Variations in 30-day readmissions and length of stay among spine surgeons: a national study of elective spine surgery among US Medicare beneficiaries

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OBJECTIVE Pay-for-performance programs are targeting hospital readmissions. These programs have an underlying assumption that readmissions are due to provider practice patterns that can be modified by a reduction in reimbursement. However, there are limited data to support the role of providers in influencing readmissions. To study this, the authors examined variations in readmission rates by spine surgeon within 30 days among Medicare beneficiaries undergoing elective lumbar spine surgery for degenerative conditions.

METHODS The authors applied validated ICD-9-CM algorithms to 2003–2007 Medicare data to select beneficiaries undergoing elective inpatient lumbar spine surgery for degenerative conditions. Mixed models, adjusting for patient demographics, comorbidities, and surgery type, were used to estimate risk of 30-day readmission by the surgeon. Length of stay (LOS) was also studied using these same models.

RESULTS A total of 39,884 beneficiaries were operated on by 3987 spine surgeons. The mean readmission rate was 7.2%. The mean LOS was 3.1 days. After adjusting for patient characteristics and surgery type, 1 surgeon had readmission rates significantly below the mean, and only 5 surgeons had readmission rates significantly above the mean. In contrast, for LOS, the patients of 288 surgeons (7.2%) had LOS significantly lower than the mean, and the patients of 397 surgeons (10.0%) had LOS significantly above the mean. These findings were robust to adjustments for surgeon characteristics and clustering by hospital. Similarly, hospital characteristics were not significantly associated with readmission rates, but LOS was associated with hospital for-profit status and size.

CONCLUSIONS The authors found almost no variations in readmission rates by surgeon. These findings suggest that surgeon practice patterns do not affect the risk of readmission. Likewise, no significant variation in readmission rates by hospital characteristics were found. Strategies to reduce readmissions would be better targeted at factors other than providers.

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KEYWORDS 30-day readmissions; length of stay; spine surgery

READMISSIONS for Medicare beneficiaries within 30 days of discharge are frequent and costly.¹⁷ Some readmissions may represent poor quality of care,¹⁶ and the risk of readmission varies among hospitals, suggesting that reduction in readmissions is possible.¹⁷ Therefore, both private payers and the Centers for Medicare and Medicaid Services (CMS) have initiated programs aimed at reducing readmissions. Some of these programs, such as the CMS Hospital Readmission Reduction Program

(HRRP), hold hospitals accountable for reducing readmissions among the medical and surgical patients they discharge.⁸ Hospitals may transfer this accountability to their physicians. However, physicians are also increasingly being held directly accountable for readmissions. For example, the CMS Quality Payment Program (QPP) holds physicians accountable for their patients' readmissions,⁷ as does public reporting of quality data by individual physicians.⁴ Despite this, it is unclear if placing accountability

ABBREVIATIONS CMS = Centers for Medicare and Medicaid Services; GLMM = generalized linear mixed model; LOS = length of stay; MEDPAR = Medicare Provider Analysis and Review.

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for readmissions on physicians is justified, because there are limited data to show that physician practice patterns influence readmissions.

The purpose of this study was to evaluate the role of physicians, and specifically spine surgeons, in readmission rates after elective lumbar spine surgery for degenerative conditions in a national study of US Medicare beneficiaries. Because variations in length of stay (LOS) have been shown to be associated with surgeon practice patterns in other populations, we also evaluated the variation in LOS in the same Medicare cohort.¹⁵

Methods

Study Population and Data Source

Medicare claims were provided by CMS, including Medicare Provider Analysis and Review (MEDPAR) hospital claims, outpatient clinic claims, carrier physician claims, and Denominator enrollment files, which were linked by beneficiary identifier and date from 2003 to 2007. This study was approved by our institutional review board. We used published and validated ICD-9-CM algorithms to select patients who underwent elective nonurgent lumbar spine surgery for degenerative conditions such as lumbar stenosis in the lumbosacral spine.^{8,16,17} Lumbar fusion and nonfusion procedures were included.

