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Hospital Charge Variability across New York State: Sociodemographic Factors in Pituitary Surgery

Sarah M. Kidwai[1] Anthony Yang[1] Mingyang L. Gray[1] Sean McKee[1] Alfred Marc Iloreta[1] Raj Shrivastava[2] Satish Govindaraj[1]

[1] Department of Otolaryngology–Head and Neck Surgery, Icahn School of Medicine at Mount Sinai, New York, New York, United States
[2] Department of Neurosurgery, Icahn School of Medicine at Mount Sinai, New York, New York, United States

Address for correspondence Sarah M. Kidwai, MD, Department of Otolaryngology–Head and Neck Surgery, Icahn School of Medicine at Mount Sinai, One Gustave L Levy Place, P.O. Box 1189, New York, NY 10029, United States (e-mail: sarah.kidwai@mountsinai.org).

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Abstract

Introduction Significant charge disparities exist across New York State (NYS). Race and income are associated with increased charges. To determine risk factor, we correlate hospital charges for pituitary surgery with socioeconomic factors. Additionally, we identify patients at risk for increased hospital charges and provide insight into cost-effective practices.

Methods Retrospective cohort study of the Statewide Planning and Research Cooperative System (SPARCS) database from the NYS Department of Health was conducted. The SPARCS database was reviewed. Patients who underwent transsphenoidal pituitary surgery from 1995 to 2015 were identified. Income and urban status were referenced from U.S. census data. Linear regression was performed to analyze the effect of sociodemographic factors, comorbidities, and complications on hospital charges while controlling for length of stay.

Results A total of 9,373 patients were identified. Black (10.8%, $p < 0.001$) and Asian (14.5%, $p < 0.001$) had higher hospital charges. Patients from nonurban cities (13.4%, $p < 0.001$), Medicaid (13.8%, $p < 0.001$), and those from the 0 to 25th (9.1%, $p < 0.001$) and 25 to 50th (11.7%, $p < 0.001$) income quartile had lower hospital charges. Patients with postoperative cerebrospinal fluid leak (24.0%, $p < 0.001$), diabetes insipidus (22.1%, $p < 0.001$), smoking history (11.8%, $p < 0.001$), hypertension (7.4%, $p < 0.001$), and hypothyroidism (6.9%, $p < 0.001$) had higher hospital charges.

Conclusion Patients incurring higher chargers were more likely to have a smoking history, hypertension, hypothyroidism, and comorbidities. The determinants of this analysis may provide insight into barriers to patient access and cost improvement strategies. In addition, this emphasizes the need for future studies to create a risk stratification model, similar to those in other fields.

Keywords
- rhinology
- skull base
- pituitary adenoma
- charge variability
- hospital costs

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Introduction

In the United States alone, more than 5,000 people undergo pituitary adenoma resection each year, with an associated annual cost of greater than $100 million.[1,2] Surgical therapy often involves a transsphenoid approach, through microscopy or endoscopy. A recent study compared health care costs of endoscopic transsphenoidal pituitary surgery to microscopic transsphenoidal pituitary surgery and found mean cost savings and utility gain marginally better for endoscopic transsphenoidal pituitary surgery, with reduced operative time and decreased nonrhinologic complications.[3] Another recent study identified important cost drivers in transsphenoidal surgery, and emphasized identifying low-risk patients a fast-track protocol for recovery including early ambulation, surgical step down care, and early discharge.[4] Identifying such cost drivers and analyzing patient cost is essential to providing insight into health care disparities. Pituitary tumors occur in a diverse group of patients with different racial groups, insurance status, and comorbidities. By identifying specific characteristics that are associated with increased hospital charges, we hope to help to identify patients that may be at a higher risk for complications and increased hospital charges.

It has been suggested that higher costs and charges do not always correlate with improved outcomes.[5] To help understand factors involved with hospital charges related to transsphenoidal pituitary surgery, we analyzed a cohort of patients across New York State (NYS) from 1995 to 2015. The purpose of our study was to establish geographic variations related to hospital charges across New York and to identify patient characteristics that are associated with increased hospital charges. This may provide help practitioners to risk-stratify patients that have characteristics associated with increased hospital charges.

