Effects of surgeon and hospital volume on 5-year survival rates following oral cancer resections: The experience of an Asian country

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Background. *Although the relationship between provider volume and treatment outcome has been established for many types of operations, such a relationship has yet to be determined for resection of oral cancers. The purpose of this report is to assess the effects of surgeon and hospital volume on 5-year survival for oral cancer.*
Methods. *A total of 6,666 patients who underwent resections of oral cancer between 1997 and 1999 were identified from the Taiwan National Health Insurance Research Database. These data were linked to the "cause of death" data file from the Department of Health in Taiwan and traced for 5 years to obtain the survival times for individual patients. Survival analysis and proportional hazard regressions were conducted to assess the association between 5-year survival rates and surgeon and hospital volumes after adjusting for patient and provider variables. Volume relationships were based on the following criteria: low-, medium-, and high-volume surgeons were defined by <52, 52 to 142, and >142 resections, respectively, during the 3-year period. Similarly, low-, medium-, and high-volume hospitals were defined by <343, 343 to 531, and >531 resections, respectively, during the 3-year period.*
Results. *With an increase in individual surgeon volume, there were increases in the unadjusted 5-year survival rates (45.5%, 49%, and 51.8% for low-, medium-, and high-volume groups, respectively;* $P < .001$*); no such association, however, was observed with hospital volumes (47.5%, 51.3%, and 49% for low-, medium-, and high-volume hospitals, respectively;* $P = .074$*). Compared with treatment by low-volume surgeons, operations by high-volume surgeons were associated with an adjusted hazard ratio of 0.810 (95% confidence interval = 0.735-0.893).*
Conclusions. *We conclude that, for patients who underwent oral cancer resections, after adjusting for differences in the case mix, high-volume surgeons had better 5-year survival rates. This association, however, was not discernible for high-volume hospitals. (Surgery 2008;143:343-51.)*

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A RELATIONSHIP BETWEEN HOSPITAL AND PHYSICIAN VOLUME AND PATIENT OUTCOMES has been well-documented in the literature for more than 3 decades.[1] The majority of studies examining this issue have demonstrated that high volume is associated with better patient outcomes. Studies also have shown, however, that the benefits of high-volume providers vary by the type of operative procedure performed. Despite the substantial body of literature investigating the effects of the volume-outcome relationship on cancer treatments,[2-10] to the best of our knowledge no study has yet examined the effects of surgeon or hospital volume on treatment outcomes after resections for oral cancer.

Globally, oral cancer is among the 10 most common forms of cancer. In 2002, more than 274,000 new cases of oral cancer were reported worldwide, with approximately 127,000 consequent deaths. Although almost two thirds of these new cases were found in developing countries,[11] cases of oral cancer are nevertheless increasing in the Western world; various reports have recently cited a rising trend in the rates of oral cancer mortality in most of Central and Eastern Europe.[12,13] In some developing countries, almost 50% percent of oncology patients suffer from cancer of the oral cavity.[11]

Of all male cancers in Taiwan, oral cancer has been ranked fifth in incidence and subsequent mortality since 1995, and both incidence and mortality continue to increase. Oral cancer also has become the number one cause of all cancer deaths in Taiwan among males between the ages of 25 and 44 years; this is probably due to the progressive increase in betel quid consumption on the island.[14] Because increasing numbers of young people are likely to suffer from oral cancer as a direct consequence of betel quid consumption, it is clearly a serious socioeconomic problem in Taiwan and a public health issue of considerable concern.

Even though the operative risk involved in most resections of oral cancers is small, a coordinated, multidisciplinary approach including surgery, radiotherapy, adjuvant chemotherapy, and dental and maxillofacial rehabilitation is required to improve the long-term survival of patients and their overall quality of life. Clearly, then, it is of considerable importance to have a firm understanding of the relationship between institutional surgical volume, individual surgeon experience, and treatment outcomes for oral cancer, to assess the coordination of the necessary care.

Therefore, the purpose of this nationwide, population-based study is to examine the effects of surgeon and hospital volume in Taiwan, focusing on the 5-year survival rates following oral cancer surgery.

PATIENTS AND METHODS

Database. Two databases were used in this study. The first of these was the Taiwan National Health Insurance Research Database (NHIRD), which is published by the Taiwan National Health Research Institute and is one of the largest and most comprehensive databases currently available. Covering almost the entire population of 23 million Taiwanese citizens, the NHIRD comprises comprehensive hospitalization data, such as medical claims for inpatient expenditure on admissions, details of inpatient orders, and a registry of contracted medical facilities, medical personnel, board-certified specialists, and beneficiaries.

