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Association Between Physician Volume and Hospitalization Costs for Patients With Stroke in Taiwan

A Nationwide Population-Based Study

Herng-Ching Lin, PhD; Sudha Xirasagar, MBBS, PhD; Chi-Hung Chen, MD; Chia-Chin Lin, PhD; Hsin-Chien Lee, MD, MPH

Background and Purpose**—**Past studies consistently show an inverse relationship between physicians' surgical procedures/diagnoses volume and cost. There is little information available on this aspect of stroke care. We used nationwide population-based data to explore the association between physician case volume and costs per discharge for patients with stroke.

Methods**—**Data on all 83 748 hospitalizations for stroke in 2004, treated by 3757 physicians in Taiwan, from Taiwan's National Health Insurance Research Database, was analyzed using hierarchical linear regression modeling to explore associations between costs per discharge and physician case volume (one to 44 cases=low volume, 44 to 135=medium volume, ≥136 cases=high volume) adjusting for patient's age, gender, comorbidities, and stroke type; hospital ownership, teaching status, and geographic region; and physician demographics.

Results**—**Unadjusted mean cost per discharge was highest for patients treated by low-volume physicians, at NT $79 993 compared with NT $78 588 for medium-volume physicians and NT $43 942 for high-volume physicians ($P<0.001$). Adjusted for patient, hospital, and physician variables, low-volume physicians had a mean case cost of NT $27 729 higher than high-volume physicians ($P=0.001$) and NT $7761 higher than medium-volume physicians ($P=0.027$).

Conclusions**—**Our data confirm an inverse volume–cost relationship for stroke care in Taiwan. After adjusting for patient, hospital, and physician characteristics, the potential cost savings if all patients were treated or supervised by high-volume physicians could be 41.0% of the mean treatment cost incurred by low-volume physicians. **(*Stroke*. 2007;38:1565-1569.)**

Key Words: costs ■ inpatient ■ stroke ■ volume–cost

Strokes account for a significant 3% of total healthcare costs in Western countries.[1] In the United States alone, approximately US $30 to 40 billion is spent annually on stroke management,[2] over half of that incurred for inpatient care.[3] Although the cost-effectiveness of the various stroke treatment modalities is well documented,[4–6] there is no published literature on physician case volumes as related to cost. For several surgical and medical care procedures, an inverse volume–cost and volume–outcome relationship is documented.[7–10] Similar evidence on stroke care could enable innovative clinical and institutional approaches to harness the expertise of high-volume physicians to improve the cost-effectiveness of stroke care.

This study, using nationwide population-based data from Taiwan, explores the association between physicians' stroke case volumes and inpatient care costs. Similar to most Western countries, 2.96% of Taiwan's health expenditures was spent on stroke care in 2004. Our findings have major implications for clinicians and policymakers in Taiwan and internationally for cost-effectiveness in stroke care.

Methods

Database

Inpatient medical benefit claims data for 2004 from Taiwan's National Health Insurance are used covering every episode of care provided to its 21 million Taiwanese citizens (approximately 97% of the island's population). Because these were deidentified secondary data, released for public access for research purposes, the study was exempt from full review by the Institutional Review Board.

Study Sample

All hospitalizations for acute stroke care between January 1 and December 31, 2004, were identified by the principal International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) diagnosis code 430.XX through 437.XX. Of a total

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From the School of Health Care Administration and the Topnotch Stroke Research Center (H.-C. Lin), Taipei Medical University, Taipei, Taiwan; the Department of Health Services Policy and Management (S.X.), University of South Carolina, Arnold School of Public Health, Columbia, South Carolina; Intensive Care Unit (C.-H.C.), Taipei Medical University Hospital, Taipei, Taiwan; the Graduate Institute of Nursing (C.-C.L.), Taipei Medical University, Taiwan; and the Department of Psychiatry (H.-C. Lee), Taipei Medical University Hospital, the School of Medicine and the Topnotch Stroke Research Center, Taipei Medical University, Taipei, Taiwan.

