Original Investigation

Underlying Reasons Associated With Hospital Readmission Following Surgery in the United States

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IMPORTANCE Financial penalties for readmission have been expanded beyond medical conditions to include surgical procedures. Hospitals are working to reduce readmissions; however, little is known about the reasons for surgical readmission.

OBJECTIVE To characterize the reasons, timing, and factors associated with unplanned postoperative readmissions.

DESIGN, SETTING, AND PARTICIPANTS Patients undergoing surgery at one of 346 continuously enrolled US hospitals participating in the American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) between January 1, 2012, and December 31, 2012, had clinically abstracted information examined. Readmission rates and reasons (ascertained by clinical data abstractors at each hospital) were assessed for all surgical procedures and for 6 representative operations: bariatric procedures, colectomy or proctectomy, hysterectomy, total hip or knee arthroplasty, ventral hernia repair, and lower extremity vascular bypass.

MAIN OUTCOMES AND MEASURES Unplanned 30-day readmission and reason for readmission.

RESULTS The unplanned readmission rate for the 498 875 operations was 5.7%. For the individual procedures, the readmission rate ranged from 3.8% for hysterectomy to 14.9% for lower extremity vascular bypass. The most common reason for unplanned readmission was surgical site infection (SSI) overall (19.5%) and also after colectomy or proctectomy (25.8%), ventral hernia repair (26.5%), hysterectomy (28.8%), arthroplasty (18.8%), and lower extremity vascular bypass (36.4%). Obstruction or ileus was the most common reason for readmission after bariatric surgery (24.5%) and the second most common reason overall (10.3%), after colectomy or proctectomy (18.1%), ventral hernia repair (16.7%), and hysterectomy (13.4%). Only 2.3% of patients were readmitted for the same complication they had experienced during their index hospitalization. Only 3.3% of patients readmitted for SSIs had experienced an SSI during their index hospitalization. There was no time pattern for readmission, and early (≤7 days postdischarge) and late (>7 days postdischarge) readmissions were associated with the same 3 most common reasons: SSI, ileus or obstruction, and bleeding. Patient comorbidities, index surgical admission complications, non-home discharge (hazard ratio [HR], 1.40 [95% CI, 1.35-1.46]), teaching hospital status (HR, 1.14 [95% CI 1.07-1.21]), and higher surgical volume (HR, 1.15 [95% CI, 1.07-1.25]) were associated with a higher risk of hospital readmission.

CONCLUSIONS AND RELEVANCE Readmissions after surgery were associated with new postdischarge complications related to the procedure and not exacerbation of prior index hospitalization complications, suggesting that readmissions after surgery are a measure of postdischarge complications. These data should be considered when developing quality indicators and any policies penalizing hospitals for surgical readmission.

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Readmission as a quality and cost-containment metric is now a major issue for hospitals, clinicians, and policy makers. Although the initial focus was on 3 medical conditions (myocardial infarction, heart failure, and pneumonia),[1-3] the Centers for Medicare & Medicaid Services has since expanded its focus on readmissions to include 2 separate measures related to surgical patients: readmissions following total hip and knee arthroplasty as part of their Hospital Readmissions Reduction Program and hospital-wide readmissions (ie, includes all surgical patients), which are publicly reported.[4] Future inclusion of additional individual operations is anticipated.[5]

Despite the emphasis on readmissions, studies have not comprehensively evaluated the underlying reasons and factors associated with readmissions after surgical hospitalizations using clinical data from a diverse, national sample of hospitals. Limitations of existing studies include the inability to identify a specific valid reason for readmission because of the use of data sources that lack clinical granularity.[6-12] Another gap in the extant literature is insufficient understanding of the relationship between surgical complications occurring during the index surgical admission and the causes for readmission (ie, whether the readmission is related to a complication from the index hospitalization or rather is a new issue that developed after discharge). It is also unclear whether early and late postsurgical readmissions have similar underlying reasons. Identification of the reasons and factors associated with unplanned surgical readmissions can help direct future surgical quality improvement efforts and policy decisions designed to reduce surgical readmission rates.

The American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) collects clinical readmission information, including the primary reason for readmission, a data element that is not available in most other multi-institutional data sources.[12-14] Having prospectively collected information about surgical readmission, ACS NSQIP enables a more precise assessment of the causes for surgical readmission than have been previously reported. The objectives of this study were to characterize the reasons for and timing of readmissions and to examine factors associated with unplanned surgical readmissions.

Methods

Data Source and Study Population

The details of the ACS NSQIP, including sampling strategy, data abstraction procedures, variables collected, outcomes, and structure, are described elsewhere.[15-21] In 2012, ACS NSQIP included 374 adult hospitals, accounting for approximately 10% of all hospitals and 30% of operations performed in the United States. Of those hospitals, 346 were continuously enrolled for the entire study period. In brief, hospitals collect standardized and audited clinical data on patient demographics, preoperative risk factors, laboratory values, operative variables, and postoperative complications for a predefined sample of their patients.[19,20] Trained clinical data abstractors use definitions standardized for all participating institutions. Onsite data audits are regularly performed. Patients are followed up for postoperative outcomes for 30 days after the index operation, irrespective of whether the patient is an inpatient, has been discharged to his or her home or another facility, or has been readmitted to another hospital. Patients are followed up by surgical clinical reviewers at each participating hospital who examine the medical record, query involved clinicians, and contact patients as needed to ascertain the required ACS NSQIP data elements.

Patients undergoing surgery at a continuously enrolled US ACS NSQIP hospital from January 1, 2012, to December 31, 2012, were included in this study. Six representative procedure groups based on *Current Procedural Terminology* (*CPT*) codes[22] (eTable 1 in the Supplement) were also examined: bariatric surgery, colectomy or proctectomy, hysterectomy, total hip or knee arthroplasty, ventral hernia repair, and lower extremity vascular bypass. These procedures were selected based on their clinical and policy relevance, because they are frequently used in public reporting and pay-for-performance programs. The Northwestern University institutional review board deemed this study as exempt.

Readmission Variables

The ACS NSQIP collects data on whether a readmission occurred to the same or a different facility, whether the readmission was planned or unplanned at the time of index discharge, and the primary suspected reason for the readmission. The accuracy of these variables has been examined against physician chart review.[13,14] The data abstractors can review inpatient and outpatient charts, contact other hospitals, and contact patients directly to ascertain whether a readmission occurred.

Consistent with other ACS NSQIP outcomes, readmission events were captured if they occurred within 30 days of the index procedure. A readmission event was defined as unplanned by the hospital's data abstractor if it was not part of the treatment plan at the time of the index procedure discharge per the ACS NSQIP definition.[13,14,23] The analyses focused on unplanned readmissions. The primary reason for readmission was identified as a standard ACS NSQIP postoperative complication (eg, surgical site infection [SSI], myocardial infarction) or, if not in the ACS NSQIP set of standard outcomes collected, a diagnosis classified by an *International Classification of Diseases, Ninth Revision* (*ICD-9*) code.[23] The hospital's clinical data abstractor assigned the reasons for the readmission after review of the entire medical record, discussions with treating physicians and outside hospitals, and contacting the patient directly as needed. Thus, although assigned an *ICD-9* diagnostic code, this was still a clinically abstracted and not administratively coded reason for hospital readmission. Prior research has validated that this assigned reason is concordant with physician case reviews.[13,14] *ICD-9* codes were grouped using the Agency for Healthcare Research and Quality Clinical Classification Software.[24,25] The resulting categories were consolidated with the ACS NSQIP postoperative occurrence categories,

resulting in a total of 18 potential reasons for readmission (eTable 2 in the Supplement).

