Patient out-of-pocket spending in cranial neurosurgery: single-institution analysis of 6569 consecutive cases and literature review

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OBJECTIVE With drastic changes to the health insurance market, patient cost sharing has significantly increased in recent years. However, the patient financial burden, or out-of-pocket (OOP) costs, for surgical procedures is poorly understood. The goal of this study was to analyze patient OOP spending in cranial neurosurgery and identify drivers of OOP spending growth.

METHODS For 6569 consecutive patients who underwent cranial neurosurgery from 2013 to 2016 at the authors' institution, the authors created univariate and multivariate mixed-effects models to investigate the effect of patient demographic and clinical factors on patient OOP spending. The authors examined OOP payments stratified into 10 subsets of case categories and created a generalized linear model to study the growth of OOP spending over time.

RESULTS In the multivariate model, case categories (craniotomy for pain, tumor, and vascular lesions), commercial insurance, and out-of-network plans were significant predictors of higher OOP payments for patients (all $p < 0.05$). Patient spending varied substantially across procedure types, with patients undergoing craniotomy for pain ($\$1151 \pm \$209$) having the highest mean OOP payments. On average, commercially insured patients spent nearly twice as much in OOP payments as the overall population. From 2013 to 2016, the mean patient OOP spending increased 17%, from \$598 to \$698 per patient encounter. Commercially insured patients experienced more significant growth in OOP spending, with a cumulative rate of growth of 42% (\$991 in 2013 to \$1403 in 2016).

CONCLUSIONS Even after controlling for inflation, case-mix differences, and partial fiscal periods, OOP spending for cranial neurosurgery patients significantly increased from 2013 to 2016. The mean OOP spending for commercially insured neurosurgical patients exceeded \$1400 in 2016, with an average annual growth rate of 13%. As patient cost sharing in health insurance plans becomes more prevalent, patients and providers must consider the potential financial burden for patients receiving specialized neurosurgical care.

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KEYWORDS cost transparency; cost sharing; out-of-pocket costs; patient payments; health care economics

HEALTH care spending in the United States is the highest in the world and continues to rise at a pace that exceeds total economic growth.¹⁵ In this evolving health care environment, patient out-of-pocket (OOP) costs totaled \$352.5 billion dollars in 2016, representing 11% of total US health care spending.⁵ Additionally, total patient OOP spending grew nearly 4% in 2016, the fastest rate of growth since 2007 and twice the average annual growth rate of the previous decade. OOP spending is projected to grow to \$542.3 billion by 2025 due to

increasing costs of health care delivery and the changing infrastructure of insurance plans.¹²

The high cost of health care continues to be a persistent concern among the general public.⁷ According to a report from the Kaiser Family Foundation, 1 in every 4 adults, including those with private or employer-sponsored insurance, struggles to pay for medical bills.⁹ In fact, medical debt is consistently cited as one of the leading causes of bankruptcies in the US.¹¹ Surgical specialties, including neurosurgery, represent a unique subset of care delivery,

ABBREVIATIONS OOP = out-of-pocket; SOL = severity of illness.

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as operative cases can be highly complex and expensive, requiring multidisciplinary teams of surgeons and/or multiple stages of surgery. Unfortunately, there are minimal data available regarding patient OOP costs associated with surgical care, and patients and providers often commit to an operative intervention without knowing the potential financial burden it may impose for a patient.

In an effort to improve cost transparency in neurosurgery, we sought to examine patient OOP spending associated with cranial neurosurgical procedures performed at our institution from a comprehensive payer mix. We examine the drivers of OOP spending at our institution, as well as changes in patient OOP spending over time, in order to provide an analysis of patients' financial contributions to neurosurgical care. To our knowledge, this represents the most comprehensive analysis of patient OOP spending in the neurosurgical literature to date.

Methods

This study was approved by our institutional review board and conducted in compliance with Health Insurance Portability and Accountability Act (HIPAA) regulations. All patients who underwent a cranial neurosurgical operation at our institution (Barrow Neurological Institute, St. Joseph's Hospital and Medical Center, Phoenix, AZ) between July 2013 and May 2016 were included in the study. We retrospectively collected the following patient demographic and clinical data from our hospital electronic medical records system (PowerChart, Cerner Corp.): age, sex, date of surgery, surgeon, length of surgery, American Society of Anesthesiologists Physical Status class (assigned by the anesthesiologist at the beginning of the procedure), elective case status, length of stay, severity of illness (SOI), and procedure details. Cases were classified into subsets based on general case characteristics and operative complexity.

