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Impact of Surgeon and Hospital Volume on Short-Term Outcomes and Cost of Oropharyngeal Cancer Surgical Care

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Abstract

Objective—To evaluate the impact of surgeon and hospital case volume and other related variables on short-term outcomes after surgery for oropharyngeal cancer.

Methods—The Maryland Health Service Cost Review Commission database was queried for oropharyngeal cancer surgical case volumes from 1990 to 2009. Multivariable regression models were used to identify significant associations between surgeon and hospital case volume, as well as independent variables predictive of in-hospital death, postoperative wound complications, length of hospitalization, and hospital-related cost of care.

Results—Overall, 1,534 oropharyngeal cancer surgeries were performed during the study period. Complete financial data was available for 1,482 oropharyngeal cancer surgeries, performed by 233 surgeons at 36 hospitals. The only independently significant factors associated with the risk of in-hospital death were an APR-DRG mortality risk score of 4 (odds ratio [OR] = 14.0, $P < .001$) and total glossectomy (OR = 5.6, $P = .020$). Wound fistula or dehiscence was associated with an increased mortality risk score (OR = 5.9, $P < .001$), total glossectomy (OR = 6.9, $P < .001$), mandibulectomy (OR = 3.4, $P < .001$), and flap reconstruction (OR = 2.1, $P = .038$). Increased mortality risk score, total glossectomy, pharyngectomy, mandibulectomy, flap reconstruction, neck dissection, and Black race were associated with an increased length of stay and hospital-related costs. After controlling for all other variables, a statistically significant negative correlation was observed between surgery at a high-volume hospital and length of hospitalization and hospital-related costs.

Conclusions—After controlling for other factors, high-volume hospital care is associated with a shorter length of hospitalization and lower hospital-related cost of care for oropharyngeal cancer surgery.

Keywords

Volume; oropharyngeal neoplasms; squamous cell cancer; surgery; cost; mortality; complications

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INTRODUCTION

Positive volume–outcome relationships have been reported in a number of population-based studies that demonstrate lower short- and long-term mortality for cardiovascular, intrathoracic, and intraabdominal procedures performed at high-volume hospitals.[1–4] High-volume surgeons have been reported to have lower surgical mortality rates, which may account for a large proportion of the favorable effect of hospital outcome on surgical mortality.[5] These observations have resulted in an increasing emphasis on volume–outcome relationships, as evidenced by the adoption of hospital volume standards as a surrogate marker for quality care by healthcare purchasing coalitions such as the Leapfrog Group.[6,7] Although limited data exists regarding the relationship between volume and outcome in head and neck surgery, similar observations regarding the positive effect of hospital[8–12] and surgeon[5,13–16] volume on outcome have been reported for surgical treatment of parotid, larynx, pharynx, thyroid disease, and cervical metastases, with improved long-term survival demonstrated for patients with laryngeal cancer who are treated at high-volume centers.[9]

There is a lack of data on important short-term outcomes of volume-based care, such as postoperative morbidity and mortality and cost of care, as measures of healthcare quality or value for head and neck cancer surgical care. We have previously reported that high-volume surgeons and hospitals are significantly more likely to perform more extensive oropharyngeal cancer operations, including total glossectomy, flap reconstruction, and neck dissection, and are more likely to treat patients with prior radiation, which suggests that there are meaningful differences in the type of surgical care provided by high volume providers.[17] The objective of this study was to evaluate the impact of surgeon and hospital volume as well as other related variables on the in-hospital mortality rate, development of postoperative wound complications, length of hospital stay, and hospital-related cost of care after surgery for oropharyngeal cancer.