The most common reasons for unplanned readmission within 30 days of the index procedure were assessed, as well as the proportion of patients readmitted for the same preexisting inpatient complication. In addition, the top 3 reasons for early (within 7 days of discharge) unplanned readmission were compared with those for late (more than 7 days after discharge) readmission.

Hospital Characteristics

Data from the 2010 American Hospital Association Annual Survey were used to evaluate whether certain hospital characteristics were associated with unplanned readmissions. Selected hospital characteristics used in previous studies of health care quality were selected a priori for inclusion in this study[26-32]: hospital ownership, rural hospital designation, resident-to-bed ratio, teaching status designated by the Accreditation Council for Graduate Medical Education (ACGME), hospital volume, and hospital disproportionate share index. Hospitals with inpatient surgical volumes in the lowest quartile were designated as low-volume centers, and those with volumes in the highest quartile were designated as high-volume centers. To evaluate the relationship between a hospital's care of vulnerable populations and readmissions, we used the Medicare disproportionate hospital share index.[33] Using a previously described approach,[34] hospitals with disproportionate hospital share index in the upper quartile were defined as safety net hospitals.

Statistical Analysis

Because ACS NSQIP captures readmission data within 30 days from the index procedure, we used time-to-event modeling using hierarchical Cox proportional hazards models with patients clustered within hospitals to characterize the time from discharge to readmission and to evaluate variables associated with readmissions. The time-to-event interval was measured from the date of surgery to the date of readmission. Patients were censored at 30 days from the index procedure or if they died prior to readmission. To focus on new postdischarge complications causing readmissions (ie, those not simply exacerbations of known complications), patients were excluded from the analyses of factors associated with readmission if they were readmitted for a complication that also occurred during their initial hospital stay. Candidate variables comprised clinical covariates, including the procedure (*CPT* codes), patient demographics, health summary status variables (eg, functional status, American Society of Anesthesiologists [ASA] class), specific comorbidities (eg, heart failure, diabetes), inpatient complications (that occurred during the index hospitalization), discharge destination, hospital characteristics, and hospital disproportionate share status. All variables were entered into the model. The proportionality assumption was confirmed graphically.

To determine the relative strength of association between each covariate and the risk of readmission, variables associated with unplanned readmission were selected into the models using a forward selection process ($P < .05$ as entry criterion). Although this approach offers some indication of the clinical relevance of the variables in predicting readmissions, the method is not specifically designed for this purpose. Variables selected earlier were the most significant of the remaining covariates after adjusting for any already selected covariates. The likelihood ratio test was used to compare all models with the null model. Only variables that had clinical relevance or that had been shown to have an association with readmissions in prior studies were included in the model. Index hospitalization complications, discharge destination, hospital characteristics, and hospital disproportionate share status were added into the models, even if not selected.

Using the individual variables examined in the models above, 5 categories of variables generally considered to be explanatory for readmission were assessed: patient factors, inpatient complications (except if the index hospitalization complication was the reason for the readmission), discharge destination, hospital characteristics, and hospital disproportionate share. The association between these factors (together and individually) and time to readmission was estimated in separate Cox models with robust clustered standard errors to account for hospital-level clustering. The proportion of variation in the outcome explained by these factors was estimated using the Royston R^2 method.[35]

Statistical significance was set at $P < .05$, and all tests were 2-tailed. All analyses were performed using SAS version 9.3 (SAS Institute) and Stata version 13.1MP (StataCorp).

Results

From 346 ACS NSQIP hospitals, 498 875 patients were identified, of which 18 143 underwent bariatric surgery, 35 112 colectomy or proctectomy, 33 895 ventral hernia repair, 25 119 hysterectomy, 38 671 hip or knee arthroplasty, and 6341 lower extremity vascular bypass (**Table 1**). The median length of stay ranged from 0 days for ventral hernia repair to 6 days for colectomy or proctectomy (Table 1). Specific patient characteristics by procedure type are detailed in eTable 3A in the Supplement. Among the 346 hospitals included in this study, 219 (63.3%) were teaching hospitals (eTable 3B in the Supplement).

Across procedure groups, planned readmissions were relatively infrequent, since the all-cause readmission rate of 6.1% closely approximated the unplanned readmission rate of 5.7%. The largest difference between rates of overall and unplanned readmission occurred in the patients undergoing lower extremity vascular bypass, for whom the planned readmission rate was 0.6%. The overall length of stay was 1 day (interquartile range, 0-4 days), and median time to readmission was 8 days (interquartile range, 3-14 days). For the individual procedures, the rate of unplanned readmission ranged from 3.8% after hysterectomy to 14.9% after lower extremity vascular bypass (Table 1).

Table 1. Thirty-Day Readmission Rates, Length of Stay, and Days From Discharge to Readmission Following Surgery

	Procedure						
	Overall (n=498 875)	Bariatric (n=18 143)	Colectomy or Proctectomy (n=35 112)	Ventral Hernia Repair (n=33 895)	Hysterectomy (n=25 119)	Total Hip or Knee Arthroplasty (n=38 671)	Lower Extremity Vascular Bypass (n=6341)
Readmission, No. (%)[a]							
All-cause	30 270 (6.1)	960 (5.3)	3907 (11.1)	1573 (4.6)	982 (3.9)	1719 (4.5)	983 (15.5)
Unplanned	28 541 (5.7)	950 (5.2)	3830 (10.9)	1549 (4.6)	945 (3.8)	1676 (4.3)	944 (14.9)
Length of stay, median (IQR), d[b]	1 (0-4)	2 (1-2)	6 (4-8)	0 (0-2)	1 (1-2)	3 (2-3)	4 (3-7)
Time to unplanned readmission, median (IQR), d[c]	8 (3-14)	8 (3-16)	6 (3-12)	7 (3-14)	7 (3-13)	9 (4-17)	10 (5-16)

Abbreviation: IQR, interquartile range.

[a] Unadjusted.

[b] For index hospitalization.

[c] Number of days from discharge to readmission.

Table 2. Ten Most Frequent Reasons for Unplanned Readmissions After Surgery (Overall and for 6 Selected Procedures)[a]