One principal diagnosis and procedure code is listed for each hospitalization, with up to four secondary diagnoses and procedure codes based on the International Classification of Disease, 9th Revision, Clinical Modification (ICD-9-CM) codes.

The second database, the "cause of death" data file published by the Department of Health (DOH) in Taiwan, provides data on all Taiwanese citizens, including marital status, employment status, place of legal residence, date of birth and death, and the underlying cause of death (ICD-9-CM code). Because the registration of all births and deaths is mandatory in Taiwan, the data are considered to be extremely accurate and comprehensive. The NHIRD was linked to the "cause of death" data file with the assistance of the DOH in Taiwan.

Study subjects. A total of 6, 666 hospitalizations were identified from the NHIRD between 1 January 1997 and 31 December 1999 for resections of oral cancer including excision of tissue of the gum (ICD-9-CM procedure code 24.31), excision of tissue of the tongue or glossectomy (ICD-9-CM procedure codes 25.1-25.4 and 25.94), excision of tissue of the bony palate (ICD-9-CM procedure codes 27.31-27.32), excision of tissue of the lip (ICD-9-CM procedure codes 27.42-27.43), other excision of tissues of the mouth (ICD-9-CM procedure code 27.49), excision of the uvula (ICD-9-CM procedure code 27.72), and removal of facial bones (ICD-9-CM procedure codes 76.01, 76.09, 76.31, and 76.39) with a diagnosis code of malignant neoplasm of the lip and oral cavity (ICD-9-CM codes 140 to 141 and 143 to 145).

These cases were then linked to the "cause of death" data file covering the years 1997 to 2004; every sampled patient was subsequently followed for 5 years to analyze the mortality after their cancer resection. No one died of accidents (ICD-9-CM codes E800-E869, E880-E928, and E950-E999), and all cause mortality was used.

Surgeon and hospital oral cancer resection volume groups. Because the 3-year surgeon and hospital volumes correlated well with annual volume, the surgeons and hospitals were divided into 3 volume groups according to the number of operations performed between 1997 and 1999. Surgeons and hospitals were sorted, in ascending order, by their total volume of resections of oral cancers. The volume category cutoff points (high, medium, and low) were determined by sorting the sample into 3 approximately equal groups, which is standard practice.[15,16] The volume cutoff points were determined deliberately so that each group would have approximately equal numbers of patients. The 3 surgeon volume groups were as follows: < 52 patients (low-volume), 52 to 142 patients (medium-volume) and > 142 cases (high-volume). The 3 hospital volume groups were as follows: < 343 patients (low-volume), 343 to 531 patients (medium-volume) and > 531 patients (high-volume).

Key variables of interest. The key dependent variable of interest was the 5-year survival of the patient; the key independent variables were the oral cancer resection volume groups for the surgeons and the hospitals. The characteristics of the providers and the patients were also taken into consideration for risk adjustment. Surgeon characteristics included specialty (ear, nose, and throat [ENT]; general or plastic; or others), sex, and age. Age was used as a surrogate for practice experience. The age of the surgeons was further categorized into 3 groups: ≤ 40, 41 to 50, or ≥ 51 years.

The hospital characteristics included the type of ownership (public, not-for-profit or for-profit), geographic location (Northern, Central, Southern, or Eastern Taiwan), teaching status (yes or no), and hospital level. The hospital level was the categorization of each hospital: a medical center (minimum of 500 beds), a regional hospital (minimum 250 beds), or a district hospital (minimum 20 beds). Hospital level could be used as a proxy for clinical service capabilities.

Patient characteristics included age (< 50, 50 to 64, 65 to 74, or > 74 years), sex, tumor subsite, and severity of illness. Tumor subsites were classified into 3 groups: tongue (ICD-9-CM codes 141.0-141.9), buccal mucosa (ICD-9-CM code 145.0), and others. No illness severity index is available at this time in Taiwan, and so we used a modified Charlson Index (the Deyo Charlson index) to adjust for patient comorbidities.[17] The comorbidities were identified by the diagnosis codes, with the total number of comorbidities being categorized as ≤1, 2, or ≥3.

