Does Physicians' Case Volume Impact Inpatient Care Costs for Pneumonia Cases?

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BACKGROUND: Increasing physician case volumes are documented to reduce costs and improve outcomes for many surgical procedures but not for medical conditions such as pneumonia that consume significant health care resources.

OBJECTIVE: This study explored the association between physicians' inpatient pneumonia case volume and cost per discharge.

DESIGN: The design was a retrospective, population-based, cross-sectional study, using National Health Insurance administrative claims data.

SETTING: The setting was Taiwan.

PARTICIPANTS: The participants were a universal sample of 270,002 adult, acute pneumonia hospitalizations, during 2002–2004, excluding transferred cases and readmissions.

MEASUREMENTS: Hierarchical linear regression modeling was used to examine the association of physician's volume (three volume groups, designed to classify patients into approximately equal sized groups) with cost, adjusting for hospital random effects, case severity, physician demographics and specialty, hospital characteristics, and geographic location.

RESULTS: Mean cost was NT$2,255 (US$1=NT$33 in 2004) for low-volume physicians (≤100 cases) and NT $1,707 for high-volume physicians (≥316 cases). The adjusted patient costs for low-volume physicians were higher (US$264 and US$235 than high- and medium-volume physicians, respectively; both $P<.001$), with no difference between high- and medium-volume physicians. High-volume physicians had lower in-hospital mortality and 14-day readmission rates than low-volume physicians.

CONCLUSIONS: Data support an inverse volume–cost relationship for pneumonia care. Decision processes and clinical care of high-volume physicians versus low-volume physicians should be studied to develop effective care algorithms to improve pneumonia outcomes and reduce costs.

Received May 21, 2007
Revised September 12, 2007
Accepted October 29, 2007
Published online November 28, 2007

KEY WORDS: pneumonia; volume–outcome; costs.
J Gen Intern Med 2007;23:304–9
DOI: 10.1007/s11606-007-0462-3
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INTRODUCTION

Pneumonia is a common cause of hospitalizations worldwide, accounting for a significant portion of medical expenditures, particularly inpatient care costs. Pneumonia incidence in Europe ranges from 1.6 to 10.8 per 1,000 adults per year.[1] Pneumonia causes approximately 1.2 million hospitalizations costing more than $US 20 billion each year in the USA[2] and costs about $US1.64 billion in Germany in 1997.[1] In Taiwan, an estimated $US725 million was spent on adult pneumonia care in 2003. Understanding the cost drivers of pneumonia care can be helpful to devise initiatives to reduce preventable costs.

Past studies on the cost drivers of pneumonia care have focused on community-acquired versus hospital-acquired pneumonia.[3,4] There is no published literature on physicians' volume of pneumonia cases as it impacts inpatient cost. Most of the volume–cost relationships have focused on surgical or medical interventional procedures,[5–7] since the pioneering work of Luft et al. 2 decades ago.[8]

Taiwan introduced National Health Insurance (NHI) in 1995, covering all citizens (about 97% of residents). Unlike many national health systems that use gatekeepers to limit specialty care, Taiwan's NHI permits free choice of any hospital or physician, together with low, fixed copayments that are affordable for virtually the total population. Providers are geographically well dispersed, with moderate to intense competition for patients prevailing in almost all health care markets. Pneumonia is reimbursed on a fee-for-service basis, based on itemized billing by the provider. Prices are fixed for each item of service or consumable used, and providers cannot charge more than the set fee. As such, charges in the claim represent the cost of care provided at NHI prices, and variations across claims are caused by differences in care volume or content. To discourage overcharging or fraudulent billing for inflated care volumes, the NHI Bureau randomly samples and verifies each month a fixed percentage of claims from every hospital. The validity of diagnosis and quality of care are assessed through chart review by an independent peer-review group. Finally, any hospital with outlier charges or patterns of care for any diagnosis group faces the risk of audits and heavy penalties in case of discrepancies or overcharging the NHI Bureau. Therefore, NHI claims data that present a unique opportunity to examine volume–cost associations without confounding by variable patient access because of geographic, financial, or gatekeeper issues or variable provider charges. This study explores the association between physicians' volume of pneumonia cases with costs per discharge in Taiwan, using 3-year nationwide, population-based data.