METHODS

A cross-sectional analysis of patients with a diagnosis of oropharyngeal cancer was performed using hospital discharge data from nonfederal acute care hospitals in Maryland collected by the Maryland Health Service Cost Review Commission (HSCRC). The HSCRC database provides information regarding the index hospital admission (surgery) and is limited to 30 days of follow-up. Adult patients (≥18 years of age) who underwent an ablative procedure for a malignant oropharyngeal neoplasm in Maryland between January 1, 1990 and July 1, 2009 comprised the study population. The International Classification of Disease, 9th revision (ICD-9) codes for malignant neoplasm of the oropharynx (141.0, 141.5, 141.6, 141.8, 145.3, 145.4, 146.0, 146.1, 146.2, 146.3, 146.6, 146.7, 146.8, 146.9, 149.0, and 149.1) were used for sorting. All cell types were included. Surgical procedures included in this analysis were limited to ablative procedures: destruction of tongue lesion (25.1), partial or total glossectomy (25.2, 25.3, 25.4), tonsillectomy (28.2), excision of lingual tonsil (28.5), excision of tonsil lesion (28.91), pharyngotomy (29.0), pharyngectomy (29.33), excision/destruction of lesion of pharynx (29.39), partial or total mandibulectomy (76.31, 76.41, 76.42), or partial or total laryngectomy (30.29, 30.3, 30.4), with or without neck dissection (40.40, 40.41, 40.42, 40.3). Patients undergoing biopsy (25.02) were included if neck dissection was the index admission procedure. Reconstructive procedures were obtained from codes for pedicled or free flap reconstruction (86.7, 86.70, 86.71, 86.72, 86.73, 86.74, 86.75, 86.8, 86.89). Postoperative wound complications were derived from codes for complications directly resulting from surgical procedures assigned at the time of hospital discharge including wound dehiscence (998.3) or fistula (998.6).

Individual surgeon annual oropharyngeal cancer case volume and individual hospital annual oropharyngeal cancer case volume were the primary independent variables in this study. Surgeons and hospitals were included in the analysis if they were involved with at least one oropharyngeal cancer surgery during the entire study period. The average annual number of oropharyngeal cancer surgery cases performed per year of surgical activity was obtained by calculating the mean of the number of cases performed each year for each individual provider, for the years in which that surgeon or hospital performed at least one oropharyngeal cancer surgery. Surgeon and hospital volume were modeled as categorical variables. Annual volumes were divided into quartiles and univariate logistic regression was performed to evaluate patterns of care among those quartiles. Based on analysis results, surgeons performing more than 6 cases/year and hospitals with more than 30 cases/year were categorized as high-volume providers.[17]

Secondary independent variables available from the HSCRC database included age, sex, race, APR-DRG mortality risk score, payer source (commercial, health maintenance organization [HMO], Medicare or Medicaid, or self-pay), nature of admission (emergent/ urgent, or other), readmission, and hospital type (university, community teaching, or community). The APR-DRG mortality risk score reflects the likelihood of dying (1–4) and incorporates the impact and interaction of multiple secondary diagnoses. A community teaching hospital was defined as a nonuniversity hospital with a residency program in Otolaryngology—Head and Neck Surgery. American Joint Commission on Cancer (AJCC) tumor stage, tumor grade, histologic subtype, and outcome beyond 30 days were not available from the HSCRC database.

The primary clinical statistical endpoints (dependent variable) of the study were in-hospital death during the index admission for primary oropharyngeal cancer surgical procedures exclusive of biopsy or staging procedures. Postoperative wound complications, length of hospital stay, and total hospital costs for the index admission were also examined as dependent variables. Hospital-related charges for each index admission were converted to the organizational cost of providing care using cost to charge ratios for individual hospitals. Cost to charge ratios were calculated from data from the HSCRC by dividing the average inpatient expense by the average inpatient revenue of each hospital during each year of the study interval.[18] This ratio was then multiplied by each patient’s charge to obtain the cost per admission.[19] All costs were adjusted for inflation based on U.S. Bureau of Labor Statistics indices, with results converted to 2009 USD.[20] Cases with incomplete financial data were excluded from analysis.

