Understanding Variation in 30-Day Surgical Readmission in the Era of Accountable Care
Effect of the Patient, Surgeon, and Surgical Subspecialties

Faiz Gani, MBBS; Donald J. Lucas, MD, MPH; Yuhree Kim, MD, MPH; Eric B. Schneider, PhD; Timothy M. Pawlik, MD, MPH, PhD

IMPORTANCE Readmission is a target area of quality improvement in surgery. While variation in readmission is common, to our knowledge, no study has specifically examined the underlying etiology of this variation among a variety of surgical procedures performed in a large academic medical center.

OBJECTIVE To quantify the variability in 30-day readmission attributable to patient, surgeon, and surgical subspecialty levels in patients undergoing a major surgical procedure.

DESIGN, SETTING, AND PARTICIPANTS Retrospective analysis of administrative claims data of patients discharged following a major surgical procedure at a tertiary care center between January 1, 2009, and December 31, 2013. A total of 22,559 patients were included in this study and underwent a major surgical procedure performed by 56 surgeons practicing in 8 surgical subspecialties.

MAIN OUTCOMES AND MEASURES In-hospital morbidity, 30-day readmission, and proportional variation in 30-day readmission at patient, surgeon, and surgical subspecialty levels.

RESULTS Among the 22,559 patients in this study, patient age, race/ethnicity, and payer type differed across surgical subspecialties. Preoperative comorbidity was common and noted in 65.1% of patients. Postoperative complications were noted in 21.6% of patients varying from 2.1% following breast, melanoma or endocrine surgery to 37.0% following cardiac surgery. The overall 30-day readmission was 13.2% (n = 2975). Readmission varied considerably across the 8 different surgical subspecialties, ranging from 24.8% following transplant surgery (n = 557) to 2.1% following breast, melanoma, or endocrine surgery (n = 32). After adjusting for patient- and surgeon-level variables, factors associated with readmission included African American race/ethnicity (odds ratio, 1.23; 95% CI, 1.11-1.36; P < .001), increasing comorbidity (Charlson Comorbidity Index score of 1: odds ratio, 1.16; 95% CI, 1.02-1.32; P = .02; and a Charlson Comorbidity Index score of 2-3: odds ratio, 1.38; 95% CI, 1.24-1.53; P < .001), postoperative complication (odds ratio, 1.19; 95% CI, 1.08-1.32; P = .003), and an extended length of stay (odds ratio, 1.78; 95% CI, 1.61-1.96; P < .001). The majority of the variation in readmission was attributable to patient-related factors (82.8%) while surgical subspecialty accounted for 14.5% of the variability, and individual surgeon-level factors accounted for 2.8%.

CONCLUSIONS AND RELEVANCE Readmission occurred in more than 1 in 10 patients, with considerable variation across surgical subspecialties. Variation in readmission was overwhelmingly owing to patient-level factors while only a minority of the variation was attributable to factors at the surgical subspecialty and individual surgeon levels.

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Readmission has been targeted as a potential area of quality improvement that could also help decrease health care costs. Readmission has become a particularly important topic for physicians and hospitals given the Centers for Medicare and Medicaid Hospital Readmission Reductions Program (HRRP). Under the HRRP, hospitals with higher than expected readmission rates incur financial penalties in the form of decreased remuneration. Additionally, hospital-wide readmissions are made publicly available as a quality measure for patient care. While the HRRP has largely focused on 3 medical conditions (myocardial infarction, pneumonia, and heart failure), the Centers for Medicare and Medicaid has expanded the HRRP to include total hip and knee arthroplasty, with additional surgical procedures to be incorporated in the near future.