Statistical analysis. Relative to surgeon and hospital oral cancer resection volume groups, chi-square or analysis of variance (ANOVA) tests were used to examine the distribution of surgeon, hospital, and patient characteristics. The cumulative 5-year survival rates and the survival curves were then calculated using the Kaplan-Meier method and compared by the log-rank test. A Cox proportional hazards regression model was conducted to evaluate the contribution of surgeon and hospital volume to the 5-year survival rate, while adjusting for the variables mentioned above. Hazard ratios (HR) are presented with the 95% percent confidence intervals (CI). Because the 2 variables were related closely to each other, the surgeon and hospital volumes were analyzed under separate regression models. A 2-sided *P* value less than .05 was considered statistically significant. The SAS statistical package (SAS System for Windows, Version 8.2; SAS Institute, Cary, NC) was used for all of the analyses in this study.

RESULTS

A total of 3,273 deaths (49.1%) were identified from the total sample of 6,666 patients undergoing resection of oral cancer between 1997 and 1999. Operations for these patients were performed by 427 surgeons, with an average of 15.6 operations per surgeon during the 3-year study period. The characteristics of the surgeons and patients, analyzed by surgeon volume, are presented in Table I. The low-volume group was composed of 391 surgeons (91.6%), whereas the medium-volume group was composed of only 27 (6.3%). Although only 9 surgeons (2.1%) made up the high-volume group, they performed one-third of all operations. The mean age of the surgeons in the sample was 38.9 years; the surgeons in the high-volume group were more likely to be older. Patients in the high-volume surgeon group were, on average, slightly younger than their counterparts in other groups, but with a higher comorbidity index score. The majority of the patients (90.5%) were male.

The characteristics of the hospitals and the patients, analyzed by hospital volume, are presented in Table II, which shows that oral cancer surgery was performed at 89 hospitals, with a mean of 74.9 resections per hospital over the 3-year period. The majority of the hospitals (92.1%) were in the low-volume group, and most of the hospitals in this group were regional hospitals. The medium-volume group was composed of only 4 hospitals, and the high-volume group was composed of just 3 hospitals. The 7 hospitals in the medium- and high-volume groups were medical centers and teaching hospitals. Patients treated in the high-volume hospitals had more comorbid conditions and tended to be younger than their counterparts in the other groups.

The unadjusted 5-year survival rates, by surgeon volume groups, are illustrated in Fig 1. With no adjustment for other characteristics, there were general improvements in the five-year survival between low- and high-volume surgeon groups, from 45.5% for patients treated by low-volume surgeons to 49.9% for those treated by medium-volume surgeons, and 51.8 % for those treated by high-volume surgeons ($P < .001$).

Table I. Surgeon and patient characteristics in Taiwan, by surgeon oral cancer resection volume groups, 1997-1999

	Surgeon oral cancer resection volume groups												
	Low (1-51)				*Medium (52-142)*				*High (>142)*				
Variables	*No.*	*%*	*Mean*	*SD*	*No.*	*%*	*Mean*	*SD*	*No.*	*%*	*Mean*	*SD*	P *value*
Surgeon characteristics (n = 427)													
Total no. surgeons	391	–	–	–	27	–	–	–	9	–	–	–	
Oral cancer resection volume	–	–	5.6	9.0	–	–	83.6	24.6	–	–	247	82.9	<.001
Surgeon age (y)	–	–	38.6	8.3	–	–	41.7	7.9	–	–	43.6	5.4	.038
≤40	257	65.7	–	–	14	51.9	–	–	2	22.2	–	–	.049
41-50	111	28.4	–	–	10	37.0	–	–	6	66.7	–	–	
>50	23	5.9	–	–	3	11.1	–	–	1	11.1	–	–	
Patient characteristics (n = 6,666)													
Total no. of patients	2,185		–	–	2,258	–	–	–	2,223	–	–	–	
Patient age (y)													
<50	918	42	–	–	1,026	45.4	–	–	1,034	46.5	–	–	<.001
50-64	810	37.1	–	–	898	39.8	–	–	813	36.6	–	–	
65-74	350	16	–	–	252	11.2	–	–	297	13.4	–	–	
>74	107	4.9	–	–	82	3.6	–	–	79	3.6	–	–	
Tumor subsite													
Tongue	743	34	–	–	702	31.1	–	–	704	31.7			
Buccal mucosa	538	24.6	–	–	729	32.3	–	–	687	30.9			<.001
Others	904	41.4	–	–	827	36.6	–	–	832	37.4			
Charlson Index score													
≤1	1,495	68.4	–	–	1,577	69.8	–	–	1,500	67.5	–	–	.027
2	125	5.7	–	–	106	4.7	–	–	92	4.1	–	–	
≥3	565	25.9	–	–	575	25.5	–	–	631	28.4	–	–	
Surgeon specialty													<.001
General or plastic surgeon	410	18.8	–	–	223	9.9	–	–	262	11.8	–	–	
ENT surgeon	958	43.8	–	–	877	38.8	–	–	1345	60.5	–	–	
Others	817	37.4	–	–	1158	51.3	–	–	616	27.7	–	–	

