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Obstructive sleep apnea surgery practice patterns in the United States: 2000–2006

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Abstract

Objectives—To determine OSA surgical volume, types, costs, and trends. To explore whether specific patient and hospital characteristics are associated with the performance of isolated palate vs. hypopharyngeal surgery and with costs.

Study Design—Cross-sectional study.

Subjects and Methods—OSA procedures were identified in the Healthcare Cost and Utilization Project Nationwide Inpatient Sample for 2000, 2004, and 2006 and from State Ambulatory Surgery Databases and State Inpatient Databases for 2006 from four representative states (California, New York, North Carolina, and Wisconsin). National combined inpatient and outpatient surgery estimates for 2006 were generated using a combination of databases. Chi-squared and regression analysis examined procedure volume and type and inpatient procedure costs.

Results—In 2006, an estimated 35,263 surgeries were performed in inpatient and outpatient settings, including 33,087 palate, 6,561 hypopharyngeal, and 1,378 maxillomandibular advancement procedures. The odds of undergoing isolated palate surgery were higher for younger (18–39 years) and Black patients. Outpatient procedures were more common than inpatient procedures. Inpatient surgical volume declined from 2000–2006, but it was not possible to evaluate trends in total volumes. In 2006, mean costs were approximately $6,000 per admission. For inpatient procedures in 2004 and 2006, costs were higher for hypopharyngeal (vs. isolated

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palate) surgery, in rural hospitals, and for patients who were younger, with greater medical comorbidity, and with primary Medicaid coverage.

Conclusions—Surgical treatment is performed in 0.2% of all adults with OSA annually. Validation of the exploratory findings concerning procedure type and cost requires additional studies, ideally including adjustment for clinical factors.

Introduction

Treatments for obstructive sleep apnea (OSA) include behavioral approaches such as weight loss, positive airway pressure, oral appliance therapy, and surgery. The most common surgical procedure to treat the palate region is uvulopalatopharyngoplasty, first described for OSA treatment in 1981.[1] The limited effectiveness of isolated uvulopalatopharyngoplasty[2,3] has prompted the development of procedures to treat the hypopharyngeal region, including tongue radiofrequency, midline glossectomy, genioglossus advancement or genioplasty, tongue stabilization, and hyoid suspension.

Despite the proliferation of surgical approaches, surgical practice patterns in the United States are poorly understood. More specifically, the numbers and the mix of procedures are unknown, as are factors that may be associated with the performance of various procedures. Equally important in the current focus on healthcare value, surgical treatment costs are unknown on a national level.

The study objectives were to determine the nationwide volume, types, costs, and trends for surgical procedures and to explore the association between specific patient and hospital characteristics and both the performance of isolated palate vs. hypopharyngeal surgery and costs for inpatient procedure admissions.

Methods

Subjects

This cross-sectional study examined data collected for patients aged 18 and older who underwent inpatient or outpatient OSA surgical procedures as defined by International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) diagnosis and procedure codes.

Specifically, patients were selected if they had an OSA diagnosis code (327.23, 780.50, 780.51, 780.53, 780.57, 780.59, or 786.03), did not have a diagnosis code for head and neck neoplasm, and underwent a palate or hypopharyngeal OSA surgery. Palate surgery procedures were defined using ICD-9-CM codes 27.64, 27.69, 27.72, 27.73, or 29.4. Hypopharyngeal procedures were defined as tongue radiofrequency or midline glossectomy (25.1, 25.2, 25.59, 25.94, or 25.99); lingual tonsillectomy (28.5); genioglossus advancement, genioplasty, or tongue stabilization (76.63, 76.64, 76.67, or 76.68); and hyoid suspension (83.02). Maxillomandibular advancement (76.43, 76.46, 76.61, 76.62, 76.65, and/or 76.66) was included as a separate category.

None of the data used in this research contained personal identifying information, and the study was exempt from UCSF institutional review.

Data sources

No single national database captures both inpatient and outpatient surgical procedures for the entire study period. Therefore, this study required the combination of a national database for inpatient procedures and separate state-level databases for inpatient and outpatient procedures.