We excluded beneficiaries who were enrolled in a Health Maintenance Organization because some of their claims may not have been in the Medicare database.³⁰ In addition, we required that all beneficiaries be continuously enrolled in Medicare from 1 year before the index surgical admission to 30 days after discharge in order to capture all relevant codes. Since reoperations could be associated with our outcomes, we excluded beneficiaries whose index admission codes indicated a reoperation. Because of the lack of sensitivity of the reoperation codes,⁸ we used the year prior to the index surgical admission as a “washout period” and excluded any beneficiaries who underwent spine surgery within the year prior to the index qualifying surgery.

Patient Characteristics

We used MEDPAR, Denominator, and Vital Status files to determine patient characteristics, including race or ethnicity, census region, and dual Medicare and state buy-in Medicaid eligibility. Comorbid conditions were identified using ICD-9-CM diagnosis codes associated with the index hospital admission. Comorbid conditions were defined according to Deyo et al.’s¹⁰ adaptation of the Charlson Comorbidity Index.⁹

Type of Surgery and Surgical Approach

Type of surgery and surgical approach were defined using the published and validated ICD-9-CM algorithms for lumbar spine.^{8,16,17} For fusion procedures, the number of levels fused was further stratified using ICD-9-CM procedure codes.^{5,12} Fusion procedures were categorized in 3 ways: 1) nonfusion procedure (baseline for comparison); 2) fusion, 1–3 levels; or 3) fusion, ≥ 4 levels. All surgical procedures were performed from a posterior approach. Although the discectomy code (ICD-9-CM 80.51) does

not specify the approach, when this code was used alone in the lumbosacral spine (without any other procedure code denoting surgical approach), the procedure was classified as posterior.

Surgeon and Hospital Characteristics

Surgeon characteristics were obtained from the American Medical Association’s Physician Professional Database. Surgeons were included if they were orthopedic surgeons or neurosurgeons and had hospital claims associated with the admission for lumbar spine surgery in our defined cohort. Year of training was defined as years from completing residency to the hospital admission. Surgeon volume was defined solely on the number of elective lumbar spine surgery cases for degenerative conditions per year among Medicare beneficiaries. Hospital characteristics were obtained from the American Hospital Association’s hospital survey. Hospital characteristics included hospital volume of elective lumbar spine surgeries per year, hospital size (number of beds), hospital for-profit status, and Council of Teaching Hospitals affiliation.

Thirty-Day Readmissions and Reasons for Readmissions

Thirty-day readmissions were defined as all readmissions to a short-term acute care hospital within 30 days of discharge among beneficiaries who were discharged alive from the index admission. Readmissions for rehabilitation were excluded (ICD-9-CM code V57). Because 30-day readmissions are currently counted after an inpatient hospital stay, all included surgeries were inpatient admissions.

Length of Stay

The LOS was defined as the number of days from the index hospital admission to the index hospital discharge.

Data Analysis

We chose a modeling method that would address the inferential needs presented by the data we collected and the question at hand. Generalized linear mixed models (GLMMs) are well suited for this investigation. First, GLMMs support both dichotomous outcomes (for 30-day readmissions) and count outcomes (for LOS) by what we call the logistic mixed model (LogMM) and the Poisson mixed model (PoiMM), respectively. Second, GLMMs handle clustered outcomes which, in this case, are due to the lack of independence between patients treated at the same hospital and/or by the same surgeon.

For each outcome, we fit a series of models of increasing complexity, which helps us assess the effect of patient and treatment characteristics as well as the relative magnitude of surgeon and hospital characteristics and clustering variation. We fit the first model with clustering for surgeon and an intercept only; i.e., no covariates. We fit the second model with clustering for surgeon and adjusting for the following covariates: age, sex, race, dual Medicare and Medicaid enrollment, census division, Charlson-Deyo Comorbidity Index, and surgery. We fit a third model with clustering for surgeon and hospital, including the same covariates as the second model. Finally, we fit a fourth model with clustering for surgeon and hospital, includ-

TABLE 1. Characteristics in 39,884 patients with elective lumbar spine surgery

Characteristic	No.	Percent
Age (yrs)		
66–70	12,808	32.1
71–75	11,595	29.1
76–80	9,317	23.4
81–90	6,164	15.5
Female sex	22,329	56.0
Race		
White	37,661	94.5
Black	1,274	3.2
Other	949	2.3
Medicaid eligible	2,181	5.5
Comorbidities, Charlson-Deyo Index		
0	22,326	56.0
1	12,252	30.7
≥2	5,306	13.3
Readmitted w/in 30 days	2,884	7.2
Median LOS in days (IQR)	3.0 (1.0–4.0)	

ing the same covariates as the second and third models, plus surgeon volume, surgeon specialty, surgeon years of training, hospital volume, number of hospital beds, hospital for-profit status, and hospital medical school affiliation (Council of Teaching Hospitals affiliation). We used the second model for our results, and we used the third and fourth models for sensitivity analysis.