Details of patients' individual health coverage, such as primary payer information and in- or out-of-network status, were obtained from our hospital administrative database (Invision, Attachmate Corp.). Insurance plans were classified as commercial, Medicaid, Medicare, others (e.g., Tricare, workers' compensation, charity), and self-pay. All accounts had more than 1 year of payment eligibility at the time of data extraction. Patient OOP spending was calculated based on patients' direct payments to the hospital, which were recorded within the hospital cost accounting system (Horizon Performance Manager, McKesson Performance Analytics), as well as patient payments for neurosurgeon professional fees, recorded within the private practice billing system (Centricity Practice Solution version 12, GE Healthcare).

Data were aggregated in Microsoft Excel (version 14.2.5), and statistical analyses were performed using Stata/SE 15 (StataCorp.). Values are expressed as the mean $\pm$ standard error, where appropriate, and statistical significance was established at $\alpha < 0.05$. We created univariate and then multivariate mixed-effects linear regression models to evaluate the effect of each demographic and clinical variable on patient OOP spending. We used a mixed-effects model to account for the nested structure of our data, as highly specialized surgeons perform specific

procedures at our institution. Extreme data were capped at the 99th percentile to reduce the effect of statistical outliers on the mean OOP spending in our univariate and multivariate analyses.

To examine changes in OOP spending over time, we created a generalized linear model with patient OOP payment as the primary outcome and year as a fixed effect. Our model controlled for case-mix differences over time by adjusting for the diagnosis-related group weights of each procedure. Partial fiscal periods for 2013 and 2016 were accounted for, as OOP payments were lower at the end of the year due to patients having met annual deductibles and OOP maximums. The postestimation margins command was used to obtain predicted OOP costs from our generalized linear model analysis. All payments were adjusted for inflation to reflect 2016 US dollar values (https://www.bls.gov/data/inflation_calculator.htm).

Results

Among the 6569 consecutive cranial neurosurgical procedures performed between 2013 and 2016 at our institution, craniotomy for tumor resection ($n = 2893$; 44%) and CSF diversion procedures ($n = 1096$; 17%) were the most frequently performed (Table 1). Most patients presented with minor/moderate (60%) SOI scores; only a small subset of patients was classified as undergoing emergency procedures ($n = 471$; 7%). The vast majority of treated patients were covered by commercial health insurance ($n = 2724$; 42%) or had government-sponsored coverage ($n = 3330$; 51%). Patients were discharged to home in most cases ($n = 4821$; 73%), while smaller subsets were discharged to a rehabilitation facility ($n = 779$; 12%) or skilled nursing facility ($n = 429$; 7%).

Univariate analysis showed that the following patient factors were associated with higher OOP spending for cranial neurosurgical patients: younger age (< 68 years); craniotomies for pain, vascular lesion, or tumor, and endoscopic endonasal/intraventricular procedures for tumor; commercial insurance (vs Medicaid/Medicare/others/self-pay) and out-of-network plans; moderate SOI (vs minor); longer length of stay (2nd quartile vs 1st quartile) (all $p < 0.05$; Table 2). Our multivariate mixed-effects linear regression model confirmed that case categories (craniotomies for vascular lesion, pain, or tumor), commercial insurance, and out-of-network plans were independent predictors of higher patient OOP spending (all $p < 0.05$; Table 3).

We then examined patient OOP spending stratified by case categories. Craniotomy for pain (e.g., microvascular decompression) was associated with the highest patient OOP spending ($\$1151 \pm \$209$), followed by endoscopic endonasal/intraventricular tumor resection ($\$834 \pm \$275$; Fig. 1). Hematoma evacuation and CSF diversion procedures were associated with the lowest patient OOP spending ($\$231 \pm \$33$ and $\$281 \pm \$54$, respectively). In a subgroup analysis, commercially insured patients, on average, contributed nearly twice as much as the overall population (Fig. 1). This disparity was starkest among deep brain stimulation implant procedures, where commercially insured patients paid over 3 times more OOP compared with all payers.