Readmission following surgery can vary considerably, with the reported incidence of readmission ranging from 3.8% to 41.0%. Factors that may account for this variability are poorly understood and may be associated with patient-, surgeon-, and hospital-level factors. For example, patient-level factors, such as age and preoperative medical comorbidity, have been noted to influence the risk of 30-day readmission following surgery. Although less extensively studied, factors pertaining to the surgeon, surgical subspecialty, and hospital may also be important effect modifiers of readmission risk. Specifically, surgeon-level factors, such as a surgeon’s subspecialty and operative case volume, may be important in understanding variations in readmission. While several studies have examined surgeon or hospital volumes and their relation to readmission, these studies have largely focused on isolated procedures. In addition, most of these data have used nationally administrative data sets. While these data sets provide a large cohort and adequate sample size, they lack the granularity to examine surgeon-specific variation. In addition, almost all previous studies on readmission have used standard univariable and multivariable analyses rather than hierarchical modeling. While univariable and multivariable analyses are limited to the finite number of variables available for analysis, a hierarchical approach allows for quality improvement efforts to be targeted at the appropriate level of care, even when all relevant variables are not explicitly known. Given this, the objective of the current study was to characterize the variability in the incidence of readmission across a large quaternary academic surgical department. In addition, we sought to define factors associated with readmission as well as to quantitate the variability in readmission attributable to the patient, surgeon, and surgical subspecialty using hierarchical modeling.

Methods

Data Sources and Patient Population
Data were collected for all patients discharged following a major therapeutic procedure defined by the Agency for Healthcare Research and Quality and performed in the care of 1 of 8 surgical specialties included in the Department of Surgery at Johns Hopkins Hospital (JHH) from January 1, 2009, through December 31, 2013. Patients who did not survive to hospital discharge were excluded from the study. Twenty-five diagnostic and procedural codes for the index hospitalization and subsequent readmission as coded by the International Classification of Diseases, Ninth Revision coding lexicon were used to collect and categorize data. Patient comorbidity was defined according to the Charlson Comorbidity Index (CCI) and categorized into 3 groups (ie, 0, 1, or ≥2). Index hospitalization was defined as the inpatient admission during which the surgical procedure was performed. Readmission was defined as rehospitalization at JHH within 30 days of discharge from the index hospitalization. Planned readmissions (eg, chemotherapy) were excluded. The JHH Institutional Review Board approved this study; individual patient consent was waived and not required.

Surgeon Volume and Length of Stay
To explore the effect of surgical volume on readmission, a mean annual surgical volume was calculated for each surgeon by dividing the total number of cases performed by the number of years active. Because JHH is a high-volume quaternary care center, previously used values categorizing surgical volume in nationwide samples as high or low did not provide appropriate cutoffs for stratifying surgeon volume. Cutoffs were explored by using JHH specialty-specific median values for surgical volume (Table 1). The length of stay (LOS) for each surgical subspecialty was dichotomized at the 75th percentile and categorized as expected LOS vs extended LOS.

Statistical Analysis
Categorical variables were compared using the Pearson χ² test while continuous variables were compared using the nonparametric Kruskal-Wallis test. To study the potential association of patient- and surgeon-level factors with 30-day readmission, a multilevel multivariable logistic regression model was built with random intercepts at the surgeon and the surgical subspecialty levels. The multilevel hierarchical logistic model was used to identify the independent proportion of variability attributable to each level of the hierarchical structure (eg, surgical service or individual surgeon) while minimizing the effects of dependency between observations within the sampling clusters. Following definitions for a logistic distribution, the overall patient variance was constrained to π²/3. Null (no explanatory variables) and full (relevant explanatory variables) models were used to obtain cluster-level variances at each level. These cluster-level variances were then used to calculate the relative proportions of variance in 30-day readmission attributable to each level within the model (ie, surgical service, individual surgeon, and patient). All tests of statistical significance were 2-sided and defined by an a priori P value of less than .05. Statistical analyses were performed using the GLLAMM package for STATA statistical software, version 12.1, for Windows (StataCorp).
### Table 1. Sociodemographic and Clinical Characteristics of Patients Discharged From 2009 to 2013