Data were analyzed using Stata 10 (StataCorp, College Station, TX). Standard statistical analysis, including the unpaired *t*-test for continuous data, and chi-square tests for categorical data were used to evaluate factors associated with volume category. Age categories were created based on the results of Lowess smoothed regression analysis. Associations between dependent variables and the endpoints of in-hospital death and postoperative wound complications were analyzed using crosstabulations and multivariate logistic regression modeling. Crosstabulations were analyzed using chi-square tests. Multiple linear regression models were used to compare associations between dependent variables and hospital length of stay and total hospital costs. Collinearity was checked by performing a multiple regression analysis and calculating the variance inflation factors (VIF) and removing variables with a VIF greater than 10.0, which suggests collinearity. Variables that were hypothesized to have predictive value as well as those that were significant in bivariate analysis were entered into the regression models. Models were sequentially built to identify significantly associated variables. A second approach used stepwise backward variable selection to determine which subset of variables were predictive of the outcome of interest. Akaike’s information criterion was used to select models by goodness of fit. Logtransformed costs and length of stay were modeled because these variables were not normally distributed. Odds ratios (OR) are expressed relative to a reference baseline category. This protocol was reviewed and approved by the Johns Hopkins Medical Institutions institutional review board.

RESULTS

A total of 1,534 cases were performed during the study period and 1,482 cases had complete financial data (Table I). During the study interval, there were 3 high-volume surgeons, 230 low-volume surgeons, 1 high-volume hospital, and 35 low-volume hospitals. The mean patient age at diagnosis was 58.3 years (range: 21–97 years). The majority of patients were male, White, had commercial or Medicare or Medicaid payer status and received their care at a university hospital. Neck dissection was the most common surgical procedure and was performed in 65.3% of all patients, whereas partial glossectomy was the most common ablative procedure and was performed in 32.4% of all patients. Postoperative wound complications occurred in 7.4% of cases and inhospital death occurred in 1.0% of cases. The distribution of subjects according to surgeon and hospital volume, as well as additional demographic characteristics related to crude in-hospital mortality rates and other short term outcomes are shown in Table II.

Multiple logistic regression analysis of independent variables associated with the risk of in-hospital death and postoperative wound complications are shown in Table III. After controlling for the effects of all variables, the only statistically and independently significant factors associated with the risk of in-hospital death were a mortality risk score of 4 and total glossectomy. The development of a postoperative wound fistula or dehiscence was associated with an increased mortality risk score, partial or total glossectomy, mandibulectomy, and pedicled or free flap reconstruction. Surgery performed by a high-volume surgeon was a statistically significant and independent predictor of surgery performed at a high-volume hospital (OR = 55.79, 95% confidence interval [CI] = 32.42–95.96, $P < .001$).

The results of multiple linear regression analyses of independent variables predictive of length of hospital stay and hospital-related costs are shown in Table IV. Mortality risk score, urgent or emergent admission, excision or destruction, partial or total glossectomy, pharyngectomy, mandibulectomy, flap reconstruction, neck dissection, and Black race were significantly associated with greater length of hospitalization and increased hospital costs. A statistically significant negative correlation was observed between surgery at a high-volume hospital and both length of hospital stay and hospital-related cost.

DISCUSSION

Most population-based studies in the literature report a positive association between volume and outcomes in cancer surgical care, with improved perioperative and long-term survival for patients treated at high-volume hospitals.[1–4,8,9,21,22] The relationship between hospital volume and outcome varies by procedure and is influenced by surgeon volume, suggesting that hospital volume is a surrogate for processes of care that directly influence patient outcomes.[5,23,24] These observations have resulted in an increasing emphasis on volume–outcome relationships and serve as the basis for the controversial adoption of hospital volume standards as a surrogate for quality and a requirement for reimbursement by healthcare purchasing coalitions such as the Leapfrog Group. [6,7] Increasingly, the medical community is focused on quantifying the potential impact of such measures on patient outcomes.