METHODS

Database

Inpatient medical benefit claims data for 2002–2004 from the NHI Research Database were used, covering every episode of care provided to 21 million Taiwanese citizens (approximately 97% of the island's population). The database provides deidentified provider information, including hospitals and attending physicians, the primary admission diagnosis (ICD-9CM) code, and up to 4 secondary diagnosis codes. 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 adult (≥18 years) inpatient claims with a principal admission diagnosis of pneumonia (ICD 9CM 480–483.8, 485–486, and 487.0) between January 2002 and December 2004 were extracted (n=284,165). Inpatient claims data exclude emergency department charges if the patient was admitted through the emergency department, as these visits are billed separately and logged into NHI's ambulatory care claims database. We excluded transfer patients (either from or to a hospital). In addition, we limited analysis to the data on the first admission only, if the patient was readmitted within 14 days of the index discharge. Based on these criteria, we had 224,882 pneumonia hospitalizations in the study.

Physician Volume Groups

We calculated the pneumonia case volume for each attending physician in 2002–2004. Physicians were sorted in ascending order by volume, with cutoff points selected to divide the sample hospitalizations into 3 approximately equal groups, consistent with the documented methodology for such studies.[9,10] This resulted in 3 volume groups: 1–100 cases (low-volume physicians who treated a total of 74,981 cases), 101–315 cases (medium-volume physicians who treated 74,792 cases), and greater than or equal to 316 cases (high-volume physicians who treated 75,109 cases).

Statistical Analysis

We used SAS for statistical analysis, using the patient as the unit of analysis. The key independent variable of interest was physician volume group, whereas the key dependent variable of interest was cost per discharge—the aggregate of all itemized costs of provided services/disposables billed to NHI.

We adjusted for attending physician's demographics (gender, age [≤40, 41–50, ≥51], and specialty [pulmonary vs others]), hospital characteristics (hospital level—medical center, regional hospital, district hospital, ownership—for-profit, not-for-profit, and public), region (north, central, south, and east), and patient characteristics (age, gender, and severity).

Patient severity is captured in 2 variables, having an intensive care unit (ICU) admission anytime during hospitalization and receiving mechanical ventilation. In addition, we adjusted for comorbidities using 2 variables, a modified Charlson Comorbidity Index (CCI; using Charlson–Deyo method of comorbidity adjustment) and presence of any other comorbidities not covered under CCI (e.g., hyperlipidemia, depression/anxiety, hypertension, enlarged prostate, gastroesophageal reflux disease, and neurological illness). The CCI (Appendix) [11] is widely used for adjusting risk when using administrative claims datasets, assigning each patient a sum of weighted scores based on the relative mortality risk of 19 conditions. We scaled each patient's comorbidities (from the secondary diagnoses) as per the CCI scale, setting it at zero if none of the CCI-qualifying comorbidities existed. We used these 4 proxies (two for severity and 2 for comorbidities) to account for case mix in the analysis. We did not control for hospital teaching status because of collinearity; all medical centers and regional hospitals are teaching hospitals, and almost all district hospitals are nonteaching hospitals.

Hierarchical linear regression modeling was done to examine whether inpatient care cost is predicted by the physician's case volume, adjusted for patient and hospital characteristics. Hierarchical linear regression modeling is used, specifying a hospital-level random effect to account for possible correlations between patients' costs within each hospital's panel, simply because of hospital policies, procedures, or physician compensation mechanisms that may be unique to a hospital and impact costs of care. Because the cost data were skewed to the left, log transformation was used to transform the data. Normality of the log-transformed cost variable was verified based on distribution symmetry (mean log cost=2.95, median=2.85, mode=3.01). A two-sided P value of .05 was used to determine statistical significance.