TABLE 1. Patient characteristics for 6569 consecutive cranial neurosurgical cases from July 2013 to May 2016

Variable	Value
Mean age in yrs ($\pm$ SD)	53.8 $\pm$ 18.0
Sex	
Female	3,368 (48.7)
Male	3,201 (51.3)
Case category	
Cranioplasty/wound revision/CSF leak repair	361 (5.5)
Craniotomy for epilepsy	51 (0.8)
Craniotomy for pain	286 (4.4)
Craniotomy for tumor	2,893 (44.0)
Craniotomy for vascular lesion	549 (8.4)
CSF diversion	1,096 (16.7)
DBS implant	383 (5.8)
Endoscopic endonasal/intraventricular for tumor	133 (2.0)
Hematoma evacuation	550 (8.4)
Intracranial biopsy procedure	267 (4.1)
Mean length of surgery in hrs ($\pm$ SD)	3.0 $\pm$ 2.0
ASA class	
I	219 (3.3)
II	1,697 (25.8)
III	2,217 (33.7)
IV	1,507 (22.9)
V	929 (14.1)
Discharge	
Home or self-care	4,821 (73.4)
Rehabilitation facility	779 (11.9)
Skilled nursing facility	429 (6.5)
Other	540 (8.2)
Insurance type	
Commercial	2,724 (41.5)
Medicaid	914 (13.9)
Medicare	2,416 (36.8)
Others	350 (5.3)
Self-pay	165 (2.5)
Insurance network	
In	5,814 (89.4)
Out	689 (10.6)
SOI	
Minor	1,916 (29.2)
Moderate	2,217 (33.8)
Major	1,507 (22.9)
Extreme	929 (14.1)
Elective status	
Elective	6,098 (92.8)
Emergency	471 (7.2)

ASA = American Society of Anesthesiologists; DBS = deep brain stimulation. Values are presented as the number of patients (%) unless stated otherwise.

TABLE 2. Univariate analysis of predictors of patient OOP spending for cranial neurosurgery cases

Variable	Mean Cost $\pm$ SE	p Value
Age in yrs		
Q1: <42	\$622 $\pm$ 64	
Q2: 42–56	\$746 $\pm$ 59	0.129
Q3: 57–67	\$760 $\pm$ 73	0.072
Q4: >67	\$263 $\pm$ 32	<0.001
Sex		
Male	\$657 $\pm$ 45	
Female	\$522 $\pm$ 37	0.053
Case category		
Hematoma evacuation	\$231 $\pm$ 33	
CSF diversion	\$281 $\pm$ 54	0.743
Cranioplasty/wound revision/CSF leak repair	\$300 $\pm$ 90	0.703
DBS implant	\$347 $\pm$ 44	0.600
Craniotomy for epilepsy	\$359 $\pm$ 223	0.831
Intracranial biopsy procedure	\$404 $\pm$ 74	0.373
Craniotomy for vascular lesion	\$673 $\pm$ 102	0.007
Craniotomy for tumor	\$786 $\pm$ 53	<0.001
Endoscopic endonasal/intraventricular for tumor	\$834 $\pm$ 275	0.011
Craniotomy for pain	\$1,151 $\pm$ 209	<0.001
Insurance		
Commercial	\$1,083 $\pm$ 60	
Medicaid	\$170 $\pm$ 58	<0.001
Medicare	\$263 $\pm$ 30	<0.001
Others	\$341 $\pm$ 116	<0.001
Self-pay	\$185 $\pm$ 76	<0.001
Insurance network		
In	\$547 $\pm$ 27	
Out	\$968 $\pm$ 156	<0.001
SOI		
Minor	\$707 $\pm$ 55	0.015
Moderate	\$638 $\pm$ 54	0.089
Major	\$472 $\pm$ 55	0.422
Extreme	\$436 $\pm$ 77	0.531
Length of stay in days		
Q1: <2	\$514 $\pm$ 48	
Q2: 2–3	\$852 $\pm$ 67	<0.001
Q3: 4–7	\$555 $\pm$ 53	0.731
Q4: >7	\$363 $\pm$ 50	0.114
Elective status		
Elective	\$604 $\pm$ 30	
Emergency	\$421 $\pm$ 126	0.207

Q = quartile.