High-volume hospital care has been shown to be inversely related to in-hospital mortality, length of stay, and total charges after radical prostatectomy and ovarian cancer surgery.[25,26] There is little data regarding the volume–outcome relationship in head and neck cancer surgical care. Improved long-term survival has been demonstrated for patients with laryngeal and oropharyngeal cancer who are treated at high-volume centers.[8,9] We have found that high-volume surgeons and high-volume hospitals are more likely to perform more extensive primary site ablative operations for laryngeal and oropharyngeal cancer as well as neck dissection, and high-volume centers are more likely to perform free flap reconstruction and treat patients with a history of prior radiation.[17,27] These findings suggest that there are differences in the type of surgical care provided between high and low-volume providers. In addition, we have found a temporal trend of increasing concentration of laryngeal and oropharyngeal cancer surgical care, with a greater proportion of surgical cases treated by high-volume surgeons and high-volume hospitals.[17] This trend parallels an observed decrease in the use of primary site ablative procedures and an increase in the proportion of patients with prior radiation, that is likely a result of the observed national increase in organ preservation with chemoradiation.[28,29] These data suggest that not only are fewer primary site ablative procedures being performed, but that an increasing proportion are being performed at high-volume hospitals and for salvage following failed chemoradiation. The influence of volume-based differences on short-term outcomes and the resulting costs of oropharyngeal cancer surgical care have not been investigated to date.

Our data suggest that both short-term mortality and oropharyngeal–cancer-specific complication rates are not associated with hospital or surgeon volume. Short-term mortality for oropharyngeal cancer surgery was low in this study, which may limit our analysis of the effect of volume on mortality given small numbers compared to previously published studies on volume–outcome relationships. Ghaferi et al.[30,31] reported that relationships between volume, complications, and mortality disappear with risk adjustment, suggesting that postoperative complications are related more to patient factors than to quality of care. However, the management of complications separated high- from low-volume hospitals, with improved mortality rates reported for the cohort of patients with postoperative complications treated at high-volume centers. We were unable to detect volume-based differences in outcome in patients with postoperative complications, but this is likely a result of small numbers in our cohort. However, there are significant differences in length of stay and hospital-related costs for high-volume hospitals that persist after controlling for the effects of other variables including mortality risk and procedures associated with a higher incidence of postoperative complications. These data suggest that oropharyngeal cancer surgery at a high-volume hospital is a significant predictor of shorter length of stay and lower hospital-related costs, despite a greater likelihood of performing more extensive surgery on a more high-risk patient population, as we have previously reported.[17]

There are several limitations to the use of hospital discharge data that may influence our findings. The Maryland HSCRC database provides no follow-up data beyond the index admission and is limited to a 30-day postoperative window, and contains no information on stage of disease, grade, subtype, human papilloma virus (HPV) status, or survival. Thus, a meaningful analysis of long-term outcomes is not possible from the available data. The HSCRC database does not contain information regarding the use of previous surgical procedures or prior chemotherapy, which could potentially affect results with regard to the extent of surgery, length of hospital stay, or perioperative morbidity. There may be differences in the type of patient or disease cared for at high-volume hospitals that are not adequately captured. Although morrtality risk scores were used for risk adjustment, the ability to adequately control for case mix is limited when discharge diagnoses from administrative databases are used, which is the case in almost all studies investigating volume and outcome associations to date, including the present study.[1,2,6,21,22]

Postoperative complications may not be apparent at the time of discharge, and as a result the incidence of complications may be underreported. Another potential limitation is that the cost analysis was based on hospital-related charges, adjusted for institutional expense-to-revenue ratios, and did not include physician-related costs, as these data are not contained in the HSCRC database.