Methods

The SPARCS (Statewide Planning and Research Cooperative System) database is a comprehensive all-payer reporting system in NYS, containing patient level data on all hospital discharges. Patients who underwent transsphenoidal surgery for pituitary masses between January 01, 1995 and October 01, 2015 were identified using International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) diagnosis and procedure codes. We chose to examine only endoscopic pituitary procedures with current procedural terminology (CPT) code 62165 (neuroendoscopy procedures on the skull, meninges, and brain) to avoid additional heterogeneity. Patient demographics obtained included age, sex, ethnicity, race, income level, and zone improvement plan (ZIP) code of residence. Income of the patient was derived using the median income of the patient's ZIP code of residence from the United States (U.S.) census. Urban or rural classification of patient's residence and hospital location was also determined by linking the ZIP code of patient's residence or hospital to the U.S. census, respectively. Provider characteristics obtained included surgeon volume, hospital volume, and teaching status of the hospital. Teaching status was defined as hospitals receiving direct graduate medical education payment from Medicare. The volume of the surgeon and hospital were calculated by annual caseload of pituitary surgery. Surgeons and hospitals were then stratified into high (top quartile), medium (25–75th percentile), and low (bottom quartile) volume categories.

Comorbidities and complications for each patient were also assessed. Comorbidities were determined using diagnosis codes those were present on admission. Complications were determined as all other procedure and diagnosis codes not present on admission. Comorbidities assessed included hypertension, diabetes mellitus, panhypopituitarism, hypothyroidism, Cushing's syndrome, history of tobacco use, diabetes insipidus, visual disturbances, and epistaxis. The enhanced Charlson's comorbidity index (CCI) was also calculated.[6] Complications assessed included diabetes insipidus, cerebrospinal fluid (CSF) leak, meningitis, and requiring a packed cell transfusion. The length of hospital stay for each patient admission was also evaluated.

The primary outcome of interest was hospital charges linked to the patients' admission. Hospital charges were adjusted for inflation using the consumer price index (CPI) for medical care from the Bureau of Labor Statistics. In this study, hospital charges indicate the actual cost of care or the amount received from third-party payers.

Univariate and multivariate linear regressions were used to assess the effect of patient and provider factors on total hospitalization charges. Length of stay and hospital charges underwent a logarithmic transformation before including it in the multivariate model. Statistical significance was set at $p < 0.05$. All analyses were performed using Statistical Analytical Software 9.4. (Cary, North Carolina, United States)

Results

A total of 9,373 patients were admitted to a hospital with a principal diagnosis involving a neoplasm of the pituitary gland and principal procedure code involving an endoscopic transsphenoidal pituitary procedure between 1995 and 2015. Patient demographics are listed in ►**Table 1**. The distribution of patient complications and comorbidities is shown in ►**Table 2**. Hospital and surgeon characteristics are shown in ►**Table 3**.

When controlling for patient characteristics and comorbidities, females were associated with a 3.41% less hospital charge compared with males ($p = 0.0013$). Patients aged 45 to 65 years had increased hospital charges by 4.26% and those over age 65 years by 3.43%; however, only the former was statistically significant. In addition, Black race and Asian race were both associated with higher hospital charges when compared with White race, 10.88% ($p < 0.001$) and 14.51% ($p < 0.001$), respectively. Average hospital charges distributed by race is shown in ►**Fig. 1**. A higher CCI (1, 2, 3, 4+) was associated with incrementally higher hospital charges when compared with a CCI of 0 by 8.89%, 12.39%, 20.49%, 23.91%, respectively ($p < 0.001$). Patients with Medicaid insurance had 13.8% lower hospital charges compared with private