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Surgical Subspecialty, No. (%)</th>
<th>Total 4578 (20.3)</th>
<th>4217 (18.7)</th>
<th>1665 (7.4)</th>
<th>4403 (19.5)</th>
<th>1539 (6.8)</th>
<th>1791 (7.9)</th>
<th>2249 (10.0)</th>
<th>2117 (9.4)</th>
<th>22 559 (100.0)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>4578 (20.3)</td>
<td>4217 (18.7)</td>
<td>1665 (7.4)</td>
<td>4403 (19.5)</td>
<td>1539 (6.8)</td>
<td>1791 (7.9)</td>
<td>2249 (10.0)</td>
<td>2117 (9.4)</td>
<td>22 559 (100.0)</td>
</tr>
<tr>
<td><strong>Age, median (IQR), y</strong></td>
<td></td>
<td>63 (53-71)</td>
<td>54 (43-66)</td>
<td>40 (26-56)</td>
<td>60 (49-69)</td>
<td>52 (40-61)</td>
<td>61 (51-69)</td>
<td>53 (41-61)</td>
<td>63 (49-73)</td>
<td>58 (46-68)</td>
</tr>
<tr>
<td><strong>Sex</strong></td>
<td></td>
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</tr>
<tr>
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<td></td>
<td>3040 (66.4)</td>
<td>1978 (46.9)</td>
<td>1034 (62.1)</td>
<td>2152 (48.9)</td>
<td>351 (22.8)</td>
<td>932 (52.0)</td>
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<td>1140 (53.9)</td>
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<td>2239 (53.0)</td>
<td>631 (37.9)</td>
<td>2251 (51.1)</td>
<td>1188 (77.2)</td>
<td>859 (48.0)</td>
<td>996 (44.3)</td>
<td>977 (46.2)</td>
<td>10 679 (47.3)</td>
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<td><strong>Race/ethnicity</strong></td>
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<tr>
<td>White</td>
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<td>3506 (76.6)</td>
<td>3186 (75.6)</td>
<td>556 (33.4)</td>
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<td>89 (2.1)</td>
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<td>15 (0.7)</td>
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<td>African American</td>
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<td>671 (14.7)</td>
<td>720 (17.1)</td>
<td>949 (57.0)</td>
<td>606 (13.8)</td>
<td>318 (20.7)</td>
<td>262 (14.6)</td>
<td>671 (29.8)</td>
<td>587 (27.7)</td>
<td>4784 (21.2)</td>
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<td>309 (6.8)</td>
<td>222 (5.3)</td>
<td>136 (8.1)</td>
<td>273 (6.2)</td>
<td>103 (6.7)</td>
<td>84 (4.7)</td>
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<td>95 (4.5)</td>
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<tr>
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<td>1672 (38.0)</td>
<td>694 (45.1)</td>
<td>634 (35.4)</td>
<td>545 (24.2)</td>
<td>518 (24.5)</td>
<td>7307 (32.4)</td>
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<td>763 (16.7)</td>
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<td>233 (14.0)</td>
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<td>437 (28.4)</td>
<td>361 (20.2)</td>
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<td>4112 (18.2)</td>
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<td>289 (6.9)</td>
<td>757 (45.5)</td>
<td>262 (6.0)</td>
<td>64 (4.2)</td>
<td>96 (5.4)</td>
<td>90 (4.0)</td>
<td>197 (9.3)</td>
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<td>Medicare</td>
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<td>1443 (22.8)</td>
<td>275 (17.9)</td>
<td>634 (35.4)</td>
<td>935 (41.6)</td>
<td>998 (47.1)</td>
<td>7617 (33.8)</td>
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<td>209 (4.6)</td>
<td>146 (3.5)</td>
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<td>137 (3.1)</td>
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<td>56 (3.1)</td>
<td>407 (18.1)</td>
<td>97 (4.6)</td>
<td>1154 (5.1)</td>
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<tr>
<td>0</td>
<td></td>
<td>1078 (23.6)</td>
<td>2236 (53.0)</td>
<td>1073 (64.4)</td>
<td>1324 (30.1)</td>
<td>649 (42.2)</td>
<td>391 (21.8)</td>
<td>574 (25.5)</td>
<td>554 (26.2)</td>
<td>7879 (34.9)</td>
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<td>1</td>
<td></td>
<td>1453 (31.7)</td>
<td>680 (16.1)</td>
<td>324 (19.5)</td>
<td>552 (11.9)</td>
<td>184 (12.0)</td>
<td>216 (12.1)</td>
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<td>557 (26.3)</td>
<td>4081 (18.1)</td>
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<td>≥2</td>
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<td>2047 (44.7)</td>
<td>1301 (30.9)</td>
<td>268 (16.1)</td>
<td>2557 (58.1)</td>
<td>706 (45.9)</td>
<td>1184 (66.1)</td>
<td>1530 (68.0)</td>
<td>1006 (47.5)</td>
<td>10599 (47.0)</td>
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<tr>
<td><strong>Volume</strong></td>
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<td></td>
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<td></td>
<td></td>
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<tr>
<td>High</td>
<td></td>
<td>925 (20.2)</td>
<td>830 (19.7)</td>
<td>872 (52.4)</td>
<td>2004 (45.5)</td>
<td>55 (3.6)</td>
<td>571 (31.9)</td>
<td>934 (41.5)</td>
<td>917 (44.3)</td>
<td>7128 (31.6)</td>
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<tr>
<td>Very high</td>
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<td>3653 (79.8)</td>
<td>3387 (80.3)</td>
<td>793 (47.6)</td>
<td>2399 (54.5)</td>
<td>1484 (96.4)</td>
<td>1220 (68.1)</td>
<td>1315 (58.5)</td>
<td>1180 (55.7)</td>
<td>15431 (68.4)</td>
</tr>
</tbody>
</table>

