 (4)	565 (4)	141 (5)	118 (3)			
Median income by quartile							
≤25th percentile	4,550 (24)	2,746 (22)	742 (28)	1,062 (26)	0.37	0.14	0.24
26th–50th percentile	4,828 (25)	3,179 (25)	575 (22)	1,074 (27)			
51st–75th percentile	5,302 (28)	3,588 (29)	747 (28)	967 (24)			
76th–100th percentile	4,559 (24)	3,085 (25)	545 (21)	929 (23)			
Comorbidity score							
0	9,449 (48)	6,306 (49)	1,265 (48)	1,878 (46)	<0.001	0.002	0.004
1	4,596 (24)	2,962 (23)	626 (24)	1,008 (25)			
2	2,628 (14)	1,706 (13)	376 (14)	546 (13)			
≥3	2,850 (15)	1,810 (14)	390 (15)	650 (16)			
Discharge destination							
Home	16,613 (85)	10,837 (85)	2,268 (85)	3,508 (86)	<0.001	<0.001	0.28
Home with care	1,776 (9)	1,148 (9)	250 (9)	378 (9)			
Nursing facility	1,115 (6)	788 (6)	133 (5)	194 (5)			
Short-term hospital	7 (0)	4 (0)	2 (0)	1 (0)			
Median length of stay							
Below median	10,324 (53)	5,947 (47)	1,665 (63)	2,712 (66)	<0.001	<0.001	0.009
Above median	9,200 (47)	6,838 (54)	992 (37)	1,370 (34)			
Hospital size							
Small	2,359 (12)	1,585 (12)	301 (11)	473 (12)	0.08	0.86	0.88
Medium	5,325 (27)	3,334 (26)	815 (31)	1,176 (29)			
Large	11,839 (61)	7,866 (62)	1,541 (58)	2,432 (60)			
Hospital teaching status							
Nonteaching hospital	5,055 (26)	3,669 (29)	579 (22)	807 (20)	0.22	0.55	0.13
Teaching hospital	14,469 (74)	9,116 (71)	2,077 (78)	3,276 (80)			
Transfusion	1,667 (9)	1,279 (10)	154 (6)	234 (6)	<0.001	0.05	0.04

RN: radical nephrectomy; open: open surgery; lap: laparoscopic surgery; robotic: robotic surgery; hospital size based on bed number and region of hospital (full breakdown found in NRD description of data elements).

Table 3. Multivariate regression of US adults readmitted after radical nephrectomy in 2014.

	Open RN			Lap RN			Robotic RN		
Variable	OR	95% CI	*p*-Value	OR	95% CI	*p*-Value	OR	95% CI	*p*-Value
Sex									
Male	1.09	0.86–1.37	0.48	1.17	0.75–1.83	0.49	0.92	0.58–1.46	0.71
Female		Reference			Reference			Reference	
Age (years)									
<75		Reference			Reference			Reference	
≥75	**1.35**	**1.03–1.78**	**0.03**	1.08	0.66–1.79	0.76	1.50	0.90–2.48	0.12
Insurance									
Private		Reference			Reference			Reference	
Medicare	**1.38**	**1.03–1.84**	**0.03**	**1.90**	**1.06–3.40**	**0.03**	1.69	0.99–2.89	0.06
Medicaid	1.27	0.81–1.98	0.29	**3.15**	**1.15–8.66**	**0.03**	2.36	0.78–7.11	0.13
Other	1.25	0.69–2.25	0.46	2.87	0.97–8.50	0.06	0.76	0.21–2.74	0.67
Median household income									
>75th percentile		Reference			Reference			Reference	
51st–75th percentile	1.24	0.89–1.74	0.21	1.41	0.75–2.63	0.29	1.60	0.91–2.82	0.10
26th–50th percentile	1.20	0.86–1.67	0.28	1.60	0.89–2.88	0.12	1.12	0.62–1.99	0.71
≤25th percentile	1.27	0.91–1.76	0.16	1.82	0.98–1.38	0.06	1.33	0.72–2.46	0.37
Comorbidity score									
0		Reference			Reference			Reference	
1	1.18	0.87–1.58	0.29	1.21	0.66–2.22	0.53	**1.86**	**1.08–3.19**	**0.02**
2	**1.61**	**1.17–2.22**	**0.004**	**1.99**	**1.08–3.67**	**0.03**	1.18	0.55–2.51	0.68
≥3	**1.85**	**1.33–2.56**	**<0.001**	**1.99**	**1.10–3.59**	**0.02**	**2.18**	**1.23–3.86**	**0.008**
Discharge location									
Home without care		Reference			Reference			Reference	
Home with care	**1.69**	**1.24–2.29**	**0.001**	1.50	0.83–2.69	0.18	1.05	0.54–2.03	0.89
Nursing facility	1.56	1.08–2.26	0.02	1.24	0.54–2.88	0.61	0.72	0.29–1.80	0.48
Short-term recovery	4.12	0.34–49.8	0.27	–	–	–	–	–	–
Other	–	–	–	14.69	1.19–182.01	0.04	–	–	–
Length of stay									
Below median stay		Reference			Reference			Reference	
Above median stay	**1.48**	**1.15–1.90**	**0.002**	1.58	0.98–2.55	0.06	1.39	0.83–2.33	0.21
Hospital type									
Non-teaching hospital		Reference			Reference			Reference	
Teaching hospital	1.23	0.91–1.76	0.10	0.85	0.52–1.38	0.51	1.46	0.89–2.41	0.14
Transfusion receipt									
No		Reference			Reference			Reference	
Yes	**1.80**	**1.15–1.90**	**<0.001**	1.19	0.59–2.41	0.63	1.51	0.77–2.96	0.23