Inpatient OSA surgeries were examined using the Nationwide Inpatient Sample (NIS) for 2000, 2004, and 2006. The NIS contains patient demographics, diagnosis and procedure codes, insurance type, and facility characteristics on all inpatient stays from a 20% stratified sample of hospitals from 28 (2000), 37 (2004), or 38 (2006) states. The NIS does not include overnight admissions after procedures performed in acute care hospitals that are coded as observation status (as opposed to inpatient status, with its greater intensity of monitoring); these observation status admissions are not included in this study. Inverse-probability-of-sampling weights are provided with the NIS data, enabling users to estimated total nationwide inpatient procedure volumes.

Outpatient procedures for 2006 were identified using data from State Ambulatory Surgery Database (SASD) and State Inpatient Database (SID) files for California, New York, North Carolina, and Wisconsin. These states were selected in order to gain a wide geographic distribution and because these states' data capture encounters from both hospital-based and freestanding ambulatory surgery centers in the former database. Data for 2000 and 2004 were not used because the relevant databases either do not exist or have substantial missing data. No weighting is required because both databases capture all outpatient (ambulatory surgery) encounters or inpatient admissions, respectively, from facilities in each state.

The 2004 and 2006 NIS contain billed hospital charges and hospital-specific cost-to-charge ratios for the majority of OSA procedures, enabling an evaluation of inpatient procedure costs from the perspective of the hospital. Cost-to-charge ratios were used to convert billed charges to costs and then adjusted using the medical component of the consumer price index.[4]

Outcomes

Outcomes of interest for this study were procedure volumes, whether the patient underwent palate or hypopharyngeal surgery, and whether or not the procedure was performed in the inpatient or outpatient setting. We also examined (in national data for 2004 and 2006 only) costs for inpatient surgery admissions.

Independent variables

We examined a number of independent patient and hospital variables that were chosen based on their potential associations with the outcome measures. The key independent variables were selected as a subset of all variables within the database.

Patient variables of interest included age, gender, race/ethnicity, insurance type, type of county of residence according to the Department of Agriculture Urban Influence Code categories,5 and median annual household income for patient zip code. Medical comorbidities were identified using the Elixhauser method;[6] categories were defined as no (0 conditions), low (1–2 conditions), or moderate to high (≥3 conditions) comorbidity, similar to previous analyses using the NIS.[7]

Hospital level predictors included location/teaching status (defined as urban teaching, urban non-teaching, or rural) and region: Northeast (including New York), Midwest (including Wisconsin), South (including North Carolina), and West (including California).

Statistical Analysis

The statistical analyses were completed using a combination of databases (Table 1). All statistical analyses of the NIS data were conducted using methods for weighted complex surveys. Inpatient procedures were analyzed using the NIS data for 2000, 2004, and 2006. The following surgical volumes were estimated using the NIS weights, as described above: total procedures, specific procedures, and procedures according to the key independent variables. Chi-square tests for trend compared the number of procedures and the distribution of procedures among categories of a specific variable (e.g., age groups) across the time period. Multiple logistic regression examined the association between the performance of isolated soft palate surgery (vs. hypopharyngeal procedure with or without palate surgery) and the key independent variables (simultaneous adjustment). Interaction terms with year were included to determine whether the expected values of the outcomes changed over time.

Costs for inpatient procedure admissions were also calculated for 2004 and 2006, with reporting of means and 95% confidence intervals (95% CI). Hospital-specific cost-to-charge ratios contained within the NIS were used to convert billed charges to costs. To compare costs across years, costs for 2006 were divided by 1.12, adjusting for medical price inflation according to the Bureau of Labor Statistics' medical component of the Consumer Price Index (derived from reimbursements).[4] Mean overall costs (in 2004 dollars) and those associated with isolated palate and hypopharyngeal (with or without palate surgery) were calculated, then compared across years and procedure categories. Because of their right-skewed distribution, costs were log-transformed to meet the assumptions of the multiple linear regression, which was then used to examine the independent association between costs and type of surgery (isolated palate vs. hypopharyngeal +/− palate surgery), simultaneously adjusting for the following potential confounders: age group, gender, race/ethnicity, medical comorbidity, median household income for zip code, primary payment source, and hospital location/teaching status.