Abbreviations: CCI, Charlson Comorbidity Index; BME, breast, melanoma, and endocrine surgery; GIS, gastrointestinal surgery; HMO, health maintenance organization; HPB, hepatopancreaticobiliary surgery; IQR, interquartile range.

*a* By surgical service based on the following mean annual surgeon volumes: cardiac surgery (n > 200); GIS (n > 100); trauma surgery (n > 50); HPB (n > 100); BME (n > 28); thoracic surgery (n > 104); transplant surgery (n > 80); and vascular surgery (n > 84).

*b* By surgical service based on the following mean annual surgeon volumes: cardiac surgery (n < 200); GIS (n < 100); trauma surgery (n < 50); HPB (n < 100); BME (n < 28); thoracic surgery (n < 104); transplant surgery (n < 80); and vascular surgery (n < 84).
Variation in 30-Day Surgical Readmission in the Era of Accountable Care

Original Investigation Research

Table 2. Median LOS, Postoperative Morbidity, Readmission Within 30 Days of Discharge, and Median Time to Readmission for Patients Discharged From 2009 to 2013

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Surgical Subspecialty</th>
<th>Cardiac</th>
<th>GIS</th>
<th>Trauma</th>
<th>HPB</th>
<th>BME</th>
<th>Thoracic</th>
<th>Transplant</th>
<th>Vascular</th>
<th>Total</th>
<th>P Value</th>
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</thead>
<tbody>
<tr>
<td>LOS of index admission, median (IQR), d</td>
<td></td>
<td>8 (6–13)</td>
<td>6 (3–10)</td>
<td>5 (2–10)</td>
<td>6 (4–10)</td>
<td>1 (1–1)</td>
<td>5 (3–8)</td>
<td>8 (4–14)</td>
<td>3 (1–8)</td>
<td>6 (3–10)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Any complication, No. (%)</td>
<td></td>
<td>1695 (37.0)</td>
<td>704 (16.7)</td>
<td>327 (19.6)</td>
<td>764 (17.4)</td>
<td>32 (2.1)</td>
<td>304 (17.0)</td>
<td>643 (28.6)</td>
<td>401 (18.9)</td>
<td>4870 (21.6)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>30-d Readmission, No. (%)</td>
<td></td>
<td>438 (9.6)</td>
<td>663 (15.7)</td>
<td>187 (11.2)</td>
<td>899 (15.5)</td>
<td>32 (2.1)</td>
<td>171 (9.6)</td>
<td>557 (24.8)</td>
<td>241 (11.4)</td>
<td>2975 (13.2)</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