Correspondence to Hsin-Chien Lee, MD, MPH, Department of Psychiatry, Taipei Medical University Hospital, the School of Medicine and the Topnotch Stroke Research Center, Taipi Medical University, 252 Wu-Hsing St., Taipei 110, Taiwan. E-mail ellalee@tmu.edu.tw

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94 602 claims, 10 854 cases were excluded as a result of lack of treatment completion at the admitting institution (7513 discharged against medical advice and 3341 cases transferred to another hospital). The remaining 83 748 cases form the study population.

Physician Volume Groups

Using unique physician codes in each claim, stroke case volume for each attending physician in 2004 was calculated. Physicians were sorted in ascending order by volume with cutoff points selected to divide the sample hospitalizations into three approximately equal

TABLE 1. Mean Costs of Stroke Hospitalizations (in NT $) for Low-, Medium-, and High-Volume Physicians by Patient Demographic and Clinical Characteristics and Hospital Characteristics in Taiwan, 2004 (N=83 748)

	Physician Volume					
	Low (1–44)		Medium (45–135)		High (≥136)	
Variables	No. (%)	Mean Costs	No. (%)	Mean Costs	No. (%)	Mean Costs
Total number of patients	27 243	79 993	28 722	78 588	27 783	43 942
Mean length of stay	12.8 (days)		12.9 (days)		8.8 (days)	
Patient characteristics						
Gender						
Male	15 561 (57.1)	82 048	16 952 (59.0)	78 959	15 937 (57.4)	43 787
Female	11 682 (42.9)	77 257	11 770 (41.0)	78 053	11 846 (42.6)	44 151
Age, years						
≤44	1718 (6.3)	120 387	1770 (6.2)	116 732	1247 (4.5)	49 773
45–64	7463 (27.4)	82 262	9377 (32.7)	81 904	8445 (30.4)	41 328
65–74	7644 (28.1)	74 523	8182 (28.5)	73 480	8621 (31.0)	42 188
75–84	8422 (30.9)	76 970	7492 (26.1)	72 126	7645 (27.5)	45 725
≥85	1996 (7.3)	70 448	1901 (6.6)	74 157	1825 (6.6)	52 867
Charlson score						
1	10 982 (40.3)	84 561	12 785 (44.5)	85 651	10 878 (39.2)	45 045
2	7575 (27.8)	80 126	8378 (29.2)	75 052	8853 (31.9)	44 288
3	4981 (18.3)	72 178	4876 (17.0)	69 776	5075 (18.3)	41 777
4	2172 (8.0)	72 588	1871 (6.5)	71 556	2031 (7.3)	41 171
≥5	1533 (5.6)	82 504	812 (2.8)	72 962	946 (3.4)	45 589
Stroke type						
Subarachnoid hemorrhage	721 (2.7)	193 796	1022 (3.6)	214 955	201 (0.7)	191 180
Intracerebral hemorrhage	5297 (19.4)	143 232	7242 (25.2)	128 498	1953 (7.0)	92 033
Ischemic	15 404 (56.5)	64 729	17 232 (60.0)	53 304	22 643 (81.5)	39 298
Unspecific	5821 (21.4)	48 745	3226 (11.2)	52 065	2986 (10.8)	37 794
Hospital characteristics						
Hospital ownership						
Public	9587 (34.8)	85 389	8521 (29.7)	78 922	4547 (16.4)	38 079
Not-for-profit	10 592 (38.9)	98 777	14 651 (51.0)	87 345	13 517 (48.7)	51 133
For-profit	7164 (26.3)	45 076	5550 (19.3)	54 957	9719 (35.0)	36 683
Hospital location						
Northern	11 558 (42.4)	96 074	13 347 (46.5)	86 227	8172 (29.4)	46 491
Central	6663 (24.5)	62 105	5559 (19.4)	75 234	9309 (33.5)	38 813
Southern	7928 (29.1)	73 552	8719 (30.4)	65 510	9717 (35.0)	45 651
Eastern	1094 (4.0)	65 728	1097 (3.8)	98 635	585 (2.1)	61 561
Teaching status						
Yes	20 788 (76.3)	95 172	24 764 (86.2)	86 317	25 792 (92.8)	45 236
No	6455 (23.7)	31 112	3958 (13.8)	30 227	1991 (7.2)	27 174

Note: χ^2 tests show that there are significant relationships between physician volume groups and the distributions of patient gender, age, Charlson score, stroke type and hospital ownership, location, and teaching status (all $P<0.001$). One-way analysis of variance shows that there are significant differences in costs of stroke hospitalizations among physician volume groups in each segment of the sampled patients in terms of patient gender, age, Charlson score, stroke type and hospital ownership, location, and teaching status (all $P<0.001$).