SD, Standard deviation; *ENT,* ear, nose, and throat.

This positive association between survival and surgeon volume, however, was not observed with regard to hospital volume. The 5-year survival rates, by hospital volume groups, are presented in Fig 2, which shows that the survival rates were 47.5% for the low-volume hospital group, 51.3% for the medium-volume hospital group, and 49% for the high-volume hospital group ($P = .074$).

The 5-year survival rates, crude hazard ratios and adjusted hazard ratios, based on the Cox proportional hazards regression model, are presented in Table III. The positive association between survival and surgeon volume remained statistically significant after adjusting for the differences in the case mix. Compared with operations performed by low-volume surgeons, patients whose operations were performed by high-volume surgeons were found to have a 19% lower risk of death (HR = 0.810; 95% CI, 0.735 to 0.893). Patients whose operations were performed by medium-volume surgeons, however, were not found to have a significantly lower risk of death after adjusting for other variables (HR = 0.923; 95% CI, 0.847 to 1.005).

Hospital volume alone, however, was not a significant predictor of 5-year survival for oral cancer resections. For those patients who had undergone oral cancer resections in the medium- and high-volume hospitals, the risk of death at 5 years was almost the same as it was for patients whose operations had been performed in the low-volume hospitals (HR = 0.944; 95% CI, 0.841 to 1.059 and HR = 0.996; 95% CI, .897 to 1.105, respectively).

Table IV describes 5-year oral cancer survival rates and adjusted HRs by surgeon resection

Table II. Hospital and patient characteristics in Taiwan, by hospital oral cancer resection volume groups, 1997-1999

	Hospital oral cancer resection volume groups												
	Low (1-342)				*Medium (343-531)*				*High (>531)*				
Variables	*No.*	*%*	*Mean*	*SD*	*No.*	*%*	*Mean*	*SD*	*No.*	*%*	*Mean*	*SD*	P *value*
Hospital Characteristics (n = 89)													
Total no. of hospitals	82	–	–	–	4	–	–	–	3	–	–	–	
Oral cancer resection volume	–	–	28.4	58.3	–	–	457.5	70.5	–	–	842	360.7	<.001
Hospital level													
Medical center	7	8.5	–	–	4	100	–	–	3	100.0	–	–	<.001
Regional hospital	50	61	–	–	–	–	–	–	–	–	–	–	
District hospital	25	30.5	–	–	–	–	–	–	–	–	–	–	
Teaching status													
Yes	75	91.5	–	–	4	100	–	–	3	100.0	–	–	.723
No	7	8.5	–	–	–	–	–	–	–	–	–	–	
Patient characteristics (n = 6,666)													
Total no. patients	2,316	–	–	–	1,824	–	–	–	2,526	–	–	–	
Patient age (y)													
<50	1,24	44.2	–	–	790	43.3	–	–	1,164	46.1	–	–	.013
50-64	851	36.7	–	–	707	38.8	–	–	963	38.1	–	–	
65-74	349	15.1	–	–	237	13.0	–	–	313	12.4	–	–	
>74	92	4	–	–	90	4.9	–	–	86	3.4	–	–	
Tumor subsite													
Tongue	728	31.4	–	–	600	32.9	–	–	821	32.5	–	–	
Buccal mucosa	605	26.1	–	–	540	29.6	–	–	808	32.0	–	–	<.001
Others	983	42.4	–	–	684	37.5	–	–	897	35.5	–	–	
Charlson Index score													
≤1	1,561	67.4	–	–	1,287	70.6	–	–	1,724	68.2	–	–	
2	153	6.6	–	–	87	4.8	–	–	83	3.3	–	–	<.001
≥3	602	26	–	–	450	24.7	–	–	719	28.5	–	–	
Surgeon specialty													<.001
General or plastic surgeon	383	16.5	–	–	80	4.4	–	–	432	17.1	–	–	
ENT surgeon	985	42.5	–	–	681	37.3	–	–	1,514	59.9	–	–	
Others	948	40.9	–	–	1063	58.3	–	–	580	23	–	–	