Abbreviations: BME, breast, melanoma, and endocrine surgery; GIS, gastrointestinal surgery; HPB, hepatopancreaticobiliary surgery; IQR, interquartile range; LOS, length of stay.

Results

Sociodemographic Patient Characteristics
A total of 22,559 patients treated by 56 surgeons representing 8 surgical subspecialties at JHH were identified (Table 1). The median age of the overall cohort was 58 years (interquartile range [IQR], 46–68 years), with most patients being male (n = 11,880; 52.7%). Most patients were white (n = 15,909; 70.5%) followed by African American (n = 4,784; 21.2%) and Asian (n = 520; 2.3%) individuals. Government or private insurance were the predominant types of insurance coverage (n = 21,189; 93.9%), with Medicare being the most common payertype (n = 7,617; 33.8%). Comorbidities were common in patients who were and were not readmitted. However, differences by race/ethnicity were noted. Specifically, 16.6% of African American patients were readmitted compared with 12.3% of white patients (P < .001). Not surprisingly, a larger proportion of patients insured with Medicare were readmitted compared with patients covered by commercial insurance (15.1% vs 12.0%; P < .001). Also, sicker patients, specifically those with a CCI score of 2 or higher, were proportionally more likely to be readmitted than those presenting with a CCI score of less than 2 (16.0% vs 10.7%; P < .001). Readmitted patients were proportionally more likely to have incurred a postoperative complication during their index hospitalization compared with patients who were not readmitted (30.4% vs 20.3%; P < .001; Table 3). Similarly, patients readmitted were more likely to have had an extended LOS for their index hospitalization (36.5% vs 21.5%; P < .001). Patients seen by a very high–volume surgeon were proportionately less likely to have been readmitted within 30 days (68.9% vs 65.5%; P < .001).

Substantial variation in 30-day readmission was noted across the different subspecialties (Figure). For example, while 2.1% of patients undergoing BME surgery were readmitted, the proportion of patients readmitted within 30 days following hepatopancreaticobiliary surgery (n = 686; 15.5%), cardiac (n = 438; 9.6%), or transplant (n = 557; 24.8%) surgery was much higher (Figure). Considerable variation in 30-day readmission was noted even within each surgical subspecialty, with individual surgeons having varied rates of readmission in any given subspecialty (Figure). For example, surgeon-specific readmission rates ranged from 9.1% to 32.9% among transplant surgeons, 11.4% to 30.0% among hepatopancreaticobiliary surgeons, and 2.1% to 24.3% among vascular surgeons (Figure).

Patient Outcomes: LOS, Postoperative Complications, and Readmission
Across the entire cohort, the median LOS for the index hospitalization was 6 days (IQR, 3–10 days). The LOS was longest among patients undergoing cardiac (median LOS, 8 days; IQR, 6–13 days) or transplant (median LOS, 8 days; IQR, 4–14 days) surgery. In contrast, the LOS was shortest among patients undergoing BME procedures (median LOS, 1 day; Table 2). Overall, 4,870 patients experienced at least 1 complication, for an overall postoperative morbidity of 21.6%. The incidence of postoperative morbidity ranged from 37.0% among patients undergoing cardiac surgery (n = 1,695) to a low of 2.1% among patients undergoing BME procedures (n = 32; Table 2).