Outpatient procedures were incorporated using 2006 state-level data from the SASD and SID files for California, New York, North Carolina, and Wisconsin. Multiple steps were required to use the state-level data to estimate total numbers of inpatient plus outpatient procedures.

First, the four state-level databases were combined. Procedures of interest were identified using the same combinations of diagnosis and procedure codes as in the NIS database. Multiple logistic regression was then used to estimate the probability that each procedure was performed in an inpatient rather than an outpatient setting, as a function of state, procedure type (palate vs. other), primary payment source, and patient age, gender, and county of residence, classified as in the NIS data. Race/ethnicity was not used in this procedure because it was missing for a large proportion of the outpatient procedures.

We then used the coefficients from these logistic models, in conjunction with the same covariates for each procedure in the NIS, to estimate the probability that each of those NIS procedures, considered as part of the universe of all such procedures, had been performed in an inpatient setting. In turn, we used those probabilities to rescale the original NIS weights and estimate total procedure volume.

To see how this works, suppose that the NIS weight for a selected observation was 5, meaning that the NIS observation represents an estimated total of 5 inpatient procedures, reflecting the NIS 20% systematic sampling. Suppose also that the estimated probability that this particular procedure was performed in an inpatient setting is 25%. Accordingly, the final weight for this observation would be calculated as 5/0.25 = 20. Thus from this one NIS observation we would project a total of 20 procedures, including 5 inpatient and 15 outpatient.

Next, we repeated the analyses using the new weights, now reflecting combined *inpatient and outpatient* procedures for 2006. Thus in this analysis, we estimated combined procedure volumes and the independent associations between performance of any *inpatient and outpatient* isolated soft palate surgery (vs. hypopharyngeal procedure with or without palate surgery) and the key independent variables.

Statistical analyses were performed using the SUDAAN (Research Triangle Institute, Research Triangle Park, NC) statistical software Version 10.0 and SAS Version 9.2 (SAS Institute, Cary, NC). P-values < 0.05 were considered statistically significant.

Results

OSA surgical volume (Table 2)

Nationwide, 35,263 OSA procedures were performed in 2006. Patients undergoing these procedures were characterized by the following: male, young or middle-aged, no or low medical comorbidity, living in metropolitan areas, and undergoing surgery in urban (teaching and non-teaching) facilities.

For inpatient facilities alone, there was a decline in palate procedures and total procedures overall but an increase in hypopharyngeal procedures and maxillomandibular advancement. In 2006, outpatient surgeries represented 78% of the total, with palate and hypopharyngeal procedures being 79% and 58% outpatient-based, respectively. For the four individual states, outpatient procedures represented from 64% (California) to 84% (North Carolina and Wisconsin) of the total, with New York (75%) in the middle of this range. Among the hypopharyngeal options, soft tissue procedures such as tongue radiofrequency and midline glossectomy comprised the majority.

For inpatient procedures, the distribution among age groups and county type of patient residence did not change over this time period; there were changes for gender (fewer male but not female patients), race/ethnicity (greater percentage declines for black and white patients than for ‘other’ and those with missing data), medical comorbidity (declines among no significant comorbidity only), and hospital location/teaching status (greater percentage declines for urban teaching and rural hospitals).

Factors associated with palate surgery vs. hypopharyngeal surgery (Table 3)

Odds of undergoing isolated palate surgery in 2006 (combined inpatient and outpatient procedures in right-hand column) were lower for patients aged 40–64 years than for those aged 18–39 years and were higher for blacks than whites. For inpatient procedures alone from 2000–2006 (middle column), the strongest association was with year of surgery, indicating a lower odds of undergoing isolated palate surgery over time. In addition, for inpatient procedures alone, females had lower odds of isolated palate surgery than males.