Results

Between 2004 and 2007, 39,884 Medicare beneficiaries underwent elective lumbar surgeries for degenerative conditions. These surgeries were performed by 3987 spine surgeons (orthopedic surgeons and neurosurgeons). Patient characteristics are listed in Table 1. The majority of the cohort was female (56%) and white (94.5%). A total of 5.5% had joint Medicare/Medicaid status, which is an indicator of low socioeconomic status. The majority of the cohort was healthy; 13.3% had ≥ 2 comorbidities.

Type of surgery, surgeon characteristics, and hospital characteristics are listed in Table 2. Overall, 60.8% of surgeons were neurosurgeons. Surgeons were divided into tertiles based on years of training and number of cases per year (< 12, 12–24, and > 24 Medicare elective lumbar surgeries per year). The majority of hospitals had not-for-profit status. Hospitals were also divided into tertiles based on hospital volume of Medicare cases per year. Hospital size ranged from < 100 beds to ≥ 300 beds. Approximately one-third of the hospitals were 100–199 beds in size. Just over half of hospitals were affiliated with medical schools (53.0%).

Thirty-Day Readmissions

The mean 30-day readmission rate was 7.2%. After adjusting for patient characteristics and type of surgery, 1

TABLE 2. Type of surgery, surgeon characteristics, and hospital characteristics in 39,884 patients with elective lumbar spine surgery

Variable	No.	Percent
Type of surgery		
Levels fused		
None	23,257	58.3
1–3 levels	14,041	35.2
≥4 levels	2,586	6.5
Surgeon and hospital characteristics		
Surgeon vol of Medicare lumbar cases per yr		
<12	10,370	26.0
12–24	14,089	35.3
>24	15,425	38.7
Surgeon yr of training		
1956–1988	13,043	33.5
1989–1996	12,803	32.9
1997 or later	13,039	33.5
Surgeon specialty		
Neurosurgeon	24,246	60.8
Orthopedic surgeon	15,638	39.2
Hospital vol of Medicare lumbar cases per yr		
<40	12,912	32.4
40–79	14,644	36.7
≥80	12,328	30.9
Hospital size (no. of beds)		
1–99	7,566	19.2
100–199	12,989	32.9
200–299	9,113	23.1
≥300	9,768	24.8
Hospital for-profit status		
For profit	5,989	15.2
Not for profit	30,394	76.9
Government	3,134	7.9
Council of Teaching Hospitals affiliation	20,928	53.0

surgeon had a 30-day readmission rate below the mean and only 5 surgeons had a readmission rate significantly above the mean (Fig. 1). Our findings were robust to adjustments for surgeon characteristics and clustering within hospitals. Hospital characteristics (volume, size, for-profit status, and medical school affiliation) were not significantly associated with 30-day readmission rates.

Length of Stay

The mean LOS was 3.1 days (SD 2.2). The median LOS was 3.0 days (IQR 1.0–4.0 days). Among those who were readmitted within 30 days, the mean LOS was 3.8 days (SD 3.0, median 3.0 days, IQR 3.0). There was no significant correlation between LOS and 30-day readmission (Spearman's rank correlation coefficient 0.1).

After adjusting for patient characteristics and type of surgery, we noted significant variations in LOS by sur-

FIG. 1. Variation in risk of 30-day readmission by spine surgeon. The dotted line represents an odds ratio of 1. Each individual spine surgeon's estimates of risk of readmission are presented as vertical bars (gray and black). The black line connects the mean estimated odds ratio for each spine surgeon, and the height of the bars represents the upper and lower 95% confidence intervals. The black bars represent spine surgeons who have 95% confidence intervals for the odds of readmission within 30 days that are above or below 1.

geon. We found that 7.2% of surgeons ($n = 288$) had significantly shorter LOS and 10% had significantly longer LOS ($n = 397$) than the mean (Fig. 2). In addition, we found significant variation in LOS by hospital for-profit status and size, with for-profit hospital status associated with shorter LOS ($p = 0.005$), but larger hospital size associated with longer LOS ($p < 0.001$).