SD, Standard deviation; *ENT,* ear, nose, and throat.

volume groups and the characteristics of the patient, surgeon, and hospital. Generally, the adjusted HR increases with the patient's age and the Charlson comorbidity index score. The risk of death at 5 years was greater for patients who underwent resections of oral cancers by general or plastic surgeons compared with those performed by ENT surgeons and other specialists (HR = 0.877; 95% CI, 0.786 to 0.978 and HR = 0.889; 95% CI, 0.794 to 0.994. respectively).

DISCUSSION

More than 90% of our sample patients were male—a pattern that reflects the prevalence of a specific risk factor, the chewing of betel quid, the same factor that is discernible in South-Central Asia and Melanesia.[11] Oral cancer is now one of the major malignancies in this area. In Taiwan specifically, there was a 5-fold increase in the incidences of oral cancer over the past 2 decades, which reflects the exact magnitude of the per capita growth in betel quid consumption on the island.[18]

To the best of our knowledge, this is the first study to undertake an examination of the volume-outcome relationship in the treatment of oral cancer. We have evaluated the long-term survival of these patients essentially because of the low-risk nature of oral cancer resections. Our findings suggest that an increase in surgeon volume corresponds to an increase in the 5-year survival rates for oral cancer patients in Taiwan; however, there

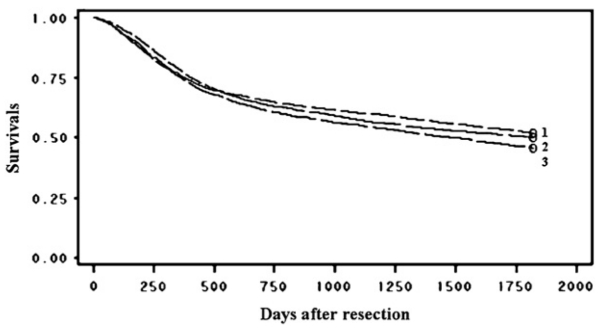

Fig 1. Oral cancer survival rates for patients hospitalized in Taiwan, by surgeon volume, 1997-1999. Surgeon volume was defined as the number of oral cancer surgeries performed between 1997 and 1999. **1,** High-volume group; **2**, Medium-volume group; **3**, Low-volume group.

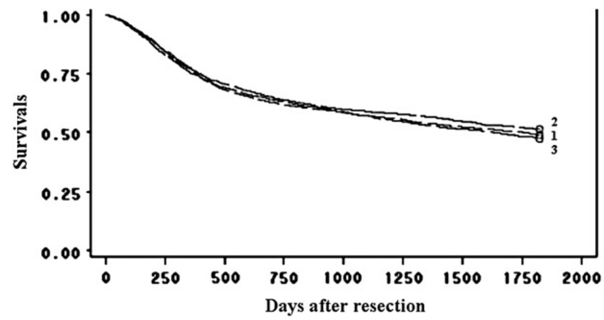

Fig 2. Oral cancer survival rates for patients hospitalized in Taiwan, by hospital volume, 1997-1999. Hospital volume was defined as the number of oral cancer surgeries taking place between 1997 and 1999. **1**, High-volume group; **2**, Medium-volume group; **3**, Low-volume group.

Table III. Five-year oral cancer survival and hazard ratios, by surgeon and hospital resection volume groups

Variables	*5-year survival rate (%)*	*Crude hazard ratio (95% CI)*	*Adjusted hazard ratio* (95% CI)*
Surgeon volume			
Low (≤51)	45.5	1.000	1.000
Medium (52-142)	49.9	0.898 (0.828-0.974)†	0.923 (0.847-1.005)
High (>142)	51.8	0.840 (0.773-0.912)‡	0.810 (0.735-0.893)‡
Hospital volume§			
Low (≤ 342)	47.5	1.000	1.000
Medium (343-531)	51.3	0.905 (0.830-0.986)||	0.944 (0.841-1.059)
High (>531)	49	0.966 (0.893-1.044)	0.996 (0.897-1.105)

CI, confidence interval.
*Hazard ratios are adjusted for patient's age, tumor subsite, the Charlson Index, surgeon's age, surgeon's specialty, and hospital characteristics, including hospital level, hospital ownership and geographical location.
†$P < .01$.
‡$P < .001$.
§Hospital volumes were analyzed under separate regression model.
||$P < .05$.

is no similar association with hospital volume. Because our nationwide study design was population-based and involved complete follow-up, we believe that the risk of selection bias is low, and that the data will remain valid if generalized.