Despite these limitations, these data suggest that oropharyngeal cancer surgery at a high-volume hospital is a significant predictor of shorter length of stay and lower hospital-related cost of care for oropharyngeal cancer surgery, after controlling for the effects of other variables including mortality risk and type of procedure. The costs associated with a given surgical procedure have been defined as the product of two variables: the unit cost of resources required for one operation, and the total number of procedures performed.[32] The total number of procedures performed may be a more important determinant of total costs than unit costs, as high volumes may be associated with higher quality diagnostic practices or patient selection, both of which are process measures. Surgical volumes are influenced by experience and judgment, and it has been shown that fellowship training correlates with increased volumes.[14] High-volume providers are more likely to present patients at multidisciplinary conferences and adhere to national care guidelines.[33] Given the temporal trend toward fewer primary oropharyngeal cancer surgical procedures in the era of chemoradiation,[29] volume-based initiatives for oropharyngeal cancer surgical care appear to be an appropriate measure to reduce costs and improve the quality of care provided.

CONCLUSIONS

High-volume hospital care is associated with a shorter length of hospitalization and lower hospital-related cost of care for oropharyngeal cancer surgery, after controlling for the effects of other variables including mortality risk and postoperative complications. These data suggest that volume-based referral strategies that concentrate oropharyngeal cancer surgical care at high-volume centers may be cost effective, particularly in an era of decreasing use of primary surgery for oropharyngeal cancer.

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TABLE I

Demographic Characteristics.

	High-Volume Hospital (N = 580)	Low-Volume Hospital (N = 902)	*P*-Value	High-Volume Surgeon (N = 329)	Low-Volume Surgeon (N = 1,153)	*P*-Value
Age			.017			.181
<40 years	42 (7.2%)	39 (4.3%)		26 (7.9%)	55 (4.8%)	
40–60 years	313 (54.0%)	453 (50.2%)		165 (50.2%)	601 (52.1%)	
60–80 years	212 (36.6%)	385 (42.7%)		130 (39.5%)	467 (40.5%)	
≥80 years	13 (2.2%)	25 (2.8%)		8 (2.4%)	30 (2.6%)	
Race			.251			.220
White	460 (79.3%)	701 (77.7%)		270 (82.0%)	891 (77.3%)	
Black	94 (16.2%)	171 (19.0%)		46 (14.0%)	219 (19.0%)	
Asian	3 (0.5%)	2 (0.2%)		1 (0.3%)	4 (0.3%)	
American Indian	0 (0%)	1 (0.1%)		0 (0%)	1 (0.1%)	
Other	22 (3.8%)	22 (2.4%)		12 (3.7%)	32 (2.8%)	
Biracial	1 (0.2%)	5 (0.6%)		0 (0%)	6 (0.5%)	
Sex			.744			.204
Male	429 (74.0%)	674 (74.7%)		236 (71.7%)	867 (75.2%)	
Female	151 (26.0%)	228 (25.3%)		93 (28.3%)	286 (24.8%)	
Hospital type			<.001			<.001
Community	0 (0%)	667 (74.0%)		15 (4.6%)	652 (56.6%)	
University	580 (100.0%)	235 (26.0%)		314 (95.4%)	501 (43.4%)	
Payer status			.004			.280
Commercial	253 (43.6%)	314 (34.8%)		141 (42.9%)	426 (37.0%)	
HMO	91 (15.7%)	163 (18.0%)		51 (15.5%)	203 (17.6%)	
Medicare or Medicaid	211 (36.4%)	393 (43.6%)		125 (38.0%)	479 (41.5%)	
Self-pay	25 (4.3%)	32 (3.6%)		12 (3.6%)	45 (3.9%)	
Mortality risk *			.827			.985
1	249 (51.8%)	373 (53.3%)		147 (52.5%)	475 (52.7%)	
2	185 (38.4%)	254 (36.3%)		106 (37.9%)	333 (37.0%)	
3	38 (7.9%)	56 (8.0%)		21 (7.5%)	73 (8.1%)	
4	9 (1.9%)	17 (2.4%)		6 (2.1%)	20 (2.2%)	