Table 1 Patient demographics

		n (%)
Age (y)	< 45	3,241 (35%)
	45–65	4,148 (44%)
	> 65	1,984 (21%)
Sex	Male	4,569 (49%)
	Female	4,804 (51%)
Ethnicity	Non-Hispanic	7,389 (79%)
	Hispanic	653 (7%)
	Unknown	1,331 (14%)
Race	White	5,262 (56%)
	Black	1,603 (17%)
	Asian	432 (5%)
	Other	1,456 (16%)
	Unknown	620 (7%)
Insurance	Private	6,537 (70%)
	Medicaid	745 (8%)
	Medicare	1,799 (19%)
	Other	292 (3%)
Income quartile	76–100	2,348 (25%)
	51–75	2,332 (25%)
	26–50	2,350 (25%)
	0–25	2,343 (25%)
Patient residence	Urban	8,776 (94%)
	Rural	597 (6%)

insurance ($p < 0.001$), while patients with Medicare insurance had 6.94% lower hospital charges compared with private insurance ($p = 0.0002$). Average hospital charges distributed by patient insurance is shown in ►**Fig. 2**. Patient residence in a rural location was associated with a 13.37% lower hospital charge compared with patient residence in an urban location ($p < 0.001$).

While rural location of hospital was associated with a 19.96% increased hospital charge, this was not statistically significant. High hospital volume was associated with 30.66% increased hospital charges compared with low hospital volume ($p < 0.001$). Surgeon volume had no statistically significant association with hospital charge. Patients in the lowest and second lowest income quartile were associated with lower hospital charges by 9.08% and 11.77%, respectively ($p < 0.001$). Average hospital charge distributed by income quartile is shown in ►**Fig. 3**. Teaching status of the hospital was associated with a 14.51% lower hospital charge compared with a nonteaching hospital ($p = 0.0003$).

The results of multivariate linear regression analysis to evaluate patient comorbidities and complications and their associated hospital charges is shown in ►**Table 4**. Hypertension, hypothyroidism, history of tobacco use, diabetes insipidus, and visual disturbance were comorbidities associated with increased hospital charges, with the highest percent increases with the latter three. All complications were associated with increased hospital charges.

Table 2 Distribution of patient comorbidities and complications

Comorbidities		*n* (%)
Hypertension	No	5,992 (64%)
	Yes	3,381 (36%)
Diabetes mellitus	No	8,018 (86%)
	Yes	1,355 (14%)
Panhypopituitarism	No	9,002 (96%)
	Yes	371 (4%)
Hypothyroidism	No	8,018 (86%)
	Yes	1,355 (14%)
Cushing's syndrome	No	8,779 (94%)
	Yes	594 (6%)
History of tobacco use	No	8,946 (95%)
	Yes	427 (5%)
Diabetes insipidus	No	9,009 (96%)
	Yes	364 (4%)
Visual disturbance	No	8,493 (91%)
	Yes	880 (9%)
Epistaxis	No	9,363 (100%)
	Yes	10 (0%)
Charlson's comorbidity index	0	6,869 (73%)
	1	1,878 (20%)
	2	422 (5%)
	3	112 (1%)
	4+	92 (1%)
Complications		
Diabetes insipidus	No	8,938 (95%)
	Yes	435 (5%)
CSF leak	No	9,262 (99%)
	Yes	111 (1%)
Meningitis	No	9,348 (100%)
	Yes	25 (0%)
Packed cell transfusion	No	9,196 (98%)
	Yes	177 (2%)

Abbreviation: CSF, cerebrospinal fluid.

Discussion

In multiple specialties, hospital charge variability exists through different geographic locations, patient characteristics, and hospital characteristics.[5,7,8] Lee et al showed that there is significant variation in charges and costs for transsphenoidal surgery within New York.[9] While they studied

Table 3 Hospital and surgeon characteristics

Location of hospital	Urban	9,360 (100%)
	Rural	13 (0%)
Hospital volume	Low	629 (7%)
	Medium	1,235 (13%)
	High	7,509 (80%)
Surgeon volume	Low	1,012 (11%)
	Medium	1,362 (15%)
	High	6,999 (75%)
Teaching status	Nonteaching	175 (2%)
	Teaching	9,198 (98%)