	Unplanned Readmissions by Reason, in Descending Order Left to Right, No. (%) [95% CI]									
Procedure	1	2	3	4	5	6	7	8	9	10
Overall	SSI	Ileus or obstruction	Bleeding	Pulmonary	VTE	Dehydration or nutrition	Sepsis	CNS or CVA	Pain	Other surgical
	5576 (19.5) [19.1-20.0]	2945 (10.3) [10.0-10.7]	1399 (4.9) [4.7-5.2]	1034 (3.6) [3.4-3.8]	978 (3.4) [3.2-3.6]	922 (3.2) [3.0-3.4]	833 (2.9) [2.7-3.1]	709 (2.5) [2.3-2.7]	694 (2.4) [2.3-2.6]	613 (2.1) [2.0-2.3]
Bariatric (n = 950)	Ileus or obstruction	Dehydration or nutrition	SSI	Pain	Bleeding	VTE	Pulmonary	Sepsis	Other surgical	CNS or CVA
	233 (24.5) [21.8-27.5]	171 (18.0) [15.6-20.4]	108 (11.4) [9.3-13.4]	77 (8.1) [6.4-9.8]	55 (5.8) [4.3-7.3]	47 (5.0) [3.6-6.3]	22 (2.3) [1.4-3.3]	18 (1.9) [1.0-2.8]	14 (1.5) [0.7-2.2]	13 (1.4) [0.6-2.1]
Colectomy or proctectomy (n = 3830)	SSI	Ileus or obstruction	Dehydration or nutrition	Bleeding	VTE	Sepsis	AKI or other GU	Pain	Other surgical	UTI
	990 (25.8) [24.5-27.2]	693 (18.1) [16.9-19.3]	255 (6.7) [5.9-7.4]	156 (4.1) [3.4-4.7]	121 (3.2) [2.6-3.7]	119 (3.1) [2.6-3.70]	115 (3.0) [2.5-3.5]	112 (2.9) [2.4-3.5]	80 (2.1) [1.6-2.5]	78 (2.0) [1.6-2.5]
Ventral hernia repair (n = 1549)	SSI	Ileus or obstruction	Bleeding	VTE	Pain	Pulmonary	CNS or CVA	Dehydration or nutrition	Sepsis	AKI or other GU
	411 (26.5) [24.3-28.7]	259 (16.7) [14.9-18.6]	100 (6.5) [5.2-7.7]	54 (3.5) (2.6-4.4)	53 (3.4) [2.5-4.3]	39 (2.5) [1.7-3.3]	28 (1.8) [1.1-2.5]	26 (1.7) [1.0-2.3]	25 (1.6) [1.0-2.2]	24 (1.5) [0.9-2.2]
Hysterectomy (n = 945)	SSI	Ileus or obstruction	Bleeding	VTE	UTI	Other surgical	Dehydration or nutrition	Pain	Sepsis	CNS or CVA
	272 (28.8) [25.9-31.7]	127 (13.4) [11.3-15.6]	79 (8.4) [6.6-10.1]	57 (6.0) [4.5-7.60]	31 (3.3) [2.1-4.4]	27 (2.9) [1.8-3.9]	23 (2.4) [1.4-3.4]	23 (2.4) [1.4-3.4]	23 (2.4) [1.4-3.4]	21 (2.2) [1.3-3.2]
Total hip or knee arthroplasty (n=1676)	SSI	Graft or prosthesis	VTE	Bleeding	Orthopedic related	Pulmonary	Cardiac	CNS or CVA	Ileus or obstruction	Sepsis
	315 (18.8) [16.9-20.7]	126 (7.5) [6.3-8.8]	105 (6.3) [5.1-7.4]	101 (6.3) [5.1-7.4]	85 (5.1) [4.0-6.1]	54 (3.2) [2.4-4.10]	41 (2.4) [1.7-3.2]	40 (2.4) [1.7-3.1]	38 (2.3) [1.6-3.0]	35 (2.1) [1.4-2.8]
Lower extremity vascular bypass (n = 944)	SSI	Graft or prosthesis	Vascular	Bleeding	Sepsis	Other surgical	Pulmonary	Cardiac	VTE	Other medical
	344 (36.4) [33.4-39.5]	71 (7.5) [5.8-9.2]	62 (6.6) [5.0-8.2]	42 (4.4) [3.1-5.8]	27 (2.9) [1.8-3.9]	24 (2.5) [1.5-3.5]	20 (2.1) [1.2-3.0]	19 (2.0) [1.1-2.9]	18 (1.9) [1.0-2.8]	14 (1.5) [0.7-2.3]

Abbreviations: AKI, acute kidney injury; CNS, central nervous system; CVA, cerebrovascular accident; GU, genitourinary; SSI, surgical site infection; UTI, urinary tract infection; VTE, venous thromboembolism.

[a] See eTable 2 for examples of each category of reasons for readmission. Percentages represent percentage of readmissions for a given procedure group attributable to the particular readmission reason.

The variation in the number of days from discharge to unplanned readmission was estimated across procedures. As a reflection of the variability in when readmissions occurred, the interquartile range of unplanned readmissions was 13 days after bariatric surgery, 11 days after ventral hernia repair, 11 days after lower extremity bypass, 13 days after hip or knee arthroplasty, 10 days after hysterectomy, and 9 days after colectomy or proctectomy. There was no particular peak in when readmissions occurred: The readmissions occurred relatively linearly over the 30-day follow-up period

Table 3. Percentage of Inpatients Readmitted for Preexisting Complications, by Specific Complication[a]

Procedure	No./Total (%) [95% CI]										
	Bleeding	Pulmonary	Sepsis	SSI	Cardiac	CNS or CVA	VTE	AKI or Other GU	UTI	Graft or Prosthesis	Other Surgical
Overall	224/1066 (21.0) [18.6-23.5]	58/932 (6.2) [4.7-7.8]	41/745 (5.5) [3.9-7.1]	164/4920 (3.3) [2.8-3.8]	13/412 (3.2) [1.5-4.9]	15/596 (2.5) [1.3-3.8]	15/822 (1.8) [0.9-2.7]	7/394 (1.8) [0.5-3.1]	6/398 (1.5) [0.3-2.7]	5/533 (0.9) [0.1-1.8]	1/547 (0.2) [0.0-0.5]
Bariatric	4/53 (7.6) [0.2-14.9]	2/22 (9.1) [0.0-22.1]	1/18 (5.6) [0.0-17.3]	3/104 (2.9) [0.0-6.2]	0/5	0/13	1/43 (2.3) [0.0-7.0]	1/4 (25.0) [0.0-100.0]	0/4	0/1	0/14
Colectomy or proctectomy	28/152 (18.4) [12.2-24.7]	3/74 (4.1) [0.0-8.7]	9/119 (7.6) [2.7-12.4]	50/986 (5.1) [3.7-6.4]	2/28 (7.1) [0.0-17.3]	3/43 (7.0) [0.0-14.9]	3/121 (2.5) [0.0-5.3]	1/114 (0.9) [0.0-2.6]	1/78 (1.3) [0.0-3.8]	0/38	0/7938
Ventral hernia repair	6/69 (8.7) [1.9-15.5]	1/28 (3.6) [0.0-10.9]	0/18	7/316 (2.2) [0.6-3.8]	0/7	1/16 (6.3) [0.0-19.6]	0/30	0/17	0/12	0/14	0/20
Hysterectomy	9/52 (17.3) [6.7-27.9]	1/17 (5.9) [0.0-18.4]	2/18 (11.1) [0.0-27.2]	0/196	0/3	0/13	0/44	0/9	2/28 (7.1) [0.0-17.2]	0/0	0/14
Total hip or knee arthroplasty	28/101 (27.7) [18.8-36.6]	2/54 (3.7) [0.0-8.9]	0/35	2/314 (0.6) [0.0-1.5]	1/41 (2.4) [0.0-7.4]	1/40 (2.5) [0.0-7.6]	2/104 (1.9) [0.0-4.6]	0/20	1/25 (4.0) [0.0-12.3]	0/126	1/22 (4.6) [0.0-14.0]
Lower extremity vascular bypass	12/42 (28.6) [14.3-42.8]	0/20	0/27	8/343 (2.3) [0.7-3.9]	2/19 (10.5) [0.0-25.7]	0/11	0/18	0/5	0/3	2/71 (2.8) [0.0-6.8]	0/24

Abbreviations: AKI, acute kidney injury; CNS, central nervous system; CVA, cerebrovascular accident; GU, genitourinary; SSI, surgical site infection; UTI, urinary tract infection; VTE, venous thromboembolism.

[a] "Preexisting complication" indicates that reason for 30-day unplanned readmission is the same as the complication that occurred during the index hospitalization. Numerators represent the number of patients readmitted for the same reason as an index hospitalization complication; denominators represent total numbers of patients readmitted for a given complication reason.

overall and for each of the individual operations examined (eFigure in the Supplement).

Reasons for Unplanned Readmissions

The reasons for unplanned readmissions are shown in **Table 2**. The most common reason for readmission was SSI (19.5%), ranging from 11.4% after bariatric surgery to 36.4% after lower extremity vascular bypass. The most common reason for readmission after bariatric surgery was ileus or obstruction (24.5%), and ileus or obstruction was the second most common reason for readmission overall (10.3%) and for colectomy or proctectomy, ventral hernia repair, and hysterectomy. Other common causes included dehydration or nutritional deficiency, bleeding or anemia, venous thromboembolism, and prosthesis or graft issues (after arthroplasty and lower extremity vascular bypass procedures).

