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Hospital Volume and 30-Day Mortality for Three Common Medical Conditions

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Abstract

Background—The association between hospital volume and the death rate for patients who are hospitalized for acute myocardial infarction, heart failure, or pneumonia remains unclear. It is also not known whether a volume threshold for such an association exists.

Methods—We conducted cross-sectional analyses of data from Medicare administrative claims for all fee-for-service beneficiaries who were hospitalized between 2004 and 2006 in acute care hospitals in the United States for acute myocardial infarction, heart failure, or pneumonia. Using hierarchical logistic-regression models for each condition, we estimated the change in the odds of death within 30 days associated with an increase of 100 patients in the annual hospital volume. Analyses were adjusted for patients' risk factors and hospital characteristics. Bootstrapping procedures were used to estimate 95% confidence intervals to identify the condition-specific volume thresholds above which an increased volume was not associated with reduced mortality.

Results—There were 734,972 hospitalizations for acute myocardial infarction in 4128 hospitals, 1,324,287 for heart failure in 4679 hospitals, and 1,418,252 for pneumonia in 4673 hospitals. An increased hospital volume was associated with reduced 30-day mortality for all conditions ($P < 0.001$ for all comparisons). For each condition, the association between volume and outcome was attenuated as the hospital's volume increased. For acute myocardial infarction, once the annual volume reached 610 patients (95% confidence interval [CI], 539 to 679), an increase in the hospital volume by 100 patients was no longer significantly associated with reduced odds of death. The volume threshold was 500 patients (95% CI, 433 to 566) for heart failure and 210 patients (95% CI, 142 to 284) for pneumonia.

Conclusions—Admission to higher-volume hospitals was associated with a reduction in mortality for acute myocardial infarction, heart failure, and pneumonia, although there was a volume threshold above which an increased condition-specific hospital volume was no longer significantly associated with reduced mortality.

THE RELATIONSHIP BETWEEN HOSPITAL volume and patient mortality for acute myocardial infarction, heart failure, and pneumonia in the United States is unclear. Admission to higher-volume hospitals has been associated with a reduction in mortality for numerous surgical conditions and medical procedures¹ but not for common medical conditions. Two studies examining acute myocardial infarction showed that admission to higher-volume hospitals was associated with reduced mortality,^{2,3} although both studies were performed before the adoption of improvements in computational power that account for the clustering of patients' outcomes within hospitals and key advances in clinical cardiology, including the widespread use of fibrinolytic therapy and glycoprotein IIb/IIIa receptor antagonists. We are aware of only one study that has examined the relationship between hospital volume and death among patients with pneumonia, which showed no reduction in mortality at higher-volume hospitals.⁴ To our knowledge, no study has examined hospital volume and the rate of death from heart failure.

Hospital volume may be a sensible surrogate for quality in deciding where to obtain surgical and interventional care but may not be similarly sensible for acute medical care. Understanding the relationship between hospital volume and mortality for medical conditions is critical for clinicians and policymakers, since they are under increasing pressure to identify strategies to improve the quality of care.^{5,6} In addition, because three of the most common and costly reasons for hospital admission among Medicare beneficiaries are acute myocardial infarction, heart failure, and pneumonia,⁷ identifying factors associated with better quality of care has great significance.

To better understand the relationship between hospital volume and patient mortality, we examined whether admission to higher-volume hospitals was associated with a reduction in 30-day mortality for Medicare beneficiaries who were hospitalized for acute myocardial infarction, heart failure, or pneumonia. We also determined whether there was a volume threshold for such an association — that is, whether there was a volume above which an increase in the hospital volume would no longer be associated with reduced mortality among patients.

METHODS

STUDY PATIENTS

The study population included fee-for-service Medicare patients 65 years of age or older who were hospitalized between January 1, 2004, and December 31, 2006, with a principal discharge diagnosis of acute myocardial infarction, heart failure, or pneumonia, as determined by the use of diagnostic codes in the International Classification of Diseases, 9th Revision, Clinical Modification (for details, see the Supplementary Appendix, available with the full text of this article at NEJM.org). Data were obtained from standard analytic files and the enrollment database of the Centers for Medicare and Medicaid Services (CMS) from 2004 through 2006, which included demographic information, principal discharge and secondary diagnosis codes, and procedure codes for each hospitalization. We included patients with 12 months of continuous enrollment in a Medicare fee-for-service plan before hospitalization to obtain complete data on coexisting conditions. To avoid survival bias, for each condition, we randomly selected one admission per year for patients with multiple admissions for the same diagnosis during any study year.