The overall 30-day readmission was 13.2% (n = 2,975). There were no significant differences in age or sex between patients who were and were not readmitted. However, differences by race/ethnicity were noted. Specifically, 16.6% of African American patients were readmitted compared with 12.3% of white patients (P < .001). Not surprisingly, a larger proportion of patients insured with Medicare were readmitted compared with patients covered by commercial insurance (15.1% vs 12.0%; P < .001). Also, sicker patients, specifically those with a CCI score of 2 or higher, were proportionally more likely to be readmitted than those presenting with a CCI score of less than 2 (16.0% vs 10.7%; P < .001). Readmitted patients were proportionally more likely to have incurred a postoperative complication during their index hospitalization compared with patients who were not readmitted (30.4% vs 20.3%; P < .001; Table 3). Similarly, patients readmitted were more likely to have had an extended LOS for their index hospitalization (36.5% vs 21.5%; P < .001). Patients seen by a very high–volume surgeon were proportionately less likely to have been readmitted within 30 days (68.9% vs 65.5%; P < .001).

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Multivariable Analysis of 30-Day Readmission
The effects of patient- and hospital-level characteristics on 30-day readmission were assessed using a multivariable multilevel logistic regression model that explicitly accounted for correlations in 30-day readmission among patients treated by the same surgeon of a particular subspecialty (Table 4). Race/ethnicity–based differences in the odds of readmission were noted even within each surgical subspecialty, with individual surgeons having varied rates of readmission in any given subspecialty (Figure). For example, surgeon-specific readmission rates ranged from 9.1% to 32.9% among transplant surgeons, 11.4% to 30.0% among hepatopancreaticobiliary surgeons, and 2.1% to 24.3% among vascular surgeons (Figure).
Insurance status was also associated with greater odds for readmission, with Medicare enrollees demonstrating a 15% greater odds of readmission compared with commercially insured patients (OR, 1.15; 95% CI, 1.03-1.29; \( P = .01 \)). The presence of a preexisting comorbidity was associated with a stepwise increase in the odds of 30-day readmission. Specifically, compared with individuals having no comorbid illness, patients with a CCI score of 1 demonstrated a 16% greater odds of readmission (OR, 1.16; 95% CI, 1.02-1.32; \( P = .02 \)) and patients with a CCI score of 2 or higher demonstrated a 38% greater odds of readmission (OR, 1.38; 95% CI, 1.24-1.53; \( P < .001 \)). Furthermore, patients who developed a postoperative complication demonstrated a 19% greater odds of readmission following surgery (OR, 1.19; 95% CI, 1.08-1.32; \( P = .001 \)) compared with those who did not develop a postoperative complication. Among all variables, extended LOS was the strongest predictor of 30-day readmission, with patients who had an extended LOS demonstrating a 78% greater odds of readmission compared with patients whose LOS was within the expected range (OR, 1.78; 95% CI, 1.61-1.96; \( P < .001 \)). However, no effect of surgeon volume on readmission was noted within the different surgical specialties (OR, 0.92; 95% CI, 0.76-1.12; \( P = .42 \)).

Cluster-level variances were used to calculate the proportion of 30-day readmission attributable to patient, surgeon, or surgical subspecialty levels. In the unadjusted model without any explanatory variables, 84.1% of the variation in 30-day readmissions was related to patient-specific factors while 12.1% and 3.8% of the variation was accounted for by factors.
related to the surgical subspecialty and individual surgeon, respectively. After accounting for patient- and hospital-level factors, 82.8% of the variability in 30-day readmission was attributable to nonmodifiable factors at the patient level while 14.5% of the variation was attributable to the surgical subspecialty and only 2.8% was attributable to the individual surgeon.