RESULTS

The mean age of the sample of 224,882 cases was 64.7 years, mean cost per discharge was US$1,957, 63.2% were male, 5.0% had a Charlson score greater than or equal to 4, 26.7% had an ICU stay during hospitalization, and 12.0% had received mechanical ventilation. Distributed by physician volume, 74,981 were treated by low-volume physicians, with mean cost of $2,255 (±$3,764), mean length of stay (LOS) of 13.44 days, 6.51% in-hospital mortality, and 8.10% with a 14-day readmission. The corresponding data for the medium volume group were 74,792 cases, mean cost of $1,909 (±$3,247), mean LOS of 12.98 days, 5.1% in-hospital mortality, and 6.7% with a 14-day readmission. The 75,109 high-volume group cases had a mean cost of $1,707 (±$2,871), LOS of 12.46 days, in-hospital mortality of 5.36%, and 5.68% with a 14-day readmission.

Figure 1 shows the sample distribution in each volume group by patient characteristics (gender, age, Charlson score, Other comorbidity, ICU admission, and mechanical ventilation) and hospital characteristics (ownership, geographic location, and hospital level). Chi-squared tests across volume

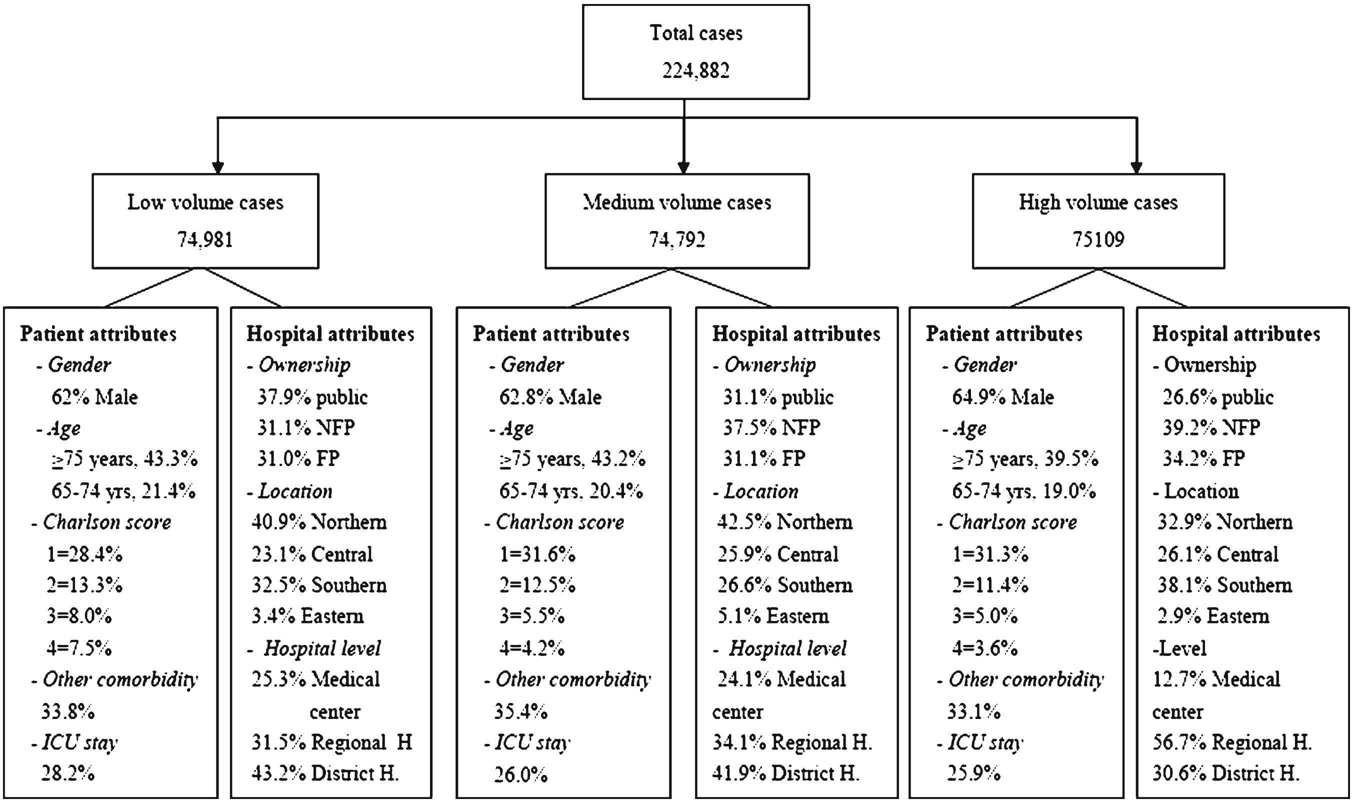

Figure 1. Adult pneumonia cases, 2002–2004 in Taiwan, by physician volume groups, patient characteristics, and hospital characteristics. Note: *ICU* Intensive care unit, *NFP* not-for-profit, *FP* for-profit, *H* hospital.

groups were significant for gender, age, Charlson score, ICU stay, hospital ownership, location, and hospital level.

One-way analysis of variance showed a significant negative association between mean cost per discharge and physician case volume ($P<.001$), being highest for low-volume physicians (US$2,255) and least (US$1,707) for high-volume physicians. LOS also decreased with physician case volume.

Figure 2 presents the sample physicians classified by physician volume tertiles and their distribution by demographics and specialty. For the total 5,925 physicians who treated patients with a primary diagnosis of pneumonia in 2002–2004, mean volume per physician was 38 cases; 5,343 (90.2%) were low-volume physicians with less than or equal to 100 admissions, 439 (7.4%) were medium volume with 101–315 admissions, and 143 (2.4%) were high-volume physicians with greater than or equal to 316 admissions. High-volume physicians were more likely to be specialized pulmonologists relative to other volume groups ($P<.001$).

