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ABSTRACT

OBJECTIVE: To determine obstructive sleep apnea (OSA) surgical volume, types, costs, and trends. To explore whether specific patient and hospital characteristics are associated with the performance of isolated palate versus hypopharyngeal surgery and with costs.

STUDY DESIGN: Cross-sectional study.

SETTING: Inpatient and outpatient medical facilities in the United States.

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-square 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, 6561 hypopharyngeal, and 1378 maxillomandibular advancement procedures. The odds of undergoing isolated palate surgery were higher for younger (18-39 yrs) and black patients. Outpatient procedures were more common than inpatient procedures. Inpatient surgical volume declined from 2000 to 2006, but it was not possible to evaluate trends in total volumes. In 2006, mean costs were approximately $6000 per admission. For inpatient procedures in 2004 and 2006, costs were higher for hypopharyngeal (vs isolated palate) surgery, in rural hospitals, and for patients who were younger, with greater medical comorbidity, and with primary Medicaid coverage.

CONCLUSION: Surgical treatment is performed in 0.2 percent 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.

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 so-called hypopharyngeal (also retrolingual or retroglossal) 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 health care 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 versus hypopharyngeal surgery and costs for inpatient procedure admissions.

Methods

Subjects

This cross-sectional study examined data collected for patients aged 18 years and older who underwent inpatient or outpatient OSA surgical procedures as defined by International Classification of Diseases, 9[th] 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.

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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 University of California San Francisco 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 percent 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); such observation status admissions are not included in this study. Inverse-probability-of-sampling weights are provided with the NIS data, enabling users to estimate 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. These 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 ($\geq$ 3 conditions) comorbidity, similar to previous analyses using the NIS.[7]

Hospital level predictors included location/teaching status (defined as urban teaching, urban nonteaching, 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). Interac-

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	

NIS, Nationwide Inpatient Sample; *SID*, State Inpatient Database; *SASD*, State Ambulatory Surgery Database.

tion 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 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 (key independent variables): 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 five, meaning that the NIS observation represents an estimated total of five inpatient procedures, reflecting the NIS 20 percent systematic sampling. Suppose also that the estimated probability that this particular procedure was performed in an inpatient setting is 25 percent. 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 five 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 statistical software Version 10.0 (Research Triangle Institute, Research Triangle Park, NC) and SAS Version 9.2 (SAS Institute, Cary, NC). *P* values < 0.05 were considered statistically significant.

Results

OSA Surgical Volume

Nationwide, 35,263 OSA procedures were performed in 2006 (Table 2). 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 percent of the total, with palate and hypopharyngeal procedures being 79 and 58 percent outpatient-based, respectively. For the four individual states, outpatient procedures represented from 64 percent (California) to 84 percent (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 versus Hypopharyngeal Surgery

As shown in Table 3, the odds of undergoing isolated palate surgery in 2006 (combined inpatient and outpatient procedures in right-hand column) were lower for patients aged 40 to 64 years than for those aged 18 to 39 years and were higher for blacks than whites. For inpatient procedures alone from 2000 to 2006 (middle column), the strongest association was with year of surgery, indicating lower odds of undergoing isolated palate surgery over time. In addition,