OSA surgery costs (inpatient only, all in 2004 dollars)

Costs for admissions associated with OSA procedures were $5115 (95% CI 4726, 5505) in 2004 and $5994 (95% CI 5507, 6482) in 2006. Not surprisingly, costs for isolated palate surgery were lower than for hypopharyngeal (with or without concurrent palate) surgery (p < 0.001) in 2004 [$4646 (95% CI 4284, 5007) vs. $6647 (95% CI 5894, 7400)] and 2006 [$5070 (95% CI 4599, 5541) vs. $7618 (95% CI 6737, 8499)]. Multiple regression analysis (Table 4) showed that costs were 45% higher for hypopharyngeal (with or without palate) procedures than for isolated palate surgery. They were also elevated for patients aged 18–39 years (vs. ≥65 years) of age, with greater medical comorbidity, with Medicaid coverage (compared to private insurance), and in rural (vs. urban teaching) hospitals.

Discussion

This study suggests that over 35,000 OSA surgical procedures are performed annually, representing less than 0.2% of the estimated 18 million American adults with the disorder.

Characteristics shared by a majority undergoing surgery are known to be associated with either the prevalence of OSA (male gender), a lower risk of perioperative complications (no or low medical comorbidity),[8] or the distribution of population and medical facilities (both more likely in metropolitan areas). Only 5% of procedures were performed on adults aged 65 years and older, a group with high OSA prevalence.[9–12] The particularly low likelihood of undergoing surgery among older adults may reflect (1) medical comorbidity not captured in the Elixhauser measure; (2) functional status (not included in this databases); and/or (3) the controversy regarding the adverse consequences of OSA and benefits of treatment, particularly the limited evidence regarding surgical outcomes, for this age group.[13–15]

Our data confirm the general impression that a majority of OSA procedures are performed in outpatient facilities. The decline in inpatient procedures occurred specifically for types of procedures (isolated palate surgery) and patient subgroups (no other significant medical comorbidity) that would be expected to have lower risks and therefore most amenable to the outpatient setting.[8] Due to incomplete outpatient data in earlier years, we could not examine whether the inpatient procedure trends were similar to outpatient or whether there was a shift of certain procedures or patient subgroups from the inpatient to outpatient setting.

Over 75% of all OSA procedures in our study were isolated palate surgery. We were surprised at this relatively high proportion given that many patients do not achieve complete resolution of OSA with isolated palate surgery and may achieve better results with combined palate and hypopharyngeal surgery.[2,3,16] Younger (age 18–39 years) patients were more likely than those aged 40–64 years to undergo isolated palate surgery, as were blacks compared to whites, but there was no association with other patient and hospital factors; the clinical significance of these findings is unclear. Future research would ideally incorporate clinical data in examination of factors associated with procedure type. Among the hypopharyngeal procedures, tongue radiofrequency or midline glossectomy were the most commonly performed; this may reflect their status as the earliest hypopharyngeal procedures, the procedures with the largest body of published evidence,[16] and the lesser technical challenges for these soft tissue procedures.

Our study gives empiric data to describe the costs associated with OSA surgery. Extrapolating mean costs according to procedure type for inpatient procedures, the costs (in 2004 dollars) were $142.5 million for isolated palate surgery and $50 million for hypopharyngeal (with or without palate) surgery, for a total of $192.5 million. These are upper limit estimates because inpatient procedures are more expensive than outpatient, as they capture more postoperative care and are more likely performed in higher-cost subgroups. It is not surprising that costs were higher for hypopharyngeal surgery than isolated palate surgery and for greater medical comorbidity; hypopharyngeal procedures are generally more challenging technically and/or time-consuming, and both of these factors are associated with perioperative complications.[8] Three findings related to costs were somewhat unexpected: the lower costs for procedures in older adults, the higher Medicaid costs, and the higher costs for admissions in rural (vs. urban teaching) hospitals. The basis for the former two is unclear, but the latter may be explained by the relatively low proportion of procedures performed in rural hospitals and a general trend for lower costs in high-volume centers. As clinical factors may also be associated with costs, future investigations can assess the association between costs, clinical factors, and other patient- and hospital-related variables.