Compelling evidence has already been presented to support the benefits of high hospital and surgeon volume on the outcomes of cancer treatment.[2-7,19-21] The independent contributions of each of these elements, however, remain uncertain. In a study of colon cancer resections using the Surveillance, Epidemiology and End Results (SEER)-Medicare linked database from 1991 to 1996 in a SEER area, Schrag et al[22] reported that outcomes were predicted by both hospital and surgeon volume, but that hospital volume may well exert a stronger effect. In contrast, Birkmeyer et al[23] used information from the national Medicare claims database for the years 1998 and 1999 to examine 4 cardiovascular procedures and 4 types of cancer resection (esophagectomy, cystectomy, and pancreatic and lung resections) for which they had previously found a relatively strong association between hospital volume and operative mortality. They concluded that, according to the procedure carried out, certain proportions of the apparent hospital volume effect were attributable to surgeon volume. Hence, the observed associations between hospital volume and operative mortality were largely mediated by surgeon volume. Moreover, in a review of 163 studies examining volume effects, Chowdhury et al[24] found that 13 studies had examined both hospital and surgeon volume, and had carried out regression analyses to identify their relative contributions. After adjusting for hospital volume, high-volume surgeons were found to be beneficial in 11 of the studies (85%), whereas, after controlling for surgeon volume, only 6 studies (46%) demonstrated significant benefit from high-volume hospitals. It would seem, therefore,

Table IV. Five-year oral cancer survival rate and adjusted hazard ratios by surgeon resection volume groups and the characteristics of the patients and providers

Variables	*Adjusted hazard ratio*	*95% CI*	P *value*
Surgeon volume			
Low (≤51)	1.000		
Medium (52-142)	0.923	0.847-1.005	.066
High (>142)	0.810	0.735-0.893	<.001
Surgeon characteristics			
Surgeon Specialty			
General or plastic	1.000		
ENT	0.877	0.786-0.978	.019
Others	0.889	0.794-0.994	.039
Surgeon's age (y)			
<41	0.940	0.866-1.022	.146
41-50	1.000		
>50	1.104	0.982-1.241	.099
Patient characteristics			
Tumor subsite			
Tongue	1.000		
Buccal mucosa	1.001	0.919-1.101	.896
Others	1.079	0.993-1.172	.072
Patient age (y)			
<50	1.000		
50-64	0.997	0.924-1.076	.937
65-74	1.217	1.100-1.347	<.001
>74	1.228	1.040-1.451	.016
Charlson Index score			
≤1	1.000		
2	1.157	0.983-1.360	.079
≥3	2.291	2.132-2.461	<.001
Hospital characteristics			
Hospital level			
Medical center	1.449	0.965-2.172	.074
Regional hospital	1.356	0.905-2.031	.140
District hospital	1.000		
Hospital ownership			
Public	0.623	0.503-0.773	<.001
Private not-for-profit	0.701	0.575-0.854	<.001
Private for-profit	1.000		
Geographic location			
Northern	1.000		
Central	1.194	1.075-1.326	.001
Southern	0.995	0.913-1.085	.914
Eastern	1.274	1.045-1.553	.017

CI, Confidence interval.

that a good number of the studies investigating hospital and surgeon volume simultaneously have suggested that, as independent variables, the surgeon volume has greater influence on treatment outcomes than institutional volume.

Thus, the results of our study of oral cancer resections are consistent with the conclusions of most of the abovementioned studies: The skills or experience of individual surgeons may be more important than supportive hospital care. Operative technique such as ensuring tumor-free margins may be an important factor. In addition, we assume that one of the possible reasons for our conclusions could be due to the surgeon's decision on, and performance of, elective or radical neck dissection. The presence of cervical lymph node metastasis is one of the most significant predictive factors for oral cancer survival.[25] The incidence of occult cervical nodal metastases has been reported to be 20% to 30%[26]; thus, a carefully judged and performed neck dissection could be a critical procedure for oral cancer resection. A study by Gilligan et al[27] reported that in treating early-stage breast cancer, higher volume surgeons were significantly more likely to perform axillary lymph node dissection in accordance with the 1990 National Institute of Health consensus statement recommendations. It may be possible that surgeons who adopt a more aggressive treatment of the neck, whether through surgical or adjuvant therapy, might achieve outcomes that are more favorable. Further investigation is necessary to clarify this possibility, along with other surgeon characteristics related to better outcomes.