Boldface type indicates statistical significance.

TABLE 3. Multivariate analysis of predictors of patient OOP spending for cranial neurosurgery cases

Variable	Estimate	p Value
Age (10-yr increments)	\$30	0.214
Sex (male vs female)*	\$-39	0.512
Case category (vs hematoma evacuation)		
CSF diversion	\$-19	0.890
Cranioplasty/wound revision/CSF leak repair	\$-35	0.834
DBS implant	\$-32	0.858
Craniotomy for epilepsy	\$68	0.847
Intracranial biopsy procedure	\$20	0.915
Craniotomy for vascular lesion	\$293	0.049
Craniotomy for tumor	\$295	0.018
Endoscopic endonasal/intraventricular for tumor	\$370	0.118
Craniotomy for pain	\$511	0.006
Insurance (vs commercial)		
Medicaid	\$-909	<0.001
Medicare	\$-781	<0.001
Others	\$-1,045	<0.001
Self-pay	\$-752	<0.001
Insurance network (in vs out)*	\$738	<0.001
SOI (vs minor)		
Moderate	\$54	0.755
Major	\$-4	0.981
Extreme	\$97	0.615
Length of stay in days (vs Q1: <2)		
Q2: 2-3	\$122	0.211
Q3: 4-7	\$-61	0.560
Q4: >7	\$-157	0.176
Elective status (elective vs emergency)*	\$143	0.268

Boldface type indicates statistical significance.

* Parenthetical categories are listed as (reference category vs effect).

Lastly, we examined the temporal trend in OOP spending from 2013 to 2016 (Fig. 2). Patient OOP payment estimates were adjusted for inflation, case-mix differences, and partial fiscal periods in our data collection. The cumulative rate of growth in individual patient OOP spending was 17%, from \$598 in 2013 to \$698 in 2016. Commercially insured patients saw more substantial increases in spending each year, with an average annual growth rate of 13%. The cumulative rate of growth for commercially insured patients was 42%, from \$991 in 2013 to \$1403 in 2016, which was statistically significant ($p < 0.001$).

Discussion

With changes to the health insurance market, patients are becoming increasingly responsible for a higher share of their health care costs in the forms of deductibles, co-insurance, and out-of-network charges.^{16,20,23,26} Our data demonstrate that for cranial neurosurgical procedures, patient OOP spending is significant and is rising at a rate that exceeds the rate of inflation and economic growth. These findings may have important implications for neurosurgical

providers and policy makers, and this analysis represents a step toward improved cost transparency in neurosurgery.

Proponents of increased patient cost sharing argue that shifting a greater proportion of health care costs onto the consumer can help reduce unnecessary care and contain overall health expenditures.^{14,24} However, increased OOP cost can impede access to care and negatively affect a patient's quality of life. A recent study showed that patients burdened by high OOP costs are likely to drop health insurance coverage, reduce their spending on other necessities such as food and clothing, or take prescribed medication less frequently.²⁷ In fact, 22% of Americans skipped medical consultations and 18% did not purchase prescribed medicine due to cost in 2016.¹⁵ Additionally, access problems disproportionately afflict patients from low socioeconomic strata,^{6,21,23,25} with 43% of low-income adults reporting unmet medical needs due to the costs of care.¹⁵

Despite the growing issue of patient cost sharing, very few studies address patient OOP cost issues in surgical specialties. A comprehensive PubMed search examining patient payments, OOP costs, and cost sharing in the surgical literature resulted in 61 articles. After screening the title and abstract, 53 articles were excluded for various reasons (e.g., without cost data, nonsurgical literature, off-topic). In our review of the literature, 8 articles examined OOP spending in surgery (obstetrics and gynecology,^{3,18,19,22} ophthalmology,¹⁷ transplant,¹⁸ orthopedics,¹⁰ plastic surgery,² and general surgery¹); however, none of the studies examined neurosurgical care. Four of these studies were conducted internationally,^{3,17,18,22} and 1 study was based on a survey of patients,¹⁹ which is prone to patient recall bias and underreporting of costs. Two studies^{2,10} that explored OOP costs in pediatric orofacial clefts and total hip arthroplasty included fewer than 50 patients, making extrapolation and generalizability of analysis challenging. Finally, one study examined OOP spending for hospitalization of 7 common inpatient procedures, including spinal fusion, using a national database.¹ The study authors found that total cost sharing increased 37% from 2009 to 2013 after controlling for inflation and case-mix differences. However, this study only analyzed medical claims from commercially insured patients.