When examining early (within 7 days of discharge) and late (more than 7 days after discharge) unplanned readmissions separately, the top 3 reasons for readmission were similar overall (SSI, ileus or obstruction, and bleeding) and when examining each of the 6 procedure groups individually (eTable 4 in the Supplement).

When examining the percentage of patients readmitted for a complication that also occurred during their index hospitalization (ie, exacerbation of a known issue), the most common reason was bleeding (21.0% of patients readmitted for bleeding also experienced a bleeding-related event during index surgical admission), followed by pulmonary complications (6.2%) and sepsis (5.5%) (**Table 3**). Overall, however, only 2.3% of patients were readmitted for a preexisting complication (ie, reason for readmission also occurred during the index hospitalization). Among patients readmitted for SSIs (the most common reason for readmission overall), only 3.3% of these patients had experienced an SSI during their index hospitalization.

Factors Associated With Unplanned Readmission

The association of patient factors, inpatient complications, discharge destination, and hospital characteristics with unplanned readmissions was examined (**Table 4**). Because we found that patients were rarely readmitted for the same type of complication that they had also experienced during the index surgical admission (2.3%)(Table 3) and most readmissions were attributable to new complications that occurred after discharge, patients readmitted for the same complication they had experienced as an inpatient were excluded from this analysis to focus on postdischarge complications and not simply exacerbations of known issues. Patient factors associated with readmission were higher ASA class, presence of ascites, disseminated cancer, bleeding disorder, renal failure, steroid use, and weight loss. Experiencing an inpatient complication (particularly bleeding, cardiac complication, sepsis, urinary tract infection, and venous thromboembolism) was associated with unplanned readmission (for a different reason). Patients discharged to a location other than home (eg, nursing facility) were also more likely to be readmitted (odds ratio [HR], 1.40 [95% CI, 1.35-1.46]). Although hospital control or ownership was not associated with unplanned readmission, teaching hospitals had a higher likelihood of unplanned readmission (HR, 1.14 [95% CI, 1.07-1.21]). Highest-volume centers also had a higher likelihood of unplanned readmission when compared with low-volume centers (HR, 1.15 [95% CI, 1.07-1.25]). Hospital

Table 4. Factors Associated With Unplanned Readmission for All Inpatient Surgical Cases

	No. of Patients (n = 498 299)[a]	Unplanned Readmission, No. (%) (n = 27 965)	HR (95%CI)	*P* Value
Patient Factors				
Age, y				
<50	161 770	6821 (4.2)	1 [Reference]	
50-64	161 067	8654 (5.4)	1.01 (0.97-1.04)	.78
65-79	132 616	8642 (6.5)	1.05 (1.01-1.09)	.007
≥80	42 846	3848 (9.0)	1.27 (1.21-1.33)	<.001
Sex				
Female	287 438	15 179 (5.3)	1 [Reference]	
Male	210 861	12 786 (6.1)	1.05 (1.03-1.08)	<.001
Race				
White	369 134	20 808 (5.6)	1 [Reference]	
Asian	15 899	694 (4.4)	0.88 (0.81-0.96)	.002
Black	49 565	3497 (7.1)	1.11 (1.07-1.15)	<.001
Hispanic	38 558	1832 (4.8)	1.01 (0.96-1.07)	.60
Others	25 143	1134 (4.5)	0.88 (0.82-0.94)	<.001
ASA class				
I and II	268 930	9087 (3.4)	1 [Reference]	
III	196 727	15 126 (7.7)	1.73 (1.68-1.79)	<.001
IV and V	31 236	3669 (11.8)	2.01 (1.91-2.12)	<.001
NA	1406	83 (5.9)	1.26 (1.01-1.59)	.045
Ascites				
No	495 923	27 661 (5.6)	1 [Reference]	
Yes	2376	304 (12.8)	1.40 (1.25-1.58)	<.001
BMI[b]				
Normal	125 147	7389 (5.9)	1 [Reference]	
Underweight	9241	840 (9.1)	1.16 (1.08-1.24)	<.001
Overweight	153 287	8209 (5.4)	0.96 (0.93-1.00)	.03
Class 1 obese	100 127	5313 (5.3)	0.95 (0.92-0.99)	.008
Classes 2 & 3 obese	103 974	5910 (5.7)	0.95 (0.91-0.98)	.003
NA	6523	304 (4.7)	0.78 (0.69-0.87)	<.001
Congestive heart failure				
No	494 434	27 418 (5.6)	1 [Reference]	
Yes	3865	547 (14.2)	1.24 (1.13-1.35)	<.001
Chronic obstructive pulmonary disease				
No	474 926	25 445 (5.4)	1 [Reference]	
Yes	23 373	2520 (10.8)	1.23 (1.17-1.28)	<.001
Diabetes				
No	421 093	21 499 (5.11)	1 [Reference]	
Yes	77 206	6466 (8.4)	1.15 (1.11-1.18)	<.001
Disseminated cancer				
No	487 765	26 627 (5.5)	1 [Reference]	
Yes	10 534	1338 (12.7)	1.64 (1.54-1.73)	<.001
Dyspnea				
No	463 049	24 777 (5.4)	1 [Reference]	
Yes	35 250	3188 (9.0)	1.11 (1.07-1.16)	<.001

(continued)

Table 4. Factors Associated With Unplanned Readmission for All Inpatient Surgical Cases (continued)

	No. of Patients (n = 498 299)[a]	Unplanned Readmission, No. (%) (n = 27 965)	HR (95%CI)	*P* Value
Emergent case				
No	449 726	24 615 (5.5)	1 [Reference]	
Yes	48 573	3350 (6.9)	1.10 (1.06-1.15)	<.001
Dependent function status				
No	481 187	25 899 (5.4)	1 [Reference]	
Yes	17 112	2066 (12.1)	1.30 (1.23-1.36)	<.001
Hypertension				
No	264 419	11 525 (4.4)	1 [Reference]	
Yes	233 880	16 440 (7.0)	1.11 (1.08-1.14)	<.001
Bleeding disorder				
No	474 100	25 161 (5.3)	1 [Reference]	
Yes	24 199	2804 (11.6)	1.31 (1.26-1.37)	<.001
Wound infection				
No	481 259	25 859 (5.4)	1 [Reference]	
Yes	17 040	2106 (12.4)	1.25 (1.19-1.32)	<.001
Renal failure				
No	489 719	26 730 (5.5)	1 [Reference]	
Yes	8580	1235 (14.4)	1.47 (1.38-1.56)	<.001
Ventilator dependent				
No	496 263	27 846 (5.6)	1 [Reference]	
Yes	2036	119 (5.8)	0.62 (0.52-0.75)	<.001
Peripheral vascular disease				
No	492 336	27 202 (5.5)	1 [Reference]	
Yes	5963	763 (12.8)	1.20 (1.11-1.30)	<.001
SIRS or sepsis or septic shock				
No	470 809	25 531 (5.4)	1 [Reference]	
Yes	27 490	2434 (8.9)	1.16 (1.11-1.22)	<.001
Smoker				
No	406 967	21 934 (5.4)	1 [Reference]	
Yes	91 332	6031 (6.6)	1.16 (1.12-1.19)	<.001
Steroid use				
No	480 374	25 906 (5.4)	1 [Reference]	
Yes	17 925	2059 (11.5)	1.55 (1.48-1.62)	<.001
Weight loss >10%				
No	491 239	27 055 (5.5)	1 [Reference]	
Yes	7060	910 (12.9)	1.42 (1.32-1.52)	<.001
Specialty				
Orthopedics	73 454	2708 (3.7)	1 [Reference]	
Cardiac	3042	304 (10.0)	1.53 (1.35-1.74)	<.001
ENT	8200	248 (3.0)	1.11 (0.98-1.27)	.11
General	265 365	15 756 (5.9)	1.83 (1.75-1.92)	<.001
Neurosurgery	30 075	1595 (5.3)	1.49 (1.39-1.59)	<.001
OB/gyn	30 710	1073 (3.5)	1.43 (1.32-1.54)	<.001
Plastic	12 549	517 (4.1)	1.45 (1.31-1.60)	<.001
Thoracic	6906	571 (8.3)	1.81 (1.65-1.99)	<.001
Urology	25 422	1337 (2.3)	1.56 (1.46-1.68)	<.001
Vascular	42 576	3856 (9.1)	1.54 (1.45-1.63)	<.001