This study has certain limitations. Office procedures are not captured in these databases. Certain palate (e.g., laser-assisted uvulopalatoplasty or palate radiofrequency) and hypopharyngeal (e.g., tongue radiofrequency) surgeries can be performed in the office setting, and these are not included. Also, observation status overnight admissions after procedures performed in acute care hospitals (but not ambulatory surgery centers affiliated with acute care hospitals) are not captured in this study; because the intensity of care after OSA surgery may more likely result in placement on inpatient status, this subgroup of admissions is likely small and may consist largely of isolated palate surgery. As a result of these two limitations, this study likely underestimates palate and hypopharyngeal (but not maxillomandibular advancement) procedures.

This study is based on administrative data with all of their inherent limitations, including a lack of certain clinical information, inaccuracies, and overcoding. In particular, we lack more-detailed risk adjustment data that might have been useful in adjusting for surgical complexity, severity of OSA, acute severity of illness, and/or other clinical factors that may confound the observed associations. In addition, the associations regarding procedure type and costs require additional validation studies in independent samples. These databases also require use of ICD-9-CM procedure codes rather than the more-specific Current Procedural Terminology codes commonly used for billing. Costs were considered from the hospital perspective only and do not include costs accrued before and after surgery, except for the same admission with inpatient procedures and those within the 90-day postoperative global period for all procedures except tongue radiofrequency.

Finally, we utilized statistical methods to incorporate data from multiple databases and generate estimates of combined inpatient and outpatient procedures. The primary limitation of our combined inpatient and outpatient procedure estimates is dependence on data from only four states in a single year, inducing bias to the extent that those data are unrepresentative of their region. Despite the fact that no additional sampling error arises, the potential for bias prevents calculation of reliable 95% confidence intervals for these totals.

Conclusions

OSA surgery is performed in over 35,000 patients annually, although this represents a small fraction of all adults with the disorder. Isolated palate surgery composes the large majority of these procedures, with younger and black patients more likely to undergo isolated palate surgery. Palate and hypopharyngeal surgery costs in 2006 were approximately $6000 per admission, for an upper limit estimate of $192.5 million. Variations in cost and procedure type are related to selected patient and hospital factors, but clinical data are needed to understand these associations. Future research would benefit from comprehensive, publicly-available databases or registries of inpatient and outpatient procedures, similar to those that have been used to examine other medical procedures or technologies. These would ideally include clinical data on disease severity and anatomical factors that may influence procedure selection and objective and subjective treatment outcomes.

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Table 1

Databases used in statistical analyses, according to outcome measure

	NIS			SID/SASD
	2000	**2004**	**2006**	**2006**
Volume	X	X	X	X
Procedure type	X	X	X	
Costs		X	X	

Table 2

OSA surgical procedure volume

	2000 Inpatient Procedures, estimated from NIS N (95% CI)	2004 Inpatient Procedures, estimated from NIS N (95% CI)	2006 Inpatient Procedures, estimated from NIS N (95% CI)	P value for X^2 test for trend for inpatient procedures	2006 Inpatient and Outpatient Procedures, estimated from NIS, SASD, and SID
Total	10047 (8506, 11588)	8406 (6984, 9828)	7877 (6499, 9255)	0.001	35263
Palate	9524 (8067, 10981)	7668 (6327, 9009)	7018 (5762, 8274)	<0.001	33087
Hypopharyngeal	1524 (1029, 2019)	1836 (1409, 2263)	2724 (1925, 3523)	<0.001	6561
Tongue Radiofrequency or midline glossectomy	1254 (788, 1720)	1516 (1123, 1909)	2168 (1442, 2894)	<0.001	5132
Genioglossus advancement, genioplasty, or tongue stabilization	331 (211,451)	336 (218, 454)	530 (316, 744)	0.053	1320
Lingual tonsillectomy	24 (3, 45)	39 (8,70)	59 (20, 98)	0.09	147
Hyoid suspension	43 (12, 74)	130 (72, 188)	273 (166, 380)	<0.001	675
Maxillomandibular advancement	267 (114, 420)	422 (248, 596)	487 (314, 660)	0.005	1378
Age: 18–39 years	3502 (2932, 4072)	3054 (2529, 3579)	2971 (2402, 3540)	0.10	14140
Age: 40–64 years	5861 (4916, 6806)	4923 (4033, 5813)	4432 (3645, 5219)		19200
Age: 65+ years	683 (524, 842)	429 (306, 552)	473 (328, 618)		1923
Female	2022 (1674, 2370)	2162 (1756, 2568)	2123 (1718, 2528)	<0.001	9998
Male	8014 (6732, 9296)	6229 (5134, 7324)	5744 (4711, 6777)		25266
Black	951 (678, 1224)	639 (466, 812)	639 (459, 819)	0.009	3203
White	5749 (4644, 6854)	4652 (3588, 5716)	3516 (2848, 4184)		16078
Other	1075 (747, 1403)	924 (677, 1171)	922 (633, 1211)		3545
Missing	2272 (1545, 2999)	2191 (1591, 2791)	2799 (1784, 3814)		12438
Comorbidity: None	5965 (4961, 6969)	4171 (3345, 4997)	3565 (2862, 4268)	<0.001	16020