TABLE 2. Stroke Case Volume Categories Versus Physician Demographic Characteristics, 2004 (N=3757)

	Physician Stroke Volume Groups											
	Low (1–44 cases); N=3165; 84.2%				Medium (45–135); N=436; 11.6%				High (≥136); N=156; 4.2%			
Variables	No.	Percent	Mean	SD	No.	Percent	Mean	SD	No.	Percent	Mean	SD
Mean age, years	...	...	42.8	8.2	...	...	42.6	7.9	...	...	41.5	6.1
Age distribution, years												
≤40	1410	44.6	...	...	180	41.3	...	...	74	47.4	...	...
41–50	1203	38.0	...	...	186	42.7	...	...	66	42.3	...	...
≥51	552	17.4	...	...	70	16.0	...	...	16	10.3	...	...
Physician gender												
Male	3155	99.7	...	...	434	99.5	...	...	156	100.0	...	...
Female	10	0.3	...	...	2	0.5	...	...	...	...	...	...

groups consistent with the documented methodology for such studies.[11,12] The three volume groups were: one to 44 cases (low volume), 34 to 135 cases (medium volume) and 136 or more cases (high volume).

Statistical Analysis

The SAS statistical package (version 8.2) was used for analysis. The key independent variable of interest was physician volume group. The key dependent variable was cost per discharge, the aggregate of all itemized costs in NT$ (New Taiwan dollars) for services and disposables billed to National Health Insurance.

We adjusted for stroke type (subarachnoid hemorrhage, ICD code 430; intracerebral hemorrhage, ICD 431; ischemic stroke, ICD 433 and 434; and unspecified strokes, ICD 436 and 437); physician demographics (gender, age, and specialty); hospital characteristics (ownership: public, private not-for-profit, and private for-profit; teaching status: dichotomous, yes/no; and geographic location: north, central, south, and east); and patient characteristics (age, gender, and comorbidities captured by the Charlson Comorbidity Index).

Because data on patient severity is not available in this claims database, a modified Charlson Index, the Deyo-Charlson index, was calculated for each patient based on their ICD-9-CM secondary diagnoses.[13] This index is widely used for risk adjustment in administrative data set, representing the sum of weighted scores that are based on the relative mortality risk of 19 comorbid conditions (congestive heart failure, myocardial infarction, liver disease, cancer, dementia, AIDS, and so on).

One-way analysis of variance was used to examine crude associations between cost per discharge and patient as well as hospital characteristics. Hierarchical linear regression modeling is used to explore relationships between costs per patient with stroke and physician case volume, adjusting for patient severity and demographics, and physician and hospital characteristics.

Hierarchical linear regression modeling is used specifying a physician-level random effect to account for possible correlations between patients' costs within each physician's panel simply because of practice style, preferences, or other unmeasured physician-specific factors.[14] Specifying a random effect partitions out the systematic variation arising out of unmeasured sources associated with each physician. The random effect is assumed to be normally distributed and centered at zero with residual error also normally distributed around mean zero and unknown constant variance. The unit of analysis is the patient with stroke. A two-sided P of ≤0.05 is used.

Study Hypothesis

Mean stroke care costs of high-volume physicians will be significantly lower than that of lower-volume physician categories adjusted for patient severity and hospital characteristics.

Results

The bivariate distribution of the study sample (83 748 cases) by physician volume category as well as patient and hospital characteristics is shown in Table 1. Mean cost per discharge was NT $67 551 (average exchange rate in 2004: US $1=NT $33). The sample mean age was 67.5 years, the majority (57.9%) was male, and the majority (66.0%) was diagnosed with ischemic stroke.

One-way analysis of variance showed a significant negative association between mean cost per discharge and physician case volume ($P<0.001$) with the highest cost for low-volume physicians (NT $79 993), moderate for medium-volume physicians (NT $78 588), and least (NT $43 942) for high-volume physicians. Length of stay (LOS) increased with the cost as expected (not shown in the table).