Discussion

Reducing hospital readmission has been identified as an important cost-containment metric by the Centers for Medicare and Medicaid Services. Not only are readmission rates used to determine financial compensation but they also serve as a publicly available quality parameter. Readmission can be viewed as an interplay of a variety of factors at multiple levels across the health care system. The Donabedian quality of care framework conceptualizes these factors into those related to structure or process and relates them to outcomes (ie, 30-day surgical readmission). Structural factors can be represented by hospital organization, hospital volume, and surgeon volume while process elements include surgical or clinical care pathways. Although previous reports have associated surgical readmission with patient-, physician-, or hospital-specific factors, to our knowledge, this is the first study to explicitly quantify variation in 30-day readmission following multiple surgical procedures at the patient, surgeon, and surgical subspecialty levels. The assessment of relative contributions demonstrated that more than 80% of the variability in 30-day surgical readmission was attributable to the level of the individual patient. Comparatively, only 14.5% of the variability was associated with surgical service while less than 3% of the overall variability was accounted for by the individual surgeon. On multivariable analysis, patient comorbidity, race/ethnicity, insurance status, a longer LOS, and the development of a postoperative complication were associated with greater odds for a 30-day readmission. The use of readmission as a quality parameter is based on the underlying premise that it accurately represents the ability of a hospital to provide care and appropriately discharge patients. Similar to findings of this study, recent evidence has demonstrated that readmission may in fact be largely a function of nonmodifiable patient factors, such as lower socioeconomic conditions and poor access to care.

Identified social factors and unmet functional needs to be associated with greater odds for 30-day readmission. Considering the postdischarge care required by patients who undergo surgery, the effect of these social factors may in fact be magnified for surgical readmissions. Contribution of such social factors to readmission is further reiterated by studies reporting racial/ethnic disparities in surgical readmissions. In their analysis of national Medicare data, Tsai et al reported a greater odds for readmission among African American patients compared with white patients. Particularly higher odds of readmission were noted in African American patients treated at minority-serving hospitals. Other studies have quantified this disparity, demonstrating that minority-serving hospitals incur a readmission penalty at approximately 3-fold higher than nonminority-serving hospitals. This study reports similar findings in that even after adjusting for patient and procedure factors, African American patients demonstrated a 23% greater odds for readmission. Our study adds to this field and highlights the need for further studies to ensure that minority-serving hospitals are not subject to increased penalties under the HRRP. Additionally, findings of this study support growing concerns that rather than being a surrogate for quality of care, readmissions may actually represent hospital usage and access to care driven largely by factors at the patient level, independent of physician-level variability.

Consistent with previous research, this study observed greater odds for readmission in patients who developed a postoperative complication during their index hospitalization. Further, similar to findings by Lucas and colleagues, patients with an extended LOS demonstrated greater odds of readmission within 30 days. The association between LOS and readmission may possibly be a result of postoperative complications or a function of greater preoperative patient comorbidity. The latter was supported by greater odds of readmission observed in patients with increasing comorbidity. Similar to findings of this study, Greysen et al reported that a worse preoperative functional status was independently associated with a 70% greater odds of readmission. Intuitively,
one might expect that hospitals caring for a higher propor-
tion of sicker patients would have a higher readmission and, 
therefore, be at greater risk for financial penalties.37 Not 
surprisingly, safety net hospitals and large academic centers 
are among hospitals most likely to be penalized for hospital 
readmission.38,39 This disproportional penalization of hospi-
tals catering to vulnerable populations may in fact serve to 
widens current health care disparities rather than improving 
the quality of patient care.9,39