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	2000 Inpatient Procedures, estimated from NIS N (95% CI)	2004 Inpatient Procedures, estimated from NIS N (95% CI)	2006 Inpatient Procedures, estimated from NIS N (95% CI)	P value for X^2 test for trend for inpatient procedures	2006 Inpatient and Outpatient Procedures, estimated from NIS, SASD, and SID
Comorbidity: Low	3490 (2913, 4067)	3483 (2866, 4100)	3419 (2756, 4082)		15206
Comorbidity: Moderate-High	592 (467, 717)	751 (589, 913)	894 (683, 1105)		4038
County: Large metropolitan		4633 (3490, 5776)	4587 (3517, 5657)	0.52	18915
County: Small metropolitan		2269 (1697, 2841)	2099 (1549, 2649)		9993
County: micropolitan		1021 (596, 1444)	734 (507, 961)		4075
County: Rural		460 (299, 621)	443 (299, 587)		2280
Median household income for zip code: <$45,000	4918 (4117, 5719)	3534 (2896, 4172)	3155 (2595, 3715)	0.5002	15237
Median household income for zip code: ≥$45,000	4928 (3925, 5931)	4686 (3669, 5703)	4484 (3530, 5438)		18941
Primary payment source: Private	7792 (6481, 9103)	6577 (5357, 7797)	5993 (4865, 7121)	0.7887	28118
Primary payment source: Medicare	1142 (909, 1375)	996 (746 1246)	923 (686, 1160)		4064
Primary payment source: Medicaid	598 (441, 755)	485 (347, 623)	514 (367, 661)		1446
Primary payment source: Other	516 (344, 688)	349 (238, 460)	446 (308, 584)		1635
Urban teaching hospital	5287 (4042, 6532)	3912 (2810, 5014)	4078 (3060, 5096)	0.0027	18071
Urban non-teaching hospital	4088 (3213, 4963)	3596 (2835, 4357)	3341 (2425, 4257)		14511
Rural hospital	663 (424, 902)	899 (422, 1376)	454 (297, 611)		2661

Note: Results obtained from data within NIS (inpatient procedures, 2000–2006) or within NIS, SASD, and SID (combined inpatient and outpatient procedures, 2006 only).

Table 3

Factors associated with performance of isolated palate surgery vs. hypopharyngeal (with or without concurrent palate) surgery