The distribution of sample hospitalizations, by physician volume, gender, specialty, and age are shown in Table 2. Mean case volume per physician was 26 patients. Physicians in the high-volume group were slightly younger on average than the remaining groups ($P<0.001$).

Table 3 presents the adjusted association between physician case volume and cost. After adjusting for stroke type and physician, hospital, and patient characteristics, mean cost per discharge for high-volume physicians was NT $27 729 lower than low-volume physicians ($P=0.001$) and NT $7761 lower than medium-volume physicians ($P=0.027$). LOS is not included in the model presented in Table 3, because it is an endogenous variable that directly impacts inpatient cost being a key mediator variable in inpatient cost. Including it would overestimate the model. (However, one may argue that there may be systematic volume-associated cost variation attributable to differences in care content above and beyond arithmetically additive inpatient stay costs. Therefore, we examined the impact of including LOS in the model and find that the results remain essentially the same.)

Table 3 also shows that hospital ownership significantly influences cost with private not-for-profits showing the highest adjusted cost per patient (NT $13 571 higher than public hospitals and NT $23 488 higher than private for-profit hospitals). Teaching hospitals had significantly higher costs, NT $34 216, more than nonteaching hospitals. Physician-level random effect was also not significant.

TABLE 3. Adjusted Costs of Stroke Care for Low-, Medium-, and High-Volume Physicians, Hierarchical Linear Regression Results (N=83 748)

Variables	Costs ($ NT) B	SE	*P* Value
Physician characteristics			
Physician volume			
≤44 (reference group)			
45–135	−7761	3307	0.027
≥136	−27 729	7222	0.001
Physician age, years			
≤40	11 032	4119	0.007
41–50	6281	4117	0.127
≥51 (reference group)			
Physician specialty			
Neurologist	−16 286	4368	<0.001
Neurosurgeon (reference group)			
Others	−5735	2776	0.039
Hospital characteristics			
Hospital ownership			
Public	−13 571	3098	<0.001
Not-for-profit (reference group)			
For-profit	−23 488	3503	<0.001
Hospital location			
Northern	6346	7159	0.375
Central	−8848	7554	0.242
Southern	−5352	7257	0.461
Eastern (reference group)			
Teaching status			
Yes (reference group)			
No	−34 216	3193	<0.001
Patient characteristics			
Patient age			
≤44	−7520	1767	<0.001
45–64	−12 259	1290	<0.001
65–74	−7973	1284	<0.001
75–84	−4608	1284	<0.001
≥85 (reference group)			
Charlson Co−morbidity Index Score			
1	−5125	1734	0.003
2	−2274	1750	0.194
3	−4275	1790	0.017
4	−1505	1993	0.450
5 or more (reference group)			
Stroke type			
Subarachnoid hemorrhage	109 928	2386	<0.001
Intracerebral hemorrhage	33 417	1386	<0.001
Ischemic	3336	1041	0.001
Unspecified (reference group)			
Patient gender			
Male (reference group)			
Female	−595	620	0.338
Random effect associated with physician	6.404×10^{-9}		
Constant	76 911	9021	<0.001

B indicates parameter estimate.

Considering the sample mean case cost of NT $67 551, and the adjusted parameter estimate of NT $27 729 for high-volume physicians, the costs for high-volume physicians were, on average, approximately 41.0% lower than under low-volume physicians after adjusting for patient comorbidities and stroke type, hospital characteristics, and physician demographics.

Discussion

Our study demonstrates that after adjusting for clinical comorbidities, stroke type, hospital teaching status, and hospital ownership, high-volume physicians have 41.0% lower costs than low-volume physicians and 29.6% lower costs than medium-volume physicians. This suggests that if all patients with stroke were treated by a high-volume physician, or received such physicians' input, a cost saving of approximately $NT 1.3 billion in total inpatient stroke care expenditures could be realized in Taiwan.