	High-Volume Hospital (N = 580)	Low-Volume Hospital (N = 902)	*P*-Value	High-Volume Surgeon (N = 329)	Low-Volume Surgeon (N = 1,153)	*P*-Value
Hospital admission type			<.001			<.001
Emergency/urgent	170 (29.3%)	126 (14.0%)		93 (28.3%)	203 (17.6%)	
Other	410 (70.7%)	776 (86.0%)		236 (71.7%)	950 (82.4%)	
Readmission within 30 days*			<.001			.002
Yes	30 (6.0%)	91 (12.0%)		14 (4.9%)	107 (11.0%)	
No	471 (94.0%)	665 (88.0%)		274 (95.1%)	862 (89.0%)	
30 day mortality			.643			.837
Alive	575 (99.1%)	892 (98.9%)		326 (99.1%)	1141 (99.0%)	
Death	5 (0.9%)	10 (1.1%)		3 (0.9%)	12 (1.0%)	

*Status was not known for all patients.

TABLE II

Summary Characteristics Related to In-Hospital Mortality, Postoperative Wound Complications, Length of Stay, and Hospital-Related Costs.

				Length of Stay (Days)			Hospital Cost of Care (2009 USD)		
	N	In-Hospital Death Rate	Wound Complications Rate	Mean	Median	Range	Mean	Median	Range
Surgeon volume									
High	329	3 (0.9%)	26 (7.9%)	7.8	7	1–236	$19,043	$15,533	$2,335–$149,391
Low	1153	12 (1.0%)	84 (7.3%)	10.2	7	1–64	$24,049	$16,875	$1,416–$298,032
Hospital volume									
High	580	5 (0.8%)	50 (8.6%)	9.0	6	1–156	$20,930	$15,613	$2,335–$286,013
Low	902	10 (1.1%)	60 (6.7%)	10.1	7	1–236	$24,229	$17,037	$1,416–$298,032
Hospital type									
Community	667	6 (0.9%)	44 (6.6%)	9.7	7	1–102	$19,437	$14,088	$1,416–$236,127
University	815	9 (1.1%)	66 (8.1%)	9.6	7	1–236	$25,803	$18,799	$2,335—$298,032
Age									
<60 years	806	6 (0.7%)	63 (7.8%)	12.8	6	1–236	$23,018	$15,657	$1,493–$298,032
≥60 years	676	9 (1.3%)	47 (6.9%)	12.4	7	1–156	$22,843	$16,838	$1,416–$256,417
Race									
White	1161	13 (1.1%)	87 (7.5%)	8.8	6	1–156	$21,274	$14,920	$1,416–$256,417
Black	265	2 (0.8%)	20 (7.5%)	13.5	9	1–236	$28,532	$21,502	$1,519–$298,032
Asian	5	0	0	16.2	5	1–60	$46,628	$12,802	$2,252–$103,413
American Indian	1	0	0	5	5	5	$34,209	$34,209	$34,209
Other	44	0	3 (6.8%)	9.7	7	1–75	$30,920	$18,335	$2,160–$286,013
Biracial	6	0	0	4.7	5	2–9	$17,672	$20,212	$6,178–$26,521
Sex									
Male	1103	11 (1.0%)	85 (7.7%)	9.3	7	1–88	$22,495	$15,914	$1,493–$236,127
Female	379	4 (1.0%)	25 (6.6%)	10.7	7	1–236	$24,227	$17,886	$1,416–$298,032
Mortality risk									
1	622	5 (0.8%)	45 (7.2%)	7.5	6	1–64	$19,196	$14,217	$1,867–$149,391
2	439	0	19 (4.3%)	6.8	4	1–67	$20,640	$13,822	$1,416–$168,446
3	94	2 (2.1%)	9 (9.6%)	12.6	10	1–53	$41,209	$34,509	$7,176–$236,127
4	26	3 (11.5%)	9 (34.6%)	20.0	15	1–75	$63,553	$53,818	$11,062–$286,013