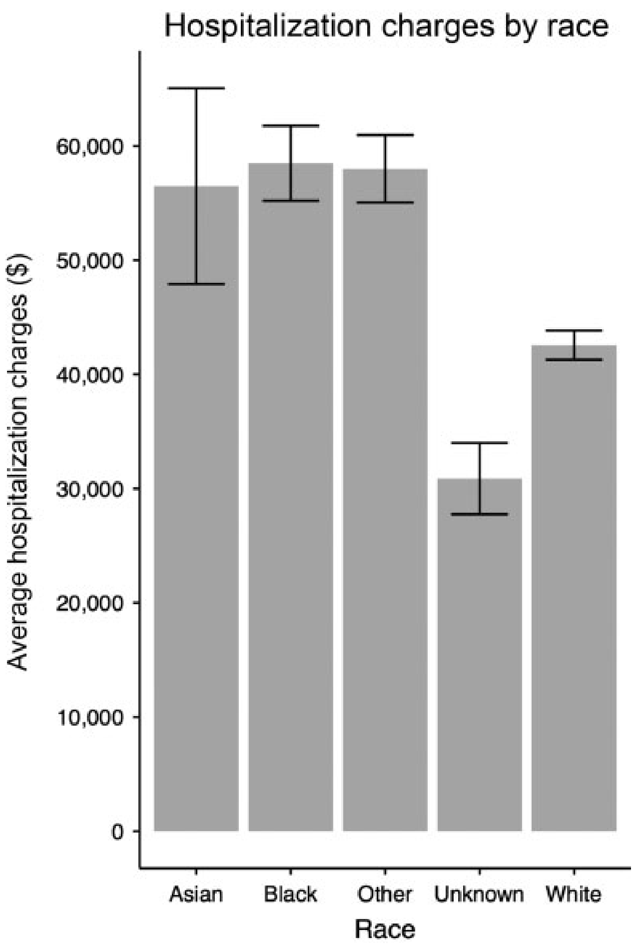

Fig. 1 Average hospitalization charge by race.

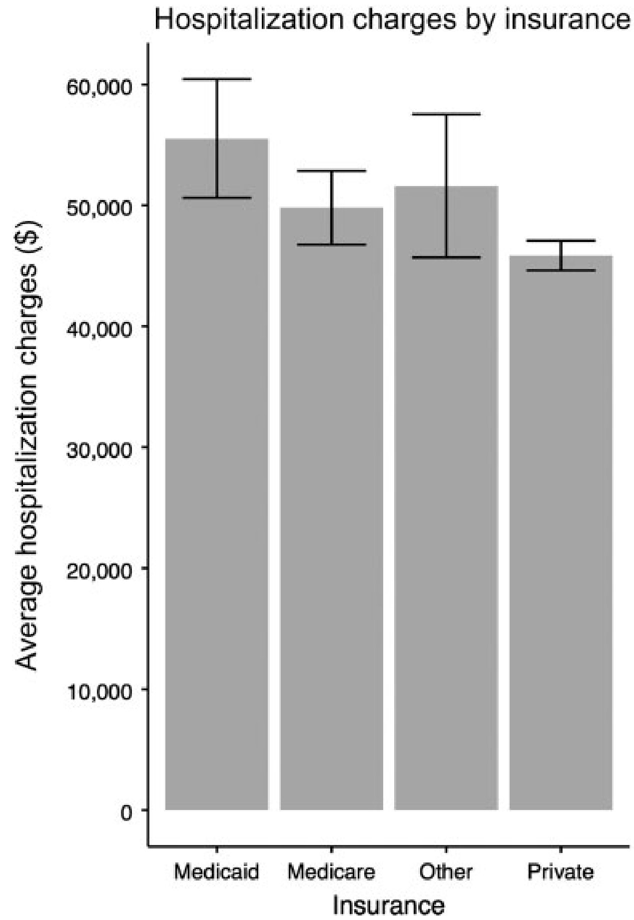

Fig. 2 Average hospitalization charge by insurance.

hospital costs and charges and cost-to-charge ratios, they did not evaluate patient and hospital characteristics and their relation to hospital charge. By studying these factors, we can better understand variations in health care costs and thereby, instrument approaches to reduce disparities in hospital charge.

Several studies illustrate health care disparities between men and women and between difference races.[10–12] For example, Schneider et al showed that Hispanic ethnicity was an independent risk factor for mortality after carotid endarderectomy.[12] In a univariate analysis, we found that Black and Asian races were associated with statistically significant increased hospital charges (28.73 and 24.34%, respectively). This same significance upheld in the multivariate analysis when controlling for patient, hospital, and surgeon characteristics with 10.88 and 14.51% increased hospital charge, respectively. This suggests that while there may be patient, hospital, and surgeon characteristics that drive these differences, when these are controlled for, there is still an associated increase in hospital charges when compared with White patients.