(continued)

Table 4. Factors Associated With Unplanned Readmission for All Inpatient Surgical Cases (continued)

	No. of Patients (n = 498 299)[a]	Unplanned Readmission, No. (%) (n = 27 965)	HR (95%CI)	*P* Value
Index hospitalization complications				
None	445 359	22 474 (5.1)	1 [Reference]	
Bleeding	34 352	3798 (11.1)	1.61 (1.55-1.68)	<.001
CNS or CVA	429	27 (6.3)	0.98 (0.67-1.42)	.91
Cardiac	979	102 (10.4)	1.70 (1.38-2.10)	<.001
AKI or other GU	629	70 (11.1)	1.50 (1.16-1.93)	.002
Graft or prosthesis	71	12 (16.9)	1.15 (0.49-2.69)	.75
Other surgical	24	1 (4.2)	0.99 (0.19-5.30)	.99
Pulmonary	2925	292 (10.0)	1.40 (1.24-1.57)	<.001
SSI	2834	235 (8.3)	1.34 (1.18-1.52)	<.001
Sepsis	7549	625 (8.3)	1.53 (1.40-1.66)	<.001
UTI	2018	204 (10.1)	1.52 (1.32-1.75)	<.001
VTE	1130	125 (11.1)	1.63 (1.36-1.95)	<.001
Discharge destination				
Home	448 586	23 240 (5.2)	1 [Reference]	
Non-home	44 916	4666 (10.4)	1.40 (1.35-1.46)	<.001
NA	4797	59 (1.2)	0.61 (0.48-0.77)	<.001
Hospital Characteristics				
Ownership				
Government	66 070	4218 (6.4)	1 [Reference]	
Investor	12 164	646 (5.3)	0.88 (0.75-1.03)	.11
Nongovernment not-for-profit	411 857	22 814 (5.5)	0.94 (0.87-1.01)	.09
Teaching				
Not ACGME	143 449	6721 (4.7)	1 [Reference]	
ACGME	347 736	20 998 (6.0)	1.14 (1.07-1.21)	<.001
NA	7114	246 (3.5)	0.92 (0.56-1.53)	.76
Surgical (inpatient) volume, cases per year				
≤3960 (lower quartile)	122 269	5593 (4.6)	1 [Reference]	
>3960 to <11 127	242 351	13 524 (5.6)	0.99 (0.93-1.05)	.74
≥11 127 (top quartile)	123 721	8460 (6.8)	1.15 (1.07-1.25)	<.001
NA	9958	388 (3.9)	0.95 (0.63-1.44)	.81
Hospital disproportionate share, %[c]				
<35	364 860	19 692 (5.4)	1 [Reference]	
≥35 (highest quartile)	121 864	7655 (6.3)	1.01 (0.95-1.08)	.65
NA	11 575	618 (5.3)	1.14 (0.98-1.33)	.10

Abbreviations: ACGME, Accreditation Council for Graduate Medical Education; AKI, acute kidney injury; ASA, American Society of Anesthesiologists; BMI, body mass index; CNS, central nervous system; CVA, cerebrovascular accident; ENT, ear, nose, throat; GU, genitourinary; HR, hazard ratio; NA, not available; OB/Gyn, obstetrics and gynecology; SIRS, systemic inflammatory response syndrome; SSI, surgical site infection; UTI, urinary tract infection; VTE, venous thromboembolism.

[a] Patients readmitted for the same reason as index complication were excluded.

[b] Calculated as weight in kilograms divided by height in meters squared (underweight = <18.5, normal = 18.5-24.9, overweight = 25.0-29.9, class I obese = 30.0-34.9, class II & III obese = ≥35).

[c] The disproportionate share patient percentage is equal to the sum of the percentage of Medicare inpatient days attributable to patients eligible for both Medicare Part A and Supplemental Security Income (SSI), and the percentage of total inpatient days attributable to patients eligible for Medicaid but not Medicare Part A.

disproportionate share was not significantly associated with unplanned postsurgical readmission.

Next, the order of selection of variables into the models was assessed using forward selection as a general indicator of the strength of the association between individual variables and readmission. Factors selected earlier were the most significant when adjusting for any already selected covariates. In the overall group of all operations, the factors associated with readmissions selected earliest into the model (same model as in Table 4) included ASA class, index hospitalization complications, and surgical specialty (**Table 5**, eTable 5 in the Supplement). Across the individual procedures, either the specific procedure performed (based on CPT codes) or ASA class were selected earliest for the variables associated with unplanned readmission for 5 of the 6 procedures groups. For lower extremity vascular bypass procedures, discharge destination after the index hospitalization was associated with unplanned readmissions and was the first variable selected into the model. Complications during the index hospitalization were frequently selected early in the overall (second) and the individual procedures models examined (ranging from second for bariatric to tenth for lower extremity vascular bypass).

Last, the relative amount of variation in risk of readmission for categories of variables was examined. Patient factors alone accounted for most of the variation in patient-level out-

Table 5. Variables Included in the Risk-Adjustment Models in Their Order of Selection Into the Models[a]

Fixed Effect	Overall[b]	Bariatric	Colectomy or Proctectomy	Ventral Hernia Repair	Hysterectomy	Total Hip or Knee Arthroplasty	Lower Extremity Vascular Bypass
1	ASA class	*CPT*	*CPT*	ASA class	*CPT*	ASA class	Discharge destination
2	Inpatient complications	Inpatient complications	ASA class	*CPT*	ASA class	*CPT*	Diabetes
3	Specialty	Steroid use	Inpatient complications	Ascites	Smoker	Discharge destination	Renal failure
4	Discharge destination	Race	Discharge destination	Inpatient complications	Inpatient complications	Bleeding disorder	Wound infection
5	Steroid use	Neurologic deficit	Steroid use	Bleeding disorder	Discharge destination	Sex	Surgical (inpatient) volume
6	Disseminated cancer	Surgical (inpatient) volume	Hypertension	Hospital disproportionate share status	Disseminated cancer	Functional status	Emergent case
7	Bleeding disorder	BMI	Disseminated cancer	COPD	Steroid use	COPD	Electronic medical records
8	Renal failure	ASA class	Age group	Emergent case	Renal failure	Age group	BMI
9	Functional status	Bleeding disorder	Bleeding disorder	Track information		Inpatient complications	Cardiac event
10	Surgical (inpatient) volume	Emergent case	COPD	Hypertension		Hypertension	Inpatient complication
11	COPD	ACS Commission on Cancer	Race	Discharge destination		Smoker	Peripheral vascular disease
12	Weight loss	Hospital disproportionate share status	Functional status	Smoker		Surgical (inpatient) volume	Track information
13	Wound infection		Smoker	BMI		ACS Commission on Cancer	SIRS or sepsis or septic shock
14	Age group		Ascites	Renal failure		Steroid use	
15	Smoker		Hospital control	Steroid use		Dyspnea	
16	Diabetes		Surgical (inpatient) volume	Wound infection		Ascites	
17	ACGME		Diabetes			Disseminated cancer	
18	Race					Emergent case	
19	SIRS or sepsis or septic shock						
20	Hypertension						
21	Ascites						
22	Hospital control						
23	BMI						
24	Ventilator dependent						
25	CHF						
26	Emergent case						
27	Dyspnea						
28	Sex						
29	Peripheral vascular disease						
Forced in variables[c]	Hospital disproportionate share status	Discharge destination	Hospital disproportionate share status		Hospital disproportionate share status	Hospital disproportionate share status	Hospital disproportionate share status
							CPT

Abbreviations: ACS, American College of Surgeons; ASA, American Society of Anesthesiology; BMI, body mass index; CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; *CPT*, *Current Procedural Terminology*; SIRS, systemic inflammatory response syndrome.