Table 2
Obstructive sleep apnea 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 χ^2 test for trend for inpatient procedures	2006 Inpatient and outpatient procedures, estimated from NIS, SASD, and SID
Total	10,047 (8506-11,588)	8406 (6984-9828)	7877 (6499-9255)	0.001	35,263
Palate	9524 (8067-10,981)	7668 (6327-9009)	7018 (5762-8274)	<0.001	33,087
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 yrs	3502 (2932-4072)	3054 (2529-3579)	2971 (2402-3540)	0.10	14,140
Age: 40-64 yrs	5861 (4916-6806)	4923 (4033-5813)	4432 (3645-5219)		19,200
Age: ≥65 yrs	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)		25,266
Black	951 (678-1224)	639 (466-812)	639 (459-819)	0.009	3203
White	5749 (4644-6854)	4652 (3588-5716)	3516 (2848-4184)		16,078
Other	1075 (747-1403)	924 (677-1171)	922 (633-1211)		3545
Missing	2272 (1545-2999)	2191 (1591-2791)	2799 (1784-3814)		12,438
Comorbidity: none	5965 (4961-6969)	4171 (3345-4997)	3565 (2862-4268)	<0.001	16,020
Comorbidity: low	3490 (2913-4067)	3483 (2866-4100)	3419 (2756-4082)		15,206
Comorbidity: moderate-high	592 (467-717)	751 (589-913)	894 (683-1105)		4038
County: large metropolitan		4633 (3490-5776)	4587 (3517-5657)	0.52	18,915
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	15,237
Median household income for zip code: ≥$45,000	4928 (3925-5931)	4686 (3669-5703)	4484 (3530-5438)		18,941
Primary payment source: private	7792 (6481-9103)	6577 (5357-7797)	5993 (4865-7121)	0.7887	28,118
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	18,071
Urban nonteaching hospital	4088 (3213-4963)	3596 (2835-4357)	3341 (2425-4257)		14,511
Rural hospital	663 (424-902)	899 (422-1376)	454 (297-611)		2661

Results obtained from data within NIS (inpatient procedures, 2000-2006) or within NIS, SASD, and SID (combined inpatient and outpatient procedures, 2006 only).
NIS, Nationwide Inpatient Sample; *CI*, confidence interval; *SASD*, State Ambulatory Surgery Database; *SID*, State Inpatient Database.

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 percent higher for hypopharyngeal (with or without palate) procedures than for isolated palate surgery. They were also elevated for patients aged 18 to 39 years (vs ≥ 65 yrs) 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 < 0.2 percent 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

Table 3
Factors associated with performance of isolated palate surgery versus hypopharyngeal (with or without concurrent palate) surgery

Covariate	Adjusted odds ratio for isolated palate surgery (95% CI): Inpatient sample, 2000 to 2006	Adjusted odds ratio for isolated palate surgery (95% CI): Combined inpatient and outpatient sample (2006 only)
Time		
2000	Referent	NA
2004	0.64 (0.44-0.93)	NA
2006	0.34 (0.23-0.51)	NA
Age		
18-39 yrs	Referent	Referent
40-64 yrs	0.67 (0.58-0.77)	0.69 (0.54-0.87)
≥65 yrs	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 nonteaching	1.11 (0.79-1.56)	1.14 (0.61-2.14)
Rural	1.43 (0.85-2.41)	1.52 (0.51-4.56)

Results obtained from multiple logistic regression models examining factors associated with isolated palate surgery versus hypopharyngeal surgery (referent) for inpatient procedures (2000, 2004, and 2006) and for combined inpatient and outpatient procedures (2006 only).
CI, confidence interval; *NA*, not applicable.

metropolitan areas). Only five percent 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]

Table 4
Factors associated with costs of inpatient admissions associated with the performance of obstructive sleep apnea 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 yrs	Referent	0.01
40-64 yrs	−2.98 (−6.77-0.95)	
≥65 yrs	−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)	
Noncore	4.29 (−9.69-20.42)	
Hospital location/teaching status		
Urban teaching	Referent	0.08
Urban/nonteaching	−0.03 (−9.33-10.22)	
Rural	16.81 (1.38-34.33)	

Results obtained from multiple logistic regression model examining factors associated with costs for inpatient admissions associated with OSA surgery for 2004 and 2006 only.
CI, confidence interval.

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 percent 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 yrs) patients were more likely than those aged 40 to 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 may be small and likely consists 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% CIs 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 makes up 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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Eric J. Kezirian, study conception and design, interpretation of data, drafting of manuscript, final approval; **Judy Maselli,** study design, statistical analysis, manuscript revision, final approval; **Eric Vittinghoff,** study design, statistical analysis, manuscript revision, final approval; **Andrew N. Goldberg,** interpretation of data, manuscript revision, final approval; **Andrew D. Auerbach,** study design, acquisition of data, interpretation of data, manuscript revision, final approval.

Disclosures

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