The CCI scores 19 different categories of comorbidities, and predicts 10-year mortality for a patient. A higher score is indicative of a greater 10-year mortality risk.[13] Previous studies in the literature have shown higher charges associated with a higher CCI. For example, Fu et al found that higher vaginal and vulvar cancer charges were associated with higher CCI.[14] Similarly, we found increased hospital charges associated with increased CCI in both our univariate and multivariate analysis. It is crucial to note that 73% of our cohort had a CCI of 0. Another study evaluating health care costs of patients who underwent acoustic neuroma surgery, found that a higher comorbidity index independently predicted a discharge disposition that was other than routine.[15]

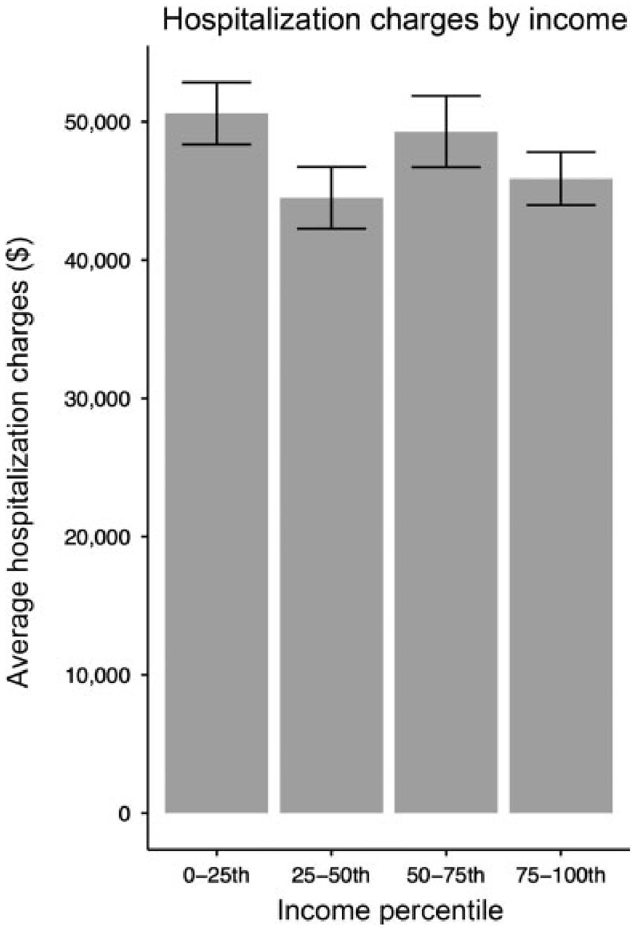

Fig. 3 Average hospitalization charge by income.

We also found in our cohort that patients with Medicare and Medicaid insurance had significantly lower charges than those with private insurance. In addition, we found that those from the lowest income quartile and the second lowest income quartile had significantly lower hospital charges when compared with patients in the highest income quartile. We suspect that patients in the lower quartiles were those with nonprivate insurance, which explains these trends. In the study by Sonig et al, they found that patients with private insurance and higher household income had significant better outcomes after surgery.[15]

In regards to hospital characteristics, we found that high volume hospitals had higher associated hospital charges compared with low volume hospitals, while teaching hospitals had lower associated hospital charges compared with nonteaching hospitals. This is a similar finding to the study by Sonig et al which also demonstrated that teaching hospitals have lower hospitalization costs than nonteaching hospitals; however, this trend was not significant in their multivariate analysis.[15] In other studies, treatment at a teaching hospital was associated with increased hospital cost but overall survival and mortality was lower at teaching hospitals; however, this was mainly studied in the orthopaedic population.[16,17] We did see in our cohort that 80% of hospitals were high volume and 98% of hospitals were teaching hospitals. Because of the multidisciplinary approach to transsphenoidal surgery and the need for neurosurgery, otolaryngology, and at times, interventional radiology availability, we expect such skewed data.