[a] Same model as in Table 4, but here the order of selection is depicted.

[b] Variables were forced in to the risk adjustment models because they were not selected as important in the stepwise selection process.

[c] Since forward selection was used, all models are nested and include all previous covariates listed. $P < .001$ for likelihood ratio test for all models compared with the null model.

comes (Royston $R^2 = 0.244$) (**Table 6**). Including inpatient complications, discharge destination, hospital characteristics, and hospital disproportionate share in the model did not substantially increase the amount of variation explained (full-model Royston $R^2 = 0.270$). Individual models relying on inpatient complications, discharge destination, hospital characteristics, or hospital disproportionate share explained less than 10% of variation in outcomes.

Table 6. Contribution of Individual Categories in Explaining the Risk of Readmission

Model	R^2
Full model	0.270
Patient factors only	0.244
Inpatient complication only	0.073
Discharge destination only	0.047
Hospital characteristics only	0.021
Disproportionate share (hospital) only	0.004

Reported R^2 is estimated using the Royston measure of explained variation in survival models. Each of the 6 models were estimated using proportional hazards Cox models for which time to event was measured as days from discharge to first readmission. Observations with no readmission within 30 days of discharge were right-censored. All models were estimated with robust clustered standard errors that account for hospital-level clustering.

Discussion

Using clinical data prospectively collected for readmission information from 346 hospitals, we found that readmissions were associated with new postoperative complications that surfaced after discharge in the majority of cases, and 2 complications, SSI (19.5%) and obstruction or ileus (10.3%), were the most frequent reasons for both early and late readmissions.

There are at least 2 main policy implications. First, because most readmissions were attributable to well-described postoperative complications, readmissions after surgery are mostly a proxy measure for postdischarge complications and in effect penalize hospitals twice for postoperative complications (ie, other pay-for-performance programs include postoperative complications such as SSI). Second, the majority of hospital readmissions were related to SSI and ileus. Identifying clinical interventions to reduce the occurrence of these complications to below current levels has been challenging. Thus, implementation of a policy penalizing hospitals for readmitting patients with these complications may be ineffective and even potentially counterproductive, because performance targets without accepted courses of intervention might be more prone to unintended or ineffective behaviors and consequences. Nonetheless, hospitals can use our findings when identifying targets for readmissions reduction efforts.

Prior studies examining surgical readmissions have not detailed the underlying reasons for the readmissions across a broad array of procedures using clinically abstracted data for which the data regarding the readmission reason was ascertained in a standardized fashion from the medical record, from discussions with involved clinicians, and by contacting the patient directly when needed (eTable 6 in the Supplement). The most common reasons for surgical readmissions were SSIs and obstruction or ileus complications, and the remaining reasons for readmission varied based on the individual procedure. Because surgical readmissions are predominantly related to postoperative complications, this information regarding the underlying reason for the readmission can be used by hospitals as they work to develop efforts to reduce readmissions.

Surgical site infections are the leading reason for surgical readmissions. However, it has been challenging to identify solutions resulting in reduced SSI rates. Most hospitals in the United States have high adherence rates for the Surgical Care Improvement Project (SCIP) SSI-prevention process measures; however, compliance with these process measures has not been shown to be strongly associated with reduced SSI rates.[36-38] Moreover, few other SSI best practices have been translated into valid process measures, and SSI reduction projects have shown modest, if any, improvements.[39] Thus, hospitals with high SSI rates or high readmission rates attributable to SSI may find improvement challenging. The existing high rates of SCIP compliance, coupled with our finding that SSI is the leading cause for readmission, indicates that SSI research should be a major priority for the surgical community if postsurgical readmission rates are to be reduced. Implementation of policies requiring reductions in readmissions without understanding how to effect improvement may be counterproductive.

However, there may be several other opportunities to reduce readmissions based on the underlying reasons for readmissions identified in the study. First, many readmissions are attributable to expected complications (eg, dehydration from a stoma after colorectal surgery); thus, better coordination of care with the outpatient care team (eg, close monitoring of stoma output by clinic nurses) could reduce hospital readmissions. Second, minimizing fragmentation in postdischarge care may reduce readmissions: when a patient is initially evaluated at a hospital other than that at which the surgery occurred, ensuring that the physicians from the outside hospital are in communication with the clinicians who treated the patient at the index admission may be beneficial in reducing readmissions.[40] Third, there are widespread concerns regarding the quality of education and discharge instructions provided to patients, as evidenced by several existing quality indicators that measure the quality of discharge instructions and a patient experience measure focused on this topic as well.[41-44] Effective patient education to set the postoperative expectations and warn about potential complications may help reduce readmission rates, but more work is needed to improve the effectiveness of the process. This education process should start preoperatively. Ensuring a postdischarge plan with clear discharge instructions and clear follow-up details may be an opportunity to reduce readmissions and improve patient experience.[45]

Last, although little supporting evidence exists, conceivably, some complications resulting in readmissions could be treated in the outpatient setting rather than necessitating a readmission. For example, SSIs could be treated in an advanced outpatient clinic where wounds could be opened and debrided and peripherally inserted central catheters could even be placed to facilitate intravenous antibiotic administration. This approach would be patient-centered, because avoiding the inconvenience and nosoco-

mial risks of a readmission are important to patients and caregivers. An advanced clinic may also be cost-effective compared with a multiday inpatient readmission, but this should be formally tested. Focusing readmission efforts on reducing postoperative complications and optimizing management of those complications in the outpatient setting offers an opportunity to reduce hospital readmissions, even if the means of actually preventing or reducing the overall rate of some these complications (eg, SSIs) remains uncertain.

Dehydration and fluid or electrolyte abnormalities were an important readmission reason for several operations, particularly bariatric and colorectal surgery. For bariatric surgery, patients may be unable to tolerate oral intake until swelling at their anastomosis subsides, so the readmission occurs for intravenous hydration and electrolyte monitoring. For colorectal surgery, patients often experience dehydration attributable to high ostomy outputs or poor oral intake attributable to prolonged ileus. There are opportunities in which the dehydration could be monitored closely by an outpatient care team or these complications could be treated in the outpatient setting, similar to SSI, if an advanced outpatient clinic were available to deliver fluids and monitor laboratory values.