	N	In-Hospital Death Rate	Wound Complications Rate	Length of Stay (Days)			Hospital Cost of Care (2009 USD)		
				Mean	Median	Range	Mean	Median	Range
Hospital admission type									
Emergency/urgent	296	3 (1.0%)	28 (9.5%)	13.5	6	1–236	$25,310	$18,814	$1,661–$286,013
Other	1186	12 (1.0%)	82 (6.9%)	8.7	9	1–156	$22,346	$15,729	$1,416–$298,032
Readmission within 30 days									
Yes	121	1 (0.8%)	11 (9.1%)	9.8	8	1–50	$25,480	$20,122	$2,280–$168,446
No	1136	9 (0.8%)	79 (6.9%)	8.0	6	1–79	$22,087	$15,309	$1,416–$286,013

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TABLE III

Multivariate Logistic Regression Analysis of Variables Associated with Risk of In-Hospital Death and Postoperative Wound Complications.

Variable	Odds Ratio	95% CI	*P*-Value
In-hospital death			
Mortality risk score 4	13.99	3.18–61.53	<.001
Total glossectomy	5.63	1.30–24.25	.020
Wound fistula/dehiscence			
Mortality risk score 4	5.85	2.30–14.90	<.001
Partial glossectomy	2.40	1.39–4.11	.002
Total glossectomy	6.92	3.38–14.17	<.001
Mandibulectomy	3.36	1.88–5.98	<.001
Pedicle or flap reconstruction	2.09	1.04–4.19	.038

CI = confidence interval.

TABLE IV

Multiple Linear Regression Analysis of Length of Stay and Hospital Costs.

Variable	Estimate	95% CI	P-Value	Geometric mean (days)
Length of stay (days)				
Intercept	0.7112	0.5893–0.8330	<0.001	2.0
High-volume hospital	−0.1613	−0.2535–−0.691	0.001	1.7
Black race	0.3659	0.2435–0.4884	<0.001	2.9
Mortality risk score 3	0.5124	0.3468–0.6780	<0.001	3.3
Mortality risk score 4	0.7534	0.4493–1.0576	<0.001	4.2
Urgent/emergent admission	0.3869	0.2602–0.5136	<0.001	2.9
Partial glossectomy	0.3952	0.2435–0.4884	<0.001	3.0
Total glossectomy	1.0314	0.8431–1.2198	<0.001	5.6
Pharyngectomy	0.5971	0.4429–0.7513	<0.001	3.6
Mandibulectomy	0.6154	0.4594–0.7713	<0.001	3.7
Neck dissection	0.5948	0.4894–0.7002	<0.001	3.6
Pedicled or free flap reconstruction	0.3487	0.1539–0.5436	<0.001	2.8
				Geometric mean (2009 USD)
Hospital costs				
Intercept	8.8880	8.7959–8.9802	<0.001	$7,245
High-volume hospital	−0.0785	−0.1551–−0.0019	0.044	$6,698
Black race	0.2449	0.1431–0.3466	<0.001	$9,255
Mortality risk score 3	0.6074	0.4700–0.7448	<0.001	$13,299
Mortality risk score 4	0.8578	0.6049–1.1106	<0.001	$17,084
Urgent/emergent admission	0.1454	0.0399–0.2508	0.007	$8,379
Partial glossectomy	0.3386	0.2571–0.4202	<0.001	$10,165
Total glossectomy	0.9506	0.7940–1.1073	<0.001	$18,745
Pharyngectomy	0.5430	0.4148–0.6713	<0.001	$12,470
Mandibulectomy	0.5332	0.4034–0.6629	<0.001	$12,348
Neck dissection	0.5279	0.4410–0.6148	<0.001	$12,283
Pedicled or free flap reconstruction	0.3611	0.1992–0.5231	<0.001	$10,396