We used Medicare Part A inpatient and outpatient data and Medicare Part B provider data to determine patients' coexisting conditions, medical history, and use of procedures during the 12 months before the index admission. Patients who were transferred between acute care facilities during a single hospitalization were linked into a single episode of care with outcomes attributed to the index hospital, regardless of whether the patient was transferred to a higher- or lower-volume hospital. For transfers, which accounted for 10.5% of cases of acute myocardial infarction and less than 1% of cases of heart failure or pneumonia, we considered

only coexisting conditions that were identified from the index hospitalization to avoid misclassifying complications as preexisting conditions.^{8,9}

We excluded hospitals with 10 or fewer cases for the diagnosis of one of the three conditions during our 3-year observational period. We also excluded patients who were discharged alive within 1 day after admission if such discharge was not against medical advice.

DEATH FROM ANY CAUSE AT 30 DAYS

Our main outcome measure was death from any cause within 30 days after hospitalization for acute myocardial infarction, heart failure, or pneumonia. The rate of death was determined by linking data from the Medicare Provider Analysis and Review (MedPAR) with the Medicare enrollment database.

HOSPITAL VOLUME

We determined the volume of patients who were treated at hospitals using annual condition-specific volume averaged over the 3-year period. To avoid endogeneity, we used the total annual number of condition-specific cases before applying our exclusion criteria. For regression analyses, volume was measured as a continuous predictor on the basis of 100-case increments and was log-transformed. For the purposes of characterizing the sample, hospitals were also categorized into quartiles. Hospitals in the fourth quartile were characterized as having a large volume, those in the third quartile as having a medium volume, and those in the first or second quartiles as having a small volume. A substantial proportion of hospitals in the first quartile of volume were subsequently excluded for having 10 or fewer cases with each condition.

HOSPITAL CHARACTERISTICS

We derived our data with respect to the characteristics of hospitals from the 2004 American Hospital Association Survey.¹⁰ Such characteristics included ownership status, teaching status, and hospital capacity to provide coronary-artery bypass grafting (CABG) or percutaneous coronary intervention (PCI).

STATISTICAL ANALYSIS

We first conducted bivariate analyses to compare demographic and clinical characteristics of patients across the categories of hospital volume. We used similar analyses to compare hospital characteristics.

We used hierarchical logistic-regression modeling to estimate the relationship between hospital volume and death from any cause within 30 days for acute myocardial infarction, heart failure, and pneumonia at the patient level. Rates of death were adjusted for age, sex, and clinical characteristics, including the same variables used for the risk-standardization measures developed for the CMS and endorsed by the National Quality Forum for the evaluation of hospital performance.^{11,12} These models are based on administrative data but produce estimates of hospital- or state-specific risk-standardized mortality that are good surrogates for estimates from a medical-record model.^{8,13-15} On the basis of hierarchical condition categories,¹⁶ the model for acute myocardial infarction includes 10 cardiovascular clinical characteristics and 15 other coexisting conditions, the heart-failure model includes 8 cardiovascular characteristics and 14 coexisting conditions, and the pneumonia model includes 7 cardiovascular characteristics and 22 coexisting conditions (for details, see the Supplementary Appendix).

For hierarchical modeling, hospital-level random intercepts were assumed to be normally distributed in order to account for the clustering (nonindependence) of patients within the same

hospital,¹⁷ permitting separation of within-hospital and between-hospital variation after adjustment for patient characteristics. Random effects for hospitals were related to hospital volume and other hospital characteristics. Hospital volume was treated as a continuous variable and log-transformed.

We calculated the association between the adjusted odds of death within 30 days after hospitalization and hospital volume for each condition. We then calculated the volume threshold by examining the relative effect on the adjusted odds of death for increasing the annual baseline volume by 100 patients for a given-size hospital, varying the given-size hospital from an annual volume of 10 cases to an annual volume of 700 cases in increments of 10. We selected 100 cases simply as a standardized increment. We defined the volume threshold as the annual hospital volume at which the upper bound of the 95% confidence interval for the odds ratio reached 1.00. To characterize uncertainty in the estimated volume threshold, we used bootstrapping techniques based on 1000 bootstrapped samples to obtain estimates of 95% confidence intervals for each volume threshold. For each bootstrap sample, we sampled hospitals with replacements from the original study cohort, fitted the hierarchical logistic-regression model to obtain the risk-adjusted odds ratio, and then determined the volume threshold by setting the upper bound of the 95% confidence interval for the odds ratio at 1.00. We also repeated analyses that were stratified according to two hospital characteristics that were hypothesized to be strongly associated with hospital volume: teaching status and capacity to provide cardiovascular revascularization services.