Prior evaluations of chronic medical conditions have suggested that most readmissions are unrelated to the reason for the index admission.[3] However, surgical patients undergo a discrete invasive event (ie, the operation), which results in complications clearly related to the surgery (eg, SSI), exacerbation of existing comorbidities (eg, fluid overload causing a myocardial infarction in a patient with coronary artery disease), or new organ system complications (eg, renal failure). A prior analysis of Medicare claims data suggested that approximately 70% of readmissions after hospitalizations for surgical procedures were attributable to "medical conditions."[46] However, we found that readmissions were more frequently attributable to complications directly related to the surgery. Moreover, the "medical conditions" in the study by Jencks et al were more likely complications related to the surgery (eg, myocardial infarction due to postoperative fluid overload). Thus, these conditions should not be interpreted as being unrelated to the surgery, and they do reflect potential targets for hospitals working to reduce postsurgical readmissions. Although the study by Jencks et al did attempt to understand why readmissions occurred, Jencks et al relied on administrative diagnosis related group (DRG) codes, which provide incomplete outpatient data for readmissions, to determine why readmissions occurred. In contrast, we were better able to identify why patients were readmitted because this information was specifically collected prospectively by a trained clinical data abstractor at each hospital.

It is also important to note that our readmission rates are lower than those from the study by Jencks et al, and this is partly attributable to differences in the follow-up time frame for readmissions between the 2 studies (ie, 30 days from discharge for Jencks et al vs 30 days from surgery for ACS NSQIP). The difference in rates may also be attributable to differences in the types of hospitals included in our study compared with those included by Jencks et al.

Nearly all readmissions were related to complications that occurred once the patient was discharged, rather than to a failure to treat a complication identified at the index admission or a failure to appropriately coordinate postdischarge care, as evidenced by the variable timing after discharge at which readmissions occurred (ie, no distinct peak readmission day). The reason for readmission was only an exacerbation of a previously identified complication in 2.3% of patients. This differs from the underlying basis for readmissions for medical conditions, such as CHF; readmissions for CHF exacerbations are more common (35%), and the quality of postdischarge coordination of care may be a driving issue.[3] Unlike readmissions occurring after admissions for medical conditions that are often related to coordination of care transitions and social issues,[1,47] our results demonstrate that surgical readmissions are related to well-described complications of surgery.

The timing of unplanned readmissions is also an important consideration when focusing on how to reduce readmissions. For example, if readmissions generally occur within a certain number of days after discharge, then an intervention such as an outpatient clinic visit or house call could be strategically timed to avert potential readmissions, as has been shown effective for patients with CHF.[3,48] Jencks et al postulated that readmissions after surgery could be reduced by providing earlier medical follow-up to mitigate comorbidities and coordinate postdischarge care. However, our findings contradict this suggestion. A peak day or certain time interval by which most readmissions occurred was not evident in our analysis. Rather, readmissions appeared relatively dispersed from discharge to 30 days after surgery. Although early follow-up after hospital discharge has been associated with reduced readmission rates among patients initially hospitalized with heart failure or chronic obstructive pulmonary disease,[49] it is unlikely that early follow-up after surgical discharge on a particular day will reduce readmissions. For example, wound infections can be clinically silent on postoperative day 8 and evident on day 9, so early follow-up on day 7 would not necessarily be helpful in averting or mitigating the complications or the resulting readmission.

Although some may argue that keeping patients in the hospital longer at the index admission may alleviate the potential subsequent readmissions a few days later, our data argue against this hypothesis, because readmissions occurred relatively uniformly over the postoperative period, there was no particular peak postdischarge day on which readmissions occurred, and early and late readmissions had similar underlying reasons. Thus, keeping patients in the hospital a few more days would not eliminate most readmissions after surgery.

This study has certain limitations that should be considered. First, the reason for readmission can be difficult to ascertain; however, our study is the first national comprehensive evaluation, to our knowledge, that offers examination of a clinically abstracted reason for the readmission. The clinical data abstractors at the hospital identified the

reasons for readmission. The reason may be challenging to determine and may be multifactorial, but the reason coded by the abstractors has been validated against physician panel chart reviews.[13,14] Second, although we examined all operations together, we examined only 6 operations separately, and the reasons for readmissions for these operations may not be representative of all operations. Third, this study included only ACS NSQIP participating hospitals and therefore may not be generalizable to all hospitals in the United States. Although ACS NSQIP includes a number of smaller, community hospitals, ACS NSQIP hospitals are not representative of all hospitals in the United States because of the disproportionately higher number of larger, academic centers.

It is important to note that many readmissions may be unavoidable and are actually the correct course of action for surgical patients. Many complications should be treated in the inpatient setting, and surgeons should not be deterred from readmitting patients because of concerns about quality measure performance and resulting penalties.

Conclusions

Readmissions after surgery were mostly associated with postdischarge complications related to the procedure and not with exacerbation of prior index admission complications. Early and late readmissions occurred for similar reasons, and readmissions occurred throughout the postoperative period. Understanding the underlying reasons for readmission, the timing, and the associated factors should help hospitals to undertake targeted quality improvement initiatives to reduce readmissions. However, surgical readmissions mostly reflect postdischarge complications, and readmission rates may be difficult to reduce until effective strategies are put forth to reduce common complications such as SSI. Efforts should focus on reducing complication rates overall than simply those that occur after discharge, and this will subsequently reduce readmission rates as well. Readmissions after surgery may not be an appropriate measure for pay-for-performance programs but rather better suited as measure for hospitals to track internally.

ARTICLE INFORMATION

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REFERENCES

1. Berenson RA, Paulus RA, Kalman NS. Medicare's readmissions-reduction program—a positive alternative. *N Engl J Med*. 2012;366(15):1364-1366.

2. Joynt KE, Orav EJ, Jha AK. Thirty-day readmission rates for Medicare beneficiaries by race and site of care. *JAMA*. 2011;305(7):675-681.

3. Dharmarajan K, Hsieh AF, Lin Z, et al. Diagnoses and timing of 30-day readmissions after hospitalization for heart failure, acute myocardial infarction, or pneumonia. *JAMA*. 2013;309(4):355-363.

4. QualityNet. Overview: Readmission Measures: Publicly reported risk-standardized, 30-day readmission measures for AMI, HF, PN, HWR, and THA/TKA. QualityNet website. http://www.qualitynet.org/dcs/ContentServer?pagename=QnetPublic%2FPage%2FQnetTier3&cid=1219069855273. Accessed June 3, 2013.

5. Fontanarosa PB, McNutt RA. Revisiting hospital readmissions. *JAMA*. 2013;309(4):398-400.

6. Curran T, Zhang JQ, Lo RC, et al. Risk factors and indications for readmission after lower extremity amputation in the American College of Surgeons National Surgical Quality Improvement Program. *J Vasc Surg*. 2014;60(5):1315-1324.

7. Zhang JQ, Curran T, McCallum JC, et al. Risk factors for readmission after lower extremity bypass in the American College of Surgeons National Surgery Quality Improvement Program. *J Vasc Surg*. 2014;59(5):1331-1339.

8. Tsai TC, Joynt KE, Orav EJ, Gawande AA, Jha AK. Variation in surgical-readmission rates and quality of hospital care. *N Engl J Med*. 2013;369(12):1134-1142.

9. Tsai TC, Orav EJ, Joynt KE. Disparities in surgical 30-day readmission rates for Medicare

beneficiaries by race and site of care. *Ann Surg*. 2014;259(6):1086-1090.

10. Girotti ME, Shih T, Revels S, Dimick JB. Racial disparities in readmissions and site of care for major surgery. *J Am Coll Surg*. 2014;218(3):423-430.

11. Fox JP, Suter LG, Wang K, Wang Y, Krumholz HM, Ross JS. Hospital-based, acute care use among patients within 30 days of discharge after coronary artery bypass surgery. *Ann Thorac Surg*. 2013;96(1):96-104.

12. Sacks GD, Dawes AJ, Russell MM, et al. Evaluation of hospital readmissions in surgical patients: do administrative data tell the real story? *JAMA Surg*. 2014;149(8):759-764.

13. Sellers MM, Merkow RP, Halverson A, et al. Validation of new readmission data in the American College of Surgeons National Surgical Quality Improvement Program. *J Am Coll Surg*. 2013;216(3):420-427.