Finally, we found that nearly all comorbidities and all complications were associated with increased hospital charge in our univariate analysis. When controlled for patient and hospital factors, we found that hypertension, hypothyroidism, history of tobacco use, diabetes insipidus, and visual disturbances were comorbidities associated with higher hospital charges. We suspect this to be the case as each of these comorbidities indicates either a larger pituitary lesion or secreting-pituitary mass that requires more extensive resection and/or the assistance of endocrinology and postoperative intensive care. A history of tobacco use, while present in only 5% of our cohort, was associated with an 11.79% increased hospital charge. It has been well documented that smoking has a detrimental impact on health and is associated with comorbidities.[18] As illustrated previously, we see an increased charge is associated with an increased comorbidity index and similarly we can explain the increased hospital charge tassociated with tobacco use. We also observed that complications including diabetes insipidus, CSF leak, meningitis, and requirement of packed cell transfusion were also associated with increased hospital charges. This is expected as these complications often require a higher level of care or increased length of stay.

In our study, we highlight a few major concerns in the care of patients with pituitary adenoma. We see that patients of Black and Asian races have increased hospital charges which illustrated that disparity in health care expenditures exists. In addition, we see that patients with comorbidity and/or complications were also associated with higher hospital charges. The most ideal approach to health care should reduce health care costs and charges, while maintaining safe and efficient care. Those patients with comorbidities and complications often need a higher level of care in an intensive care unit and with consultation from different specialties. Karsy et al suggested stratification of patients into low-risk and high-risk cohorts, to select patients that require more acute intensive care monitoring versus those that can be monitoring in a surgical step down setting.[4] Others have also proved that using a short-stay protocol for patients after pituitary surgery was safe and associated with a low rate of complications and readmissions.[19,20] In urology, similar studies have been conducted to risk stratify patients that require surgical intensive care unit admission after radical cystectomy and urinary diversion procedures.[21] In pediatric surgery, a prospective study was conducted to identify a risk stratification system correlating outcome and resource utilization with increasing grade of perforated appendicitis.[22] In our study, we identify factors that are associated with increased cost. Our next step to build a risk stratification model is to conduct a prospective study to assess if these identified factors can predict complications, length of hospital stay, and morbidity after transsphenoidal surgery. Next, we would implement a risk stratification model in a prospective study.

Table 4 Multivariate linear regression of patient comorbidities and complications

		Percentage change (95% CI)	*p*-Value
Age (y)	< 45	Ref	
	45–65	4.26% (1.79, 6.72)	0.0007
	> 65	3.43% (−0.55, 7.41)	0.0916
Sex	Male	Ref	
	Female	−3.41% (−5.49, −1.33)	0.0013
Ethnicity	Non-Hispanic	Ref	
	Hispanic	2.1% (−2.23, 6.44)	0.3417
	Unknown	−36.79% (−40.44, −33.13)	< 0.0001
Race	White	Ref	
	Black	10.88% (7.83, 13.93)	< 0.0001
	Asian	14.51% (9.51, 19.5)	< 0.0001
	Other	24.05% (20.84, 27.27)	< 0.0001
	Unknown	−9.11% (−14.19, −4.04)	0.0004
Insurance	Private	Ref	
	Medicaid	−13.8% (−17.78, −9.81)	< 0.0001
	Medicare	−6.94% (−10.58, −3.3)	0.0002
	Other	−8.19% (−14.13, −2.26)	0.0068
Patient residence	Urban	Ref	
	Rural	−13.37% (−17.68, −9.06)	< 0.0001
Location of hospital	Urban	Ref	
	Rural	19.96% (−7.73, 47.65)	0.1577
Hospital volume	Low	Ref	
	Medium	8.14% (3.08, 13.2)	0.0016
	High	30.66% (25.92, 35.39)	< 0.0001
Surgeon volume	Low	Ref	
	Medium	−3.1% (−7.27, 1.07)	0.1456
	High	−4.11% (−7.83, −0.39)	0.0303
Income quartile	76–100	Ref	
	51–75	−2.39% (−5.3, 0.52)	0.1074
	26–50	−11.77% (−14.74, −8.79)	< 0.0001
	0–25	−9.08% (−12.2, −5.96)	< 0.0001
Teaching status	Nonteaching	Ref	
	Teaching	−14.51% (−22.39, −6.64)	0.0003
Comorbidities			
Hypertension	No	Ref	
	Yes	7.36% (5.01, 9.71)	< 0.0001
Diabetes mellitus	No	Ref	
	Yes	−3.48% (−7.51, 0.55)	0.0907
Panhypopituitarism	No	Ref	
	Yes	1.58% (−3.74, 6.9)	0.5603
Hypothyroidism	No	Ref	
	Yes	6.89% (3.94, 9.84)	< 0.0001
Cushing's syndrome	No	Ref	