This study analyzed a broad spectrum of surgical 
patients treated by high-volume surgeons at a tertiary care 
hospital and demonstrated that more than 80% of the vari-
ability associated with the likelihood of 30-day readmission 
after surgical intervention is at the level of the individual 
patient. Further, more than 80% of the remaining variability 
was associated with the surgical service, suggesting that 
disease- and procedure-related factors may also drive read-
mission while only less than 3% of the overall variability is 
accounted for by the surgeon. Variability attributed to the 
surgical subspecialty may actually represent patient-level 
variability with regard to disease pathology and the specific 
therapeutic procedures performed. Patients presenting with 
more aggressive pathology/disease severity may require 
more extensive radical surgeries associated with a higher 
risk of readmission. In contrast, odds of readmission for a 
specific procedure may vary by pathology.40 In their review of 
patients undergoing a pancreaticoduodenectomy, Ahmad 
and colleagues40 noted that patients with chronic pancreati-
tis demonstrated greater odds for readmission relative to 
patients undergoing pancreaticoduodenectomy for other 
pathologies. Moving forward, efforts should focus on under-
standing the complex interplay of factors at the level of the 
patient, disease, and procedure that may drive readmission. 
With more than 80% of readmissions accounted for by 
factors at the patient level, additional emphasis must be placed 
on understanding nonmodifiable patient-specific variables 
driving readmission.

The current study should be interpreted with several 
limitations. First, although the use of administrative claims 
data allowed for a large sample of patients, it lacked specific 
details regarding patients’ socioeconomic status, peri-
operative course, and a more granular understanding of 
underlying disease processes, all which may affect 
readmission.16,41 To account for this limitation, we used 
modeling techniques that allowed for the quantification of vari-
ability without the need to explicitly identify all important vari-
able at each level.20 Second, this study represented the 
experiences at 1 tertiary care hospital with its own unique pa-
tient mix. Therefore, the results may not be generalizable to 
the entire population; however, data from the current study 
can provide important insight to challenges faced by hospi-
tals with similar characteristics and case mixes in regards to 
the assessment of 30-day readmission.

Conclusions

Significant variability was noted in 30-day readmission fol-
lowing surgical procedures. Although some of this variability 
can be explained by differences in disease pathology and the 
type of procedure performed, the overwhelming majority of 
this variability was attributable to nonmodifiable patient-
level factors. Although implementation of the HRRP has 
seen a decrease in hospital readmission, our study echoes 
growing concerns regarding the use of readmission as a qual-
ity metric based on its current methods.36,42,43 Iterations of 
this program in the future will need to use appropriate sta-

tistical modeling of readmission to account for patient case 
mix, disease severity, and social factors outside the care of 
the hospital to ensure that appropriate penalties are based on 
the quality of care. Doing so will not only decrease the 
financial burden on the health care system but, more impor-
tantly, provide greater and more appropriate incentives for 
improving patient care.

REFERENCES
Variation in 30-Day Surgical Readmission in the Era of Accountable Care

Original Investigation | Research

Invited Commentary

Variation Reduction to Reduce Readmission: A Figment of Imagination or Reality of the Future?

Sharon M. Weber, MD; Gregory D. Kennedy, MD, PhD

One of the principles of the Six Sigma methodology is variation reduction. Since the publication of the Institute of Medicine’s monograph, “To Err Is Human: Building a Safer Health System,” health care systems and the Centers for Medicare and Medicaid Services have been interested in reducing variation through the application of standard process measures in an attempt to achieve the following 6 pillars of high-quality health care: safety, timeliness, effectiveness, efficiency, equity, and patient centeredness. The standardization of process measures and management pathways has clearly led to improved results in many clinical situations. However, we face a significant problem in medicine, referred to as common cause variation in the principles of the Six Sigma. This is the variation introduced by uncontrollable patient factors. The study by Gani et al addresses a gap in knowledge regarding the problem of readmission. This article tackles the issue of variation introduced by uncontrollable patient factors. The authors discuss the importance of considering patient factors in the analysis of readmission rates. They highlight the need for a comprehensive approach that considers both hospital and surgeon factors to improve outcome following rectal cancer resection. The article emphasizes the role of administrative claims–derived data set, including the lack of subspecialty–specific factors. There are limitations in this administrative claims-derived data set, including the lack of

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