Discussion

Among our cohort of 39,884 Medicare beneficiaries undergoing elective lumbar spine surgeries, we found no significant variation in readmission rates by spine surgeon. This suggests that individual surgeon practice patterns do not significantly impact the risk of readmission, and is consistent with prior research that showed that physicians do not impact risk of readmission for medical inpatients and that patient factors contribute the most to the risk of readmission.^{11,15} In addition, studies of unplanned readmissions after spine surgery have shown significant associations with patient race, comorbid conditions, preoperative diagnoses, and complications after surgical procedures.^{1-3,13,19,21,23,26,29} Variations by spine surgeon specialty have been studied, but no significant differences were noted between orthopedic and neurological surgeons in spine surgery.^{22,24,25} Our findings suggest that patient characteristics may be important factors influencing readmission rates. Programs that target physicians to reduce readmission rates may have limited effectiveness.

In contrast, we found significant variations in LOS by spine surgeons, even after adjustment for patient and hos-

pital factors. We found no correlation between LOS and readmission rates. This is also consistent with previous research, and points to surgical practice patterns contributing to LOS.^{15,28} Goodwin et al. and Krell et al. separately showed that LOS for hospitalized patients varies by physician, even after adjustment for patient factors.^{14,20} Caminiti et al. then showed that LOS could be reduced by placing accountability on physicians.⁶ As hospitals try to meet the challenge of providing more care in the face of declining reimbursement,²⁷ our findings represent an opportunity for spine surgeons to impact the cost of care by decreasing variation in their clinical practice to also decrease LOS. Our finding of no significant correlation between LOS and readmission rates has also been described before among medical readmissions,¹⁸ and is reassuring because quality improvement to reduce LOS would be unlikely to have the unintended consequence of increasing readmission rates.

We found similar findings in studying hospital characteristics. Hospital volume of lumbar spine surgery, size, for-profit status, and medical school affiliation were not significantly associated with readmission rates. However, size and for-profit status were significantly associated with LOS.

Our study has limitations. It is an observational study and susceptible to bias and confounding. We studied Medicare beneficiaries; our findings may not apply to a younger population. Our study is limited by use of ICD-9-CM codes and their lack of detailed descriptions of surgical procedures, but we limited our sample to elective lumbar spine surgeries only, and stratified the sample by

FIG. 2. Variation in LOS by spine surgeon. The *dotted line* represents the average LOS normalized to a value of 1. Each individual spine surgeon's estimates of LOS in multiples of the mean are presented as *vertical bars* (gray and black). The *black line* connects the mean estimated LOS for each spine surgeon, and the height of the bars represents the upper and lower 95% confidence intervals. The *black bars* represent spine surgeons who have 95% confidence intervals for the LOS that are above or below the normalized average of 1.

the number of levels fused. Surgeon volume could only be defined using elective lumbar spine surgeries for degenerative conditions, but spine surgeons would typically perform surgery in other levels of the spine as well. This data set did not include the number of spine surgeries performed in all populations—for example, among patients with private insurance or younger patients. Spine surgery volume for urgent spine conditions was not counted. Hospital characteristics were also limited to those included in the data set, and other factors may play a role in these outcomes. Despite these limitations, use of this Medicare data set allowed us to follow patients longitudinally to determine the 30-day readmission rates. Our study data precedes major policy changes impacting readmissions, such as the Hospital Readmission Reduction Program, but is still relevant because readmissions have been a persistent issue.

Conclusions

Our study shows that individual spine surgeons did not significantly influence variations in 30-day readmission rates, after adjusting for patient and hospital characteristics. However, similar to other studies of hospital LOS, individual spine surgeons did significantly influence variations in LOS. Our findings suggest that efforts to reduce readmission rates targeted at individual spine surgeons may have limited effectiveness.

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Disclosures

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Author Contributions

Conception and design: Wang, Singh. Acquisition of data: Wang, Sparapani. Analysis and interpretation of data: all authors. Drafting the article: all authors. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Wang. Statistical analysis: all authors. Administrative/technical/material support: Wang. Study supervision: Wang.

Supplemental Information

Previous Presentations

This study was presented at the CNS Annual Meeting in New Orleans, Louisiana (oral presentation), 2015.

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