14. Wick EC, Shore AD, Hirose K, et al. Readmission rates and cost following colorectal surgery. *Dis Colon Rectum*. 2011;54(12):1475-1479.

15. Khuri SF, Daley J, Henderson W, et al; National VA Surgical Quality Improvement Program. The Department of Veterans Affairs' NSQIP: the first national, validated, outcome-based, risk-adjusted, and peer-controlled program for the measurement and enhancement of the quality of surgical care. *Ann Surg*. 1998;228(4):491-507.

16. Khuri SF, Henderson WG, Daley J, et al; Principal Investigators of the Patient Safety in Surgery Study. Successful implementation of the Department of Veterans Affairs' National Surgical Quality Improvement Program in the private sector: the Patient Safety in Surgery study. *Ann Surg*. 2008;248(2):329-336.

17. Khuri SF, Henderson WG, Daley J, et al; Principal Site Investigators of the Patient Safety in Surgery Study. The Patient Safety in Surgery study: background, study design, and patient populations. *J Am Coll Surg*. 2007;204(6):1089-1102.

18. American College of Surgeons. *National Surgical Quality Improvement Program: Semiannual Report, July 2012*. Chicago, IL: American College of Surgeons; 2012.

19. American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP). ACS NSQIP: How It Works. ACS NSQIP website. http://site.acsnsqip.org/wp-content/uploads/2012/02/TechnicalPaper1.pdf. Accessed December 3, 2014.

20. 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(2):336-46.

21. Ingraham AM, Richards KE, Hall BL, Ko CY. Quality improvement in surgery: the American College of Surgeons National Surgical Quality Improvement Program approach. *Adv Surg*. 2010;44:251-267.

22. American Medical Association. *CPT 2013: Current Procedural Terminology*. Chicago, IL: American Medical Association; 2013.

23. American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP). Chapter 4: Variable definitions. In: *ACS NSQIP Operations Manual*. Chicago, IL: American College of Surgeons; 2013.

24. Duffy SQ, Elixhauser A, Sommers JP. *Diagnosis and Procedure Combinations in Hospital Inpatient Data: Healthcare Cost and Utilization Project (HCUP 3) Research Note 5*. Rockville, MD: Agency for Healthcare Policy and Research; 1996. AHCPR Publication 96-0047.

25. Cowen ME, Dusseau DJ, Toth BG, Guisinger C, Zodet MW, Shyr Y. Casemix adjustment of managed care claims data using the clinical classification for health policy research method. *Med Care*. 1998;36(7):1108-1113.

26. Bilimoria KY, Bentrem DJ, Stewart AK, Winchester DP, Ko CY. Comparison of commission on cancer-approved and -nonapproved hospitals in the United States: implications for studies that use the National Cancer Data Base. *J Clin Oncol*. 2009;27(25):4177-4181.

27. Bilimoria KY, Chung J, Ju MH, et al. Evaluation of surveillance bias and the validity of the venous thromboembolism quality measure. *JAMA*. 2013;310(14):1482-1489.

28. Werner RM, Bradlow ET. Relationship between Medicare's hospital compare performance measures and mortality rates. *JAMA*. 2006;296(22):2694-2702.

29. Lehrman WG, Elliott MN, Goldstein E, Beckett MK, Klein DJ, Giordano LA. Characteristics of hospitals demonstrating superior performance in patient experience and clinical process measures of care. *Med Care Res Rev*. 2010;67(1):38-55.

30. Schmaltz SP, Williams SC, Chassin MR, Loeb JM, Wachter RM. Hospital performance trends on national quality measures and the association with Joint Commission accreditation. *J Hosp Med*. 2011;6(8):454-461.

31. Brand CA, Barker AL, Morello RT, et al. A review of hospital characteristics associated with improved performance. *Int J Qual Health Care*. 2012;24(5):483-494.

32. Friese CR, Earle CC, Silber JH, Aiken LH. Hospital characteristics, clinical severity, and outcomes for surgical oncology patients. *Surgery*. 2010;147(5):602-609.

33. Centers for Medicare & Medicaid Services (CMS). Disproportionate Share Hospital (DSH): The Medicare DSH Adjustment (42 CFR 412.106). CMS website. http://www.cms.gov/Medicare/Medicare-Fee-for-Service-Payment/AcuteInpatientPPS/dsh.html. 2012. Accessed April 2, 2014.

34. Chatterjee P, Joynt KE, Orav EJ, Jha AK. Patient experience in safety-net hospitals: implications for improving care and value-based purchasing. *Arch Intern Med*. 2012;172(16):1204-1210.

35. Royston P. Explained variation for survival models. *Stata J*. 2006;6(1):83-96.

36. Ingraham AM, Cohen ME, Bilimoria KY, et al. Association of Surgical Care Improvement Project infection-related process measure compliance with risk-adjusted outcomes: implications for quality measurement. *J Am Coll Surg*. 2010;211(6):705-714.

37. Stulberg JJ, Delaney CP, Neuhauser DV, Aron DC, Fu P, Koroukian SM. Adherence to Surgical Care Improvement Project measures and the association with postoperative infections. *JAMA*. 2010;303(24):2479-2485.

38. Hawn MT, Vick CC, Richman J, et al. Surgical site infection prevention: time to move beyond the surgical care improvement program. *Ann Surg*. 2011;254(3):494-499.

39. Tillman M, Wehbe-Janek H, Hodges B, Smythe WR, Papaconstantinou HT. Surgical care improvement project and surgical site infections: can integration in the surgical safety checklist improve quality performance and clinical outcomes? *J Surg Res*. 2013;184(1):150-156.

40. Tsai TC, Orav EJ, Jha AK. Care fragmentation in the postdischarge period: surgical readmissions, distance of travel, and postoperative mortality [published online December 3, 2014]. *JAMA Surg*. doi:10.1001/jamasurg.2014.2071.

41. National Quality Foundation (NQF). Venous Thromboemolism Warfarin Discharge Instructions (VTE-5 NwnoLaD). NQF website. http://www.qualityforum.org/Home.aspx. 2014. Accessed January 13, 2015.

42. National Quality Foundation (NQF). Heart Failure: Detailed Discharge Instructions (HF-1 NwnoLaD). NQF website. http://www.qualityforum.org/Home.aspx. 2014.

43. Alper J, Hernandez L. *Facilitating Patient Understanding of Discharge Instructions: Workshop Summary*. Washington, DC: Institute of Medicine; 2014.

44. Hospital Compare. Survey of Patients' Experiences. Medicare.gov website. http://www.medicare.gov/hospitalcompare/Data/Overview.html?AspxAutoDetectCookieSupport=1. Accessed December 14, 2014.

45. Detsky AS, Krumholz HM. Reducing the trauma of hospitalization. *JAMA*. 2014;311(21):2169-2170.

46. Jencks SF, Williams MV, Coleman EA. Rehospitalizations among patients in the Medicare fee-for-service program. *N Engl J Med*. 2009;360(14):1418-1428.

47. McCarthy D, Johnson MB, Audet AM. Recasting readmissions by placing the hospital role in community context. *JAMA*. 2013;309(4):351-352.

48. Hernandez AF, Greiner MA, Fonarow GC, et al. Relationship between early physician follow-up and 30-day readmission among Medicare beneficiaries hospitalized for heart failure. *JAMA*. 2010;303(17):1716-1722.

49. Sharma G, Kuo YF, Freeman JL, Zhang DD, Goodwin JS. Outpatient follow-up visit and 30-day emergency department visit and readmission in patients hospitalized for chronic obstructive pulmonary disease. *Arch Intern Med*. 2010;170(18):1664-1670.