RN: radical nephrectomy; open: open surgery; lap: laparoscopic surgery; robotic: robotic surgery; OR: odds ratio; CI: confidence interval. Bold values are represent statistically significant variables that increased the odds for readmission after radical nephrectomy.

approach was $19,720 [standard error of mean (SEM), $700], laparoscopic approach $18,990 (SEM $1,276), and robotic approach $19,168 (SEM $890), which was 126%, 127%, 108%, of the mean cost of the index admission ($15,014–$17,695, SEM $141–242), respectively. There was no significant difference in cost between readmission to the index vs non-index hospital.

Discussion

In this study, we showed higher rates of readmission after radical nephrectomy than previously reported. We identified causes of readmission stratified by surgical approach and analyzed clinical and non-clinical factors associated with increased odds of short-term readmission. Lastly, we report the financial burden associated with readmissions after radical nephrectomy and ways to mitigate readmissions to lower overall cost.

Overall, 7.7% of patients undergoing radical nephrectomy were readmitted. In previous national database analyses, Antorino et al. [6] and Schmid et al. [13] used the American College of Surgeons National Quality Improvement Program (ACS–NSQIP) database and found lower readmission rates of 5.7 and 5.2%, respectively. Similarly, Hwang et al. reported a 4.1% rate in a cohort of patients with clinical stage T3b renal cancer using the National Cancer Database [7]. However, the ACS–NSQIP database only records hospital readmission within 30-days of the date of surgery. Given that patients undergoing radical nephrectomy may require extended hospital stays to recover prior to discharge [6–8], this database likely underestimates the 30-day post-discharge rehospitalization rate. Conversely, the Nationwide Readmission Database captures 30-day post-discharge readmissions, in concordance with the methodology used by HRRP to penalize hospitals, providing a reliable baseline readmission value.

We captured a robust set of patient and hospital factors associated with increased readmission risk (Table 2). Based on the surgical approach, we found that age, insurance status, Charlson scores, discharge location, and transfusion status increase the odds of being readmitted. These findings differ, in part, from the results of prior population-based studies, which did not find a significant association with insurance status and rates of readmission [7,13]. Discrepancies are likely due to our large sample size. Notably, discharge with specialized care or to a nursing facility and receiving treatment at a teaching hospital was associated with a higher likelihood of readmission. Also, greater comorbidity scores and prolonged index hospital stay were associated with increased odds of readmission, in concordance with prior studies [14,15]. We hypothesized that patients admitted to teaching institutions may have more complex medical problems requiring further specialized perioperative treatment, recovery, and rehabilitation. Given these circumstances, standardizing the quality of care and patterns of discharge to nursing facilities may lessen readmission rates. In fact, a systematic review revealed that quality improvement initiatives such as using a hospital pharmacist for medication reconciliation prior to transfer, standardized transfer and follow-up protocols, and empowerment strategies for nursing facility staff was shown to reduce readmissions [16]. In addition, 67% of all readmissions in our study, regardless of surgical approach, were readmitted within 14 days of discharge. Targeted interventions during this time period can play a crucial role in managing risk factors associated with increased rates of readmission. With the growing role of telemedicine, video conference visits can aid in managing care. Initial evidence shows that utilizing telemedicine visits after major urologic surgery increases patient adherence to post-op care, higher urine outputs, and an overall trend of reduced 30-day readmissions [17].