Table 1 presents the adjusted relationship between physician case volume and costs per discharge based on hierarchical linear regression modeling. Of the total 515 hospitals, the majority was for-profit hospitals (68.4%), regional hospitals (81.8%), and hospitals located in southern Taiwan (38.1%). The likelihood ratio test indicated that the hospital level random effects model was highly significant ($P<.001$). The random effects assumption of normality was checked using the best linear unbiased predictor,[12] which indicated there was no violation of the normality assumption. After adjusting for hospital and patient characteristics, low-volume physicians incurred US$264 higher cost per patient than high-volume physicians' cases and US$235 higher than medium-volume physicians (both $P<.001$). The difference between medium- and high-volume physicians is not significant. Medical centers and regional hospitals (both teaching hospitals) show lower adjusted costs. Not-for-profits hospitals show higher costs than for-profit hospitals. As expected, cost increased with the Charlson score level. To verify whether physician characteristics might alter the volume–outcome relationship, physician's age and gender, and specialty (pulmonologist or otherwise) were entered last into the regression model. There was essentially no change in the volume–cost relationship, although pulmonologists had significantly lower cost than other specialties (data not presented). Examining the volume–cost relationship among pulmonologists, we found that adjusted costs for low-volume relative to high-volume and medium-volume pulmonologists are significantly higher (data not presented). The likelihood ratio test showed that the constant slope assumption for the hospital level random effect was sustained, with no additional variance being explained by a random slope effect.

When the random effects term is deleted from the model, the adjusted R^2 for the model is .353 (table not presented), indicating that these variables explain 35.3% of the variation in pneumonia hospitalization costs.

DISCUSSION

Given the high worldwide health care costs for pneumonia, our findings have significant implications for professional organizations and policy makers. We found significantly higher adjusted costs of inpatient care for patients admitted with a