	Inpatient sample, 2000-2006	**Combined inpatient and outpatient sample (2006 only)**
Covariate	**Adjusted odds ratio for isolated palate surgery (95% CI)**	**Adjusted odds ratio for isolated palate surgery (95% CI)**
Time		
2000	Referent	NA
2004	0.64 (0.44, 0.93)	NA
2006	0.34 (0.23, 0.51)	NA
Age		
18–39	Referent	Referent
40–64	0.67 (0.58, 0.77)	0.69 (0.54, 0.87)
≥ 65	0.72 (0.51, 1.01)	0.64 (0.36, 1.15)
Gender		
Male	Referent	Referent
Female	0.84 (0.72, 0.98)	0.82 (0.62, 1.08)
Race/ethnicity		
White	Referent	Referent
Black	1.75 (1.18, 2.58)	1.82 (1.03, 3.22)
Other	1.36 (0.97, 1.90)	0.96 (0.58, 1.60)
Missing	0.69 (0.48, 1.00)	0.67 (0.35, 1.32)
Comorbidity index		
None	Referent	Referent
Low	0.93 (0.79, 1.10)	0.82 (0.61, 1.09)
Moderate-High	1.01 (0.76, 1.36)	0.80 (0.51, 1.26)
Income		
$1-$44,999	Referent	Referent
≥ $45,000	0.89 (0.71, 1.10)	0.79 (0.57, 1.08)
Missing	0.70 (0.46, 1.05)	1.05 (0.53, 2.07)
Primary payment source		
Private	Referent	Referent
Medicare	0.90 (0.67, 1.19)	0.77 (0.48, 1.23)
Medicaid	1.18 (0.81, 1.71)	1.07 (0.63, 1.83)
Other	1.43 (0.92, 2.22)	1.19 (0.65, 2.16)
Hospital location and teaching status		
Urban teaching	Referent	Referent
Urban non-teaching	1.11 (0.79, 1.56)	1.14 (0.61, 2.14)

	Inpatient sample, 2000-2006	**Combined inpatient and outpatient sample (2006 only)**
Covariate	**Adjusted odds ratio for isolated palate surgery (95% CI)**	**Adjusted odds ratio for isolated palate surgery (95% CI)**
Rural	1.43 (0.85, 2.41)	1.52 (0.51, 4.56)

Note: Results obtained from multiple logistic regression models examining factors associated with isolated palate surgery vs. hypopharyngeal surgery (referent) for inpatient procedures (2000, 2004, and 2006) and for combined inpatient and outpatient procedures (2006 only).

Table 4

Factors associated with costs of inpatient admissions associated with the performance of OSA surgery

Variable	**Adjusted % difference (95% CI)**	**P value**
Time		
2004	Referent	0.11
2006	6.62 (−1.52, 15.42)	
Surgery type		
Palate only	Referent	<0.001
Hypopharyngeal +/− palate	45.63 (35.66, 56.00)	
Age		
18–39 years	Referent	0.01
40–64 years	−2.98 (−6.77, 0.95)	
≥65 years	−15.95 (−25.35, −5.38)	
Gender		
Male	Referent	0.32
Female	−2.27 (−6.64, 2.30)	
Race		
White	Referent	0.45
Black	6.81 (−1.71, 16.07)	
Other	3.68 (−4.55, 12.63)	
Missing	2.61 (−6.20, 12.24)	
Comorbidity index		
None	Referent	<0.001
Low	9.80 (4.84, 14.99)	
Moderate-High	31.53 (20.86, 43.16)	
Primary payment source		
Private	Referent	0.003
Medicare	6.59 (−2.81, 16.91)	
Medicaid	15.08 (3.29, 28.22)	
Other	18.98 (6.59, 32.83)	
Missing	6.34 (−9.34, 24.74)	
Median household income		
$1-$44,999	Referent	0.59
≥ $45,000	1.20 (−4.10, 6.78)	
Missing	−5.16 (−16.75, 8.03)	
County of residence		
Large metro	Referent	0.93
Small metro	0.20 (−8.51, 9.74)	
Micropolitan	0.22 (−10.43, 12.13)	
Non-core	4.29 (−9.69, 20.42)	

Variable	Adjusted % difference (95% CI)	P value
Hospital location/teaching status		
Urban teaching	Referent	0.08
Urban/non-teaching	−0.03 (−9.33, 10.22)	
Rural	16.81 (1.38, 34.33)	

Note: Results obtained from multiple logistic regression model examining factors associated with costs for inpatient admissions associated with OSA surgery for 2004 and 2006 only.