Our finding of an inverse volume–cost association is consistent with other studies, Shook[7] (percutaneous transluminal coronary angioplasty), Slattery et al[8] (acoustic neuroma surgery), Martineau et al[9] (primary hip arthroplasty), and Gutierrez et al[10] (knee replacement surgery). Past authors have speculated on two mechanisms mediating the inverse cost–outcome relationship.[15,16] The "practice makes perfect" hypothesis proposes that increased case load of a given diagnosis provides opportunities for physicians to develop cost-effective as well as technically effective medical treatment skills. Furthermore, increasing case loads may make them more savvy in coordinating the various treatment elements and discharge planning, leading to further reductions in costs related to care content as well as LOS.

The second hypothesis proposes that "selective referral" may be the operative mechanism with referral either by physicians or self-referral by patients selectively favoring physicians known for lower care costs and LOS, which automatically releases bed capacity for more admissions. Although this is theoretically plausible, in practice, it is unlikely within Taiwan's context of universal health benefit coverage, fee-for-service reimbursement for stroke care and very low out-of-pocket copayments for patients for inpatient care. Furthermore, because stroke care is not regionalized in Taiwan, patients with stroke are generally sent to the nearest hospital. This practice leaves little room for deliberate patterns of selective referral either to specific hospitals or attending physicians. The most plausible explanation therefore remains the "practice makes perfect" hypothesis.

A few study limitations need to be recognized. Although we adjusted for the two major determinants of stroke patient severity, comorbidities (using the Charlson Index), and stroke type, a potential weakness of the study is that we were unable to adjust for stroke severity (although our adjustments do serve as a considerably accurate proxy for severity). The data needed to use the ideal criteria for stroke risk adjustment such as the National Institutes of Health Stroke Scale, the Barthel index, the Glasgow outcome scale, and the Stroke Impact scale were not available in the administrative claims database. It could be argued that possibly, some high-volume physicians may have a very low threshold of admission or admitting patients at their request. Although our adjustments provide good proxies for these sources of systematic variation, studies using more sophisticated risk-adjustment methods, outlined previously, may be required to confirm our findings.[17]

Three other caveats should be noted. First, claims data do not necessarily reflect "actual" costs, but "charge" costs, which could vary across hospitals. However, the National Health Insurance Bureau has detailed price lists for various hospital service items and consumables as well as audit mechanisms in place that are activated when a hospital's charges are way out of the general norm. Therefore, there is no reason to believe that this factor could have materially influenced our findings. Second, some physicians had very small stroke caseloads, somewhat limiting our study's statistical power. However, the magnitude of effects and statistical significance render the findings quire robust relative to this issue. Third, stroke diagnoses are sourced from physician/hospital reported claims and therefore, the accuracy of the stroke diagnosis could be questioned, which would compromise our findings. In defense, it must be noted however that the National Health Insurance regularly samples a percentage of cases from hospitals to verify the validity of diagnosis and quality of care through chart reviews using touring professional teams.

Overall, therefore, our finding of an inverse volume–cost relationship in stroke care in Taiwan appears to be solidly rooted in the empirical reality. Designing policy interventions to leverage these findings, however, may be a tricky proposition. Although suggestions have been mooted for regionalized or centralized programs, which would address the issue of volume–cost relationship, caution has also been sounded about unduly focusing on volumes as a proxy for cost and outcomes. This is because of several reasons. There are no doubt, several low-volume physicians providing very cost-effective stroke care as well as high-volume physicians providing high-cost care. In addition, payers' emphasis on case volumes may create incentives for physicians to admit more patients by lowering their admission thresholds. Another issue is to verify that the cost savings with increasing patient volume do not compromise quality of care.

Notwithstanding these concerns, some policy interventions are indicated by our findings. Payers and research organizations should sponsor clinical quality improvement research driven by experts to identify the care and treatment organization differences of low- and high-volume physicians. Based on the findings, appropriate clinical protocols and practice guidelines for the vast majority of clinical situations could be developed. Intraprofessional monitoring mechanisms to ensure adherence to protocols when applicable should be established. Payers may also consider additional reimbursements to high-volume physicians to serve as expert consultants to low-volume physicians seeking such advice, also aligning incentives appropriately to encourage such consultations. The financial outgo on such an arrangement is likely to be highly cost-effective. Ultimately, the potential cost savings could be as much as 41.0%% of the mean treatment costs for cases treated by low-volume physicians and 29.6% of the medium-volume physicians' cases.

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Disclosures

None.

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