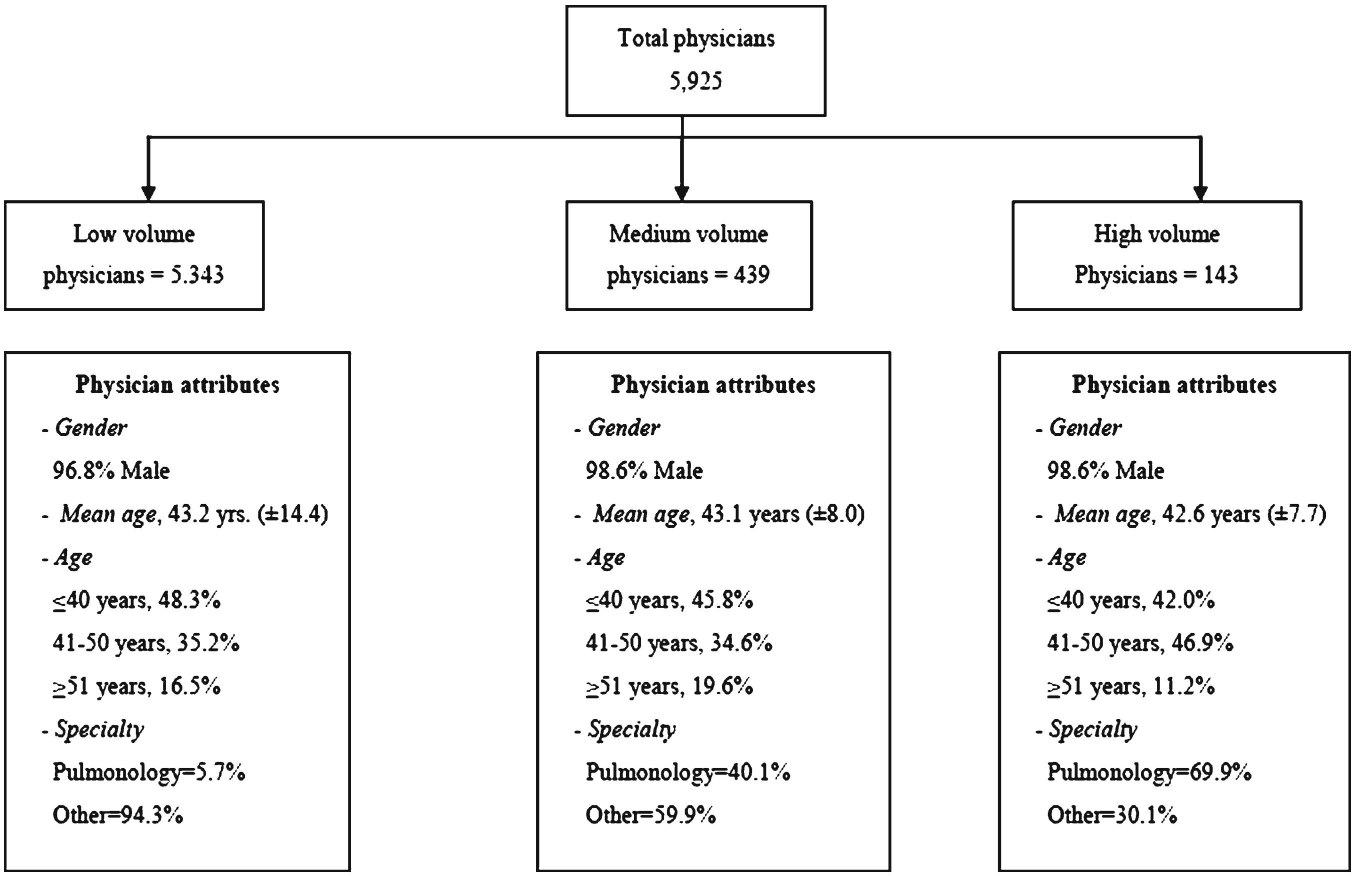

Figure 2. Demographic and specialty distribution of physicians who treated adult pneumonia cases in Taiwan, 2002–2004.

primary diagnosis of pneumonia among low-volume physicians, relative to medium- and high-volume physicians. However, these differences cannot be explained by differences in physician characteristics. There was no difference between medium- and high-volume physicians, indicating that the volume–cost issue is limited to low volumes.