In contrast, the role of hospital volume seems to be of less importance. Birkmeyer et al[23] suggested that both surgeon and hospital volume could be of significant importance in most high-risk procedures, with the relative importance varying according to the procedure being performed. Because the resection of oral cancer is not a risky operation, the hospital facilities and surgical team support may not play such an important role in determining the treatment outcome. Furthermore, with the increasing threat of oral cancer in Taiwan, health authorities already have taken steps to control this highly recurrent malignancy by instituting various policies, such as the development of a core measurement set on the quality of care. Standards of care may have already been adopted in hospitals that would minimize the influence of hospital-specific care in low-volume hospitals.

Questions remain as to the underlying mechanisms by which higher volume providers can achieve better surgical outcomes. Whether provider volume affects outcomes (the "practice makes perfect" hypothesis) or whether better institutes and physicians attract more patients (the "selective referral" hypothesis) remains difficult to ascertain, and we cannot jump to any conclusions based upon our cross-sectional study. Nevertheless, we do have reason to believe that, in Taiwan, the "selective referral" hypothesis may be more important. Apart from the relatively low copayment requirements of the compulsory National Health Insurance program, there are basically no restrictions with regard to a patient's choice of hospital or surgeon. Consulting with relatives and friends has been found to be the most popular way for patients in Taiwan to obtain information about physicians. As a result, those physicians with good reputations will invariably attract greater numbers of patients through 'word of mouth' recommendations.[28] However, further longitudinal studies will be required to determine the true underlying mechanisms.

Limitations of this study arise primarily from the nature of the administrative data. Important information relating to the initial diagnosis, such as the cancer stage or the time elapsed between diagnosis and operation, are not available from the data. However, in a study by Begg et al[21] using a SEER-Medicare linked database, cancer stage and patient age were basically independent of hospital volume. Therefore, considering the relatively large sample population in our study, we have no reason to believe that such confounding would be a major caveat. Besides, the overall survival instead of cancer-specific survival was used, because it was difficult to differentiate the cause-specific mortality based on the registry data. A similar volume-outcome study, however, by Roohan et al[4] reported no significant differences in 5-year survival models for mortality from all causes and from breast cancer.

The volume cutoff points for our study were determined deliberately so that each volume group would have approximately equal numbers of patients; therefore, the cutoff points for hospital and surgeon volume groups were different. The threshold used to define high and low volume and the number of volume groups may have substantially influenced the result of the analyses. Moreover, owing to the incompleteness of the data, we did not adjust for adjuvant therapy, a factor that could be more important for coordinating hospital care. Hence, it is possible that there may be some association between hospital volume and oral cancer survival that we failed to identify.

Another important limitation of using administrative information is the quality of the risk-adjustment technique. Although we adjusted for comorbidities using a widely adopted method,[17] it may not reflect adequately the clinical condition or health status of the patients. Accordingly, it should not be surprising to find that the risk of death is greater for the general or plastic surgeon group, whose patients may need more extensive reconstructive surgery, but this possibility cannot be identified from the administrative database we used. Finally, although the results of our study are highly significant statistically, the differences we measured in oral cancer survival rates may be of questionable clinical significance.

In summary, despite the abovementioned limitations, our findings provide support for earlier studies on the effects of provider volume with regard to treatment outcomes. We found that for those patients who had undergone oral cancer resections in Taiwan, after adjusting for differences in the case mix, there was an association between high-volume surgeons and better 5-year survival. This association was not discernible, however, for high-volume hospitals. Even with such strong evidence of a volume-outcome relationship, it is important to recognize that, at an individual level, low-volume surgeons or hospitals may well be providing excellent care and positive outcomes, and that higher volume does not necessarily equate to superior outcomes. Further research should be carried out in an attempt to determine the specific operative techniques or processes of care that contribute to such variations if we are to succeed in improving the quality of care for oncology patients.

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