In our multivariate analyses of 6569 consecutive cranial neurosurgical cases of all payer types, we found that case categories (craniotomy for pain, tumor, and vascular lesions), commercial insurance, and out-of-network plans were significantly associated with higher patient OOP spending. Craniotomy for microvascular decompression, for example, was associated with a 5 times higher mean OOP payment when compared with ventriculoperitoneal shunt insertion. This large variation in costs among case categories highlights the importance of financial considerations by patients and providers prior to surgery, as some elective procedures may be associated with significant patient financial burden. At our institution, we recommend providers use this information to improve patient-physician communication about potential health care costs, and we offer patient financial counseling services to help patients better anticipate their fiscal responsibilities.

Another important finding of our study is the significant growth of OOP spending over time, which was most pro-

FIG. 1. All patients (blue) and commercially insured patients (red) OOP spending by case category. Crani = craniotomy; Endo/IV = endoscopic endonasal/intraventricular; DBS = deep brain stimulation.

nounced for commercially insured patients. After controlling for inflation, the cumulative rate of growth for commercially insured patients was 42% in our study period, which exceeded \$1400 for average OOP payments in 2016. Additionally, as health care costs continue to rise, provider networks have grown smaller, leading consumers to seek out-of-network care.²⁰ “Narrow networks,” insurance plans that include a small group of contracted physicians in the area, have grown popular in recent years due to lower premiums and the individual mandate; however, OOP costs for patients in these narrow networks could be significant.⁸ Our analysis supports these findings, as out-of-network coverage was independently associated with increased patient OOP spending in our multivariate model. In our evolving health care environment, with discussion of new legislative changes to health insurance plans, our findings warrant greater attention from policy makers seeking to provide affordable and accessible care networks to surgical patients.

Although our analysis represents a large cohort of patients undergoing a variety of cranial neurosurgery procedures, it is limited by its retrospective nature and single-institution study design. Treatments in all cases were performed at a single, highly specialized, tertiary referral center for neurosurgical procedures, and our work may not be representative of neurosurgical cases nationally, as there is known geographic variation in costs.^{13,28} Additionally, our study population has an underrepresentation of commercially insured patients (42%), compared with national averages of 68%,⁴ and an overrepresentation of Medicare patients (37%). The smaller proportion of commercially insured patients, who have high mean OOP spending as suggested by our data, likely lowers our mean OOP cost estimates. Despite these limitations, our examination of patient OOP spending represents the largest analysis of neurosurgical procedures to date. Future investigations

focused on patient OOP spending on a national scale are warranted.

Conclusions

Patient OOP spending for cranial neurosurgical procedures is significant and increased from 2013 to 2016 in our cohort of patients. Independent drivers of patient OOP spending included commercial insurance coverage, out-of-network care, and specific case categories, including craniotomy for pain, vascular lesion, and tumor, among others. As health care costs continue to rise and patient cost sharing becomes more prevalent, the potential financial burden of neurosurgical care should be considered by patients, providers, and policymakers.

FIG. 2. Patient OOP spending for all patients (blue) and commercially insured patients (red) who underwent cranial neurosurgery between 2013 and 2016. All payments are adjusted for inflation to reflect 2016 US dollar values. *** $p < 0.001$.

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Disclosures

Dr. Little: ownership in Kogent and Spiway.

Author Contributions

Conception and design: Lawton, Yoon, Mooney. Acquisition of data: Yoon, Mooney, Bohl, Sheehy. Analysis and interpretation of data: Yoon, Mooney. Drafting the article: Yoon, Mooney. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Statistical analysis: Yoon. Study supervision: Lawton, Nakaji, Little.

Supplemental Information

Videos

Video Abstract. <https://vimeo.com/263549642>.

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