Whereas there is no documented literature on cost of pneumonia care versus physicians' case volume, the evidence for outcomes versus volume is mixed. Lindenauer et al.[2] using Medicare fee-for-service hospital claims data found that odds ratios for 30-day mortality rates were similar between high-volume and low-volume hospitals for the treatment of pneumonia. On the contrary, Marrie et al.[13] in Canada documented high-volume physicians to have lower in-hospital mortality among their patients with community-acquired pneumonia.

Three possible hypotheses for the cost–volume associations have been proposed.[8] The "practice makes perfect" or "learning effect" theory[8,14] proposes that increasing case loads create learning opportunities for cost effectiveness and better implementation of the treatment process, including antimicrobials, procedure, and discharge planning, causing better outcomes and lower cost. The second hypothesis invokes "selective referral" to high-volume providers, based on a reputation for lower treatment costs.[15] This is unlikely to be a factor in Taiwan because of universal, low-cost access to care for all patients and high competition among providers. As a result, the important factor in selecting a hospital is perceived quality and geographic distance, rather than price elasticity of demand.

A third hypothesis has been that some high-volume physicians may be admitting healthier patients or some low-volume physicians may be attracting more critically ill patients, incurring greater cost. Our severity adjustments (CCI, ICU stay, and receiving mechanical ventilation) should account for most of the clinical severity differences, making our findings quite robust to this criticism. However, there could be some scope for unmeasured severity differences that could be teased out from clinical details such as chest x-ray finding and the Pneumonia Severity Index,[16] which are not documented in the claims. In reality, this hypothesis is unlikely; our data show that ICU admission during the inpatient stay and mechanical ventilation usage is significantly more frequent for high-volume physicians. This is consistent with the intuition that more serious patients will actively seek a reputed physician. Lindenauer et al.[2] also found that highest-volume providers were more likely to treat more severely ill patients.

Our concomitant findings that the volume–cost relationship is sustained even among pulmonologists and that quality is not compromised are important for policymakers and professional bodies. Notwithstanding the cross-sectional nature of the study, these concurrent findings point in 1 direction: Increasing practice with a process is associated with better performance, both on cost and outcomes. High-volume physicians have significantly lower inpatient mortality than low-volume physicians (5.36 vs 6.51%) and lower 14-day readmission rates (5.68 vs 8.10%), despite having higher proportions of patients with an ICU stay (40.7 vs 34.5%) and receiving mechanical ventilation (22 vs 15.4%).

Table 1. Adjusted Costs of Pneumonia Care for Low-, Medium-, and High-volume Physicians, Hierarchical Linear Regression Results (*N*=224,882)

Variables	Log (costs in $US)		
	B	SE	*P* value
Physician characteristics			
Physician volume			
≤122 (reference group)			
123–375	−0.038*	0.002	<.001
≥376	−0.042*	0.003	<.001
Hospital characteristics			
Hospital ownership			
Public	0.213	0.024	<.001
NFP	0.216	0.026	<.001
FP (reference group)			
Hospital location			
Northern (reference group)			
Central	−0.038	0.023	.101
Southern	0.007	0.022	.764
Eastern	−0.037	0.049	.447
Hospital level			
Medical center	−0.050	0.015	.001
Regional hospital	−0.087	0.010	<.001
District hospital (reference group)			
Patient characteristics			
Patient gender			
Male	0.011	0.002	<.001
Patient age			
≤64 (reference group)			
65–74	0.096	0.002	<.001
≥75	0.127	0.002	<.001
Charlson Comorbidity Index Score			
0 (reference group)			
1	0.198	0.003	<.001
2	0.234	0.003	<.001
3	0.261	0.004	<.001
4 or more	0.300	0.004	<.001
Other comorbidities			
Yes	0.151	0.003	<.001
ICU admission			
Yes	0.411	0.002	<.001
Mechanical ventilation			
Yes	0.384	0.003	<.001
Random effect associated with hospital	0.03397		
Constant	2.376	0.0187	<.001

B Parameter estimate, SE standard error, NFP not for profit, FP for profit
*Translates into $264 and $235 higher- for low-volume physicians than high- and medium-volume physicians, respectively

Several potential limitations of our study should be noted. First, although the charged costs are comparable on price across providers because of the NHI's fixed price regime, there is still the potential that some providers could inflate items of care to achieve higher reimbursement. There is no way to verify this possibility, although the NHI Bureau's checks and balances described earlier strongly discourage fraudulent billing for services not provided. The second potential limitation is that the admission diagnosis is coded into patient charts by physicians and then claimed by the hospital. There could be errors or upcoding at either level, although such coding error is unlikely to systematically impact a specific category of providers.