Among reasons for readmission, gastrointestinal comorbidities, cardiac diagnoses, wound-related factors, and renal/-genitourinary complications accounted for more than half and this did not vary significantly between surgical approaches. Strategies targeting these complications may significantly decrease readmission rates and mitigate costs. Gastrointestinal complications were the leading cause of readmission for all three surgical approaches, with up to 51% of readmissions in this category due to digestive problems and ileus. Prior studies have shown that implementation of Enhanced Recovery After Surgery (ERAS) pathways lead to fewer motility-related issues, but its efficacy in patients undergoing radical nephrectomy is not well studied [18]. Similar interventions like avoiding opioid analgesia, early mobilization post operatively, and optimizing the preoperative health of patients have been successful in decreasing ileus and length of stay [19]. Renal and cardiac issues were also prevalent reasons for readmission. For instance, chronic kidney disease has been shown to be a major risk factor for cardiovascular disease [20]. Actually, some research suggests including glomerular filtration rate and proteinuria in the surgical risk stratification may better predict adverse outcomes including cardiac events [21]. This highlights the importance of preoperative assessment of renal function, which may lead to a referral for cardiac clearance prior to surgery and may aid in cardiovascular complications prevention. Additionally, streamlined venous thromboembolism guidelines including medical anticoagulation prophylaxis, pneumatic calf compression devices, and compression stocking has been shown to prevent thromboembolic complications and readmissions in cancer patients [22]. However, the role and potential readmission benefit of extended venous thromboembolic prophylaxis after radical nephrectomy continue to be debated [23]. Furthermore, wound infection may be the most preventable cause of readmission. Perioperative oral cavity cleansing, caregiver education, wound assessment before discharge, early follow-up, and wound care training for medical staff have been shown to reduce readmission for surgical patients [24–26]. Lastly, genitourinary complications are often associated with urinary tract infection secondary to exposure to bowel content, catheterization, and renal insufficiency. Current antibiotic prophylaxis guidelines for radical nephrectomy recommend 24 or fewer hours of treatment which aims to prevent intraoperative infection and decrease the post-procedure risk of *Clostridium difficile* colitis [27]. Although antibiotics are among the most important intervention for genitourinary tract infection prevention, further research on antimicrobial stewardship and optimal antibiotic timing is necessary.

Our study is the first to report associated short-term readmission costs in radical nephrectomy. The total cost of readmissions was $30.7 million during an 11-month period, and patients who were readmitted accrued hospital costs totaling 1.26 times the mean cost of the index admission. This amount is likely increasing yearly if we consider that renal malignancies and subsequent surgical interventions are most common among older adults, who represent a steadily increasing proportion of the United States population [28]. Regardless of future policy changes, our study may be considered as an assessment of the financial burden of readmissions after these procedures which may be used to assess future interventions aimed at quality care improvement. Mitigating risk factors that increase the risk of readmission is the key to reducing the overall cost associated with the management of renal pathology.

The results of our study can be interpreted in the context of several limitations. Information coded by clinicians and administrative staff can contain human errors and under-coding, especially regarding diagnoses not addressed during the course of the admission. Additionally, we were unable to differentiate between elective and unplanned readmissions. Oncologic characteristics, such TNM staging, are not present in this dataset which can influence the decision to perform a radical nephrectomy as well as potential complications that would result in readmissions. Furthermore, emergency department visits after discharge and their associated cost were not accounted for in our dataset. Lastly, adverse outcomes beyond 30-day post-discharge were not recorded in our study.

Conclusion

Readmission after radical nephrectomy is predominantly caused by gastrointestinal, cardiovascular, wound, and genitourinary complications. The associated cost of readmission is up to 1.26 times more than the cost for the index admission. Our findings may be applied to efforts aiming to reduce hospital readmissions and curtail healthcare costs. Further readmission studies are warranted to add evidence to the literature.

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Disclosure statement

No potential conflict of interest was reported by the author(s).

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