(*Continued*)

Table 4 (*Continued*)

		Percentage change (95% CI)	*p*-Value
	Yes	−1.22% (−5.57, 3.12)	0.581
History of tobacco use	No	Ref	
	Yes	11.79% (6.87, 16.72)	< 0.0001
Diabetes insipidus	No	Ref	
	Yes	16.15% (10.79, 21.51)	< 0.0001
Visual disturbance	No	Ref	
	Yes	22.41% (18.86, 25.97)	< 0.0001
Epistaxis	No	Ref	
	Yes	−18.87% (−49.98, 12.25)	0.2346
Charlson's comorbidity index	0	Ref	
	1	8.89% (5.55, 12.23)	< 0.0001
	2	12.39% (6.92, 17.87)	< 0.0001
	3	20.49% (10.72, 30.25)	< 0.0001
	4+	23.91% (13.32, 34.5)	< 0.0001
Complications			
Diabetes insipidus	No	Ref	
	Yes	22.14% (17.21, 27.07)	< 0.0001
CSF leak	No	Ref	
	Yes	23.98% (14.47, 33.49)	< 0.0001
Meningitis	No	Ref	
	Yes	33.76% (13.69, 53.84)	0.001
Packed cell transfusion	No	Ref	
	Yes	17.17% (9.53, 24.82)	< 0.0001

Abbreviations: CI, confidence interval; CSF, cerebrospinal fluid; Ref, reference.
Note: Multivariate analysis was adjusted for length of stay.

Our study is not without its limitations. We used a statewide database to perform a retrospective review which only captures data from NYS and cannot be generalizable to all other populations. The NYS population includes both urban and nonurban populations and thus, these results may only be generalizable to similar populations. In addition, the database relies on accurate diagnostic and procedural coding and entry by hospitals which is subject to error. Race and ethnicity classifications are extracted from hospital records and may not be accurate. Surgeon and patient income level is derived from home ZIP codes and contain significant heterogeneity. The total hospital charges referred to in this study indicate the actual cost of care or the amount received from third-party payers. Because of the limitations of the database, we were only able to capture complications and comorbidities that occurred during the patient's inpatient stay, so outpatient costs are not accounted for. We were also unable to capture surgery characteristics, such as tumor size, presence or absence of compressive symptoms and hormonal disturbances, and whether surgery was a primary or a revision surgery. Finally, pituitary surgery and management of these patients has changed drastically over the time period studied. Preoperative, intraoperative, and postoperative care has changed and the volume of pituitary surgery has also increased. When looking at the hospital charges for pituitary surgery throughout NYS, we saw increase in charges, which is likely attributed to this change in management of these patients and the increase in volume.

Conclusion

Patients in NYS who are associated with increased hospital charges are those of Black or Asian race, aged 45 to 65 years, comorbidities and complications during hospital stay. Patients of the lower income quartiles and those receiving care at a teaching hospital had decreased hospital charges. We demonstrate that a racial and economic disparity exists within the field of transsphenoidal surgery and this is further compounded by patient comorbidities and complications. Further population health studies are needed to clarify why such racial disparities exist. Risk stratification studies to identify patients that can be treated with an early discharge disposition and those that require additional monitoring and intensive care are also needed.

Meeting Information
Podium presentation at the Triological Society Combined Sections Meeting, Scottsdale, Arizona, U.S.A.

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The authors have no funding, financial relationships, or conflicts of interest to disclose.

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