A third potential source of bias is that coding of the secondary diagnosis could be of variable accuracy across hospitals. Several inbuilt NHI procedures minimize coding biases or inaccuracies. The Bureau of the NHI randomly samples each year a fixed percentage of claims from every hospital to be verified for diagnosis validity and quality of care through chart review by an independent peer group. In addition, hospitals with outlier charges or patterns of care for any diagnosis group face audits and heavy penalties in case of discrepancies or overcharging the NHI Bureau. Finally, a hospital's global reimbursement category for its services is governed by its overall case severity level, driven by the number and severity of comorbidities. Thus, there is an inbuilt incentive to document all comorbidities.

Policy Implications

The contribution of this study, using nationwide data from a uniquely well-regulated, market-driven, single-payer health system may be questioned, given that such conditions rarely prevail in much of the developed world. Its contribution to policymakers from other countries, however, arises precisely from the above strengths. It demonstrates that when reporting conditions and prices are equalized across providers (eliminating most major sources of confounding), low-volume providers are indeed at a disadvantage, incurring higher costs concurrent with poorer outcomes, despite lower case complexity. However, it must be added that there are undoubtedly many low-volume providers who are providing cost-effective care.

Our study, although cross-sectional, provides support for the practice-makes-perfect hypothesis. It makes a strong case for longitudinal studies to evaluate whether providers improve their cost and quality profile as they move from low-volume to high-volume status. Such studies are expensive, but our study justifies them. Additionally, our study also justifies studies of the practice patterns and care planning of high-volume versus low-volume physicians to uncover the keys to cost-effective and high-quality care.

Because pneumonia is a widespread medical condition, General Internists practicing in the general populace will remain the primary care resource for this condition. Although practice guidelines have been developed [17–20] and are widely used in Taiwan and in many developed countries, the continuing wide variations in costs and outcomes indicates that the best practice and care-planning patterns may be still eluding current practice guidelines. With pay-for-performance in some form becoming commonplace policy worldwide, physicians should be heartened to learn that much of the puzzling variation in performance is not random and that narrowing the search for the keys to high performance among high-volume providers' practice profiles is likely to yield significant results. Payers and policymakers will also be heartened with the finding that in the virtual absence of confounding, potentially, as much as 12% of the cost difference between low and high volume can be reduced among low-volume physicians' care of pneumonia cases. Whereas this study cannot impute this figure directly to other health systems internationally, it provides a glimpse of the potential cost savings to be realized from appropriately designed research studies and policies.

Acknowledgments: *This study was supported by a grant from the National Science Council (NSC 95-2416-H-038-001). This study is based in part on data from the NHI Research Database provided by the Bureau of NHI, Department of Health, and managed by National Health Research Institutes. The interpretation and conclusions contained herein do not represent those of Bureau of NHI, Department of Health, or National Health Research Institutes.*

Conflict of Interest: *None disclosed.*

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APPENDIX

Table 2. The Deyo–Charlson Index of 19 Comorbidities and the Assigned Weights

Medical conditions	Original Charlson weights
Myocardial infarct	1
Congestive heart failure	1
Peripheral vascular disease	1
Cerebrovascular disease	1
Dementia	1
Chronic pulmonary disease	1
Connective tissue disease	1
Ulcer disease	1
Mild liver disease	1
Diabetes	1
Hemiplegia	2
Moderate or severe renal disease	2
Diabetes with end organ damage	2
Any tumor	2
Leukemia	2
Lymphoma	2
Moderate or severe liver disease	3
Metastatic solid tumor	6
AIDS	6

Source: Deyo et al.[11]