Preliminary analyses indicated that we could pool the 3 years of data because differences across categories of hospital volume did not vary according to year. All analyses were performed independently for acute myocardial infarction, heart failure, and pneumonia and were conducted with the use of SAS software, version 9.1.3 (SAS Institute) and HLM software, version 6.0 (Scientific Software International). All statistical tests were two-tailed and used a type I error rate of 0.05.

RESULTS

HOSPITALIZATIONS

From 2004 through 2006, we identified 734,972 distinct hospitalizations for acute myocardial infarction in 4128 hospitals, 1,324,287 hospitalizations for heart failure in 4679 hospitals, and 1,418,252 hospitalizations for pneumonia in 4673 hospitals. The mean ($\pm$ SD) number of annual hospitalizations for acute myocardial infarction was 17 ± 10 for small-volume hospitals, 70 ± 19 for medium-volume hospitals, and 236 ± 141 for large-volume hospitals. For heart failure, the mean number of annual hospitalizations was 42 ± 26 for small-volume hospitals, 157 ± 38 for medium-volume hospitals, and 422 ± 204 for large-volume hospitals. For pneumonia, the mean number was 59 ± 33 for small-volume hospitals, 179 ± 36 for medium-volume hospitals, and 405 ± 170 for large-volume hospitals.

PATIENT CHARACTERISTICS

Although the vast majority of patients were admitted to large-volume hospitals, many patients received care at small-volume hospitals. For acute myocardial infarction, 68% of all admissions were to large-volume hospitals, 22% were to medium-volume hospitals, and 10% were to small-volume hospitals. This pattern of hospitalization was similar for heart failure (62%, 24%, and 13%, respectively) and pneumonia (56%, 26%, and 18%, respectively). For each condition, patients who were admitted to large-volume hospitals were younger and more likely to have undergone PCI or CABG surgery in the past year, as compared with patients who were admitted to small-volume hospitals ($P\leq0.01$ for all comparisons) (Table 1).

HOSPITAL CHARACTERISTICS

Approximately 25% of hospitals were teaching institutions, and 27% had the capacity to provide cardiovascular revascularization services. For each condition, large-volume hospitals were more likely to be teaching institutions and to provide cardiovascular revascularization than were small-volume hospitals, and large-volume hospitals were less likely to be publicly owned ($P \leq 0.01$ for all comparisons) (Table 2).

ASSOCIATION BETWEEN VOLUME AND MORTALITY

There was heterogeneity in the observed rates of death among hospitals with a large, medium, or small volume for all three conditions (Fig. 1). In an analysis of the relationship between the condition-specific hospital volume (log-transformed) and 30-day risk-standardized mortality, an increased hospital volume was associated with a reduced 30-day rate of death for patients with acute myocardial infarction (risk-adjusted odds ratio, 0.89; 95% confidence interval [CI], 0.88 to 0.90), heart failure (risk-adjusted odds ratio, 0.91; 95% CI, 0.90 to 0.92), and pneumonia (risk-adjusted odds ratio, 0.95; 95% CI, 0.94 to 0.96) ($P < 0.001$ for all comparisons) (Fig. 2).

ATTENUATION OF VOLUME–MORTALITY ASSOCIATION

For all three conditions, the association between the hospital volume and the risk-adjusted mortality was attenuated as the hospital's annual volume increased (Fig. 3). In other words, at greater volumes, the marginal benefit became increasingly small. This relationship did not change in analyses that were stratified according to hospital teaching status and capacity to provide cardiovascular revascularization services.

On the basis of the mean annual volumes for hospitals with a small, medium, or large volume as reference points, at a hospital with an annual volume of 17 patients with acute myocardial infarction, increasing the annual volume by 100 would be associated with a 20% reduction in the odds of death within 30 days (odds ratio, 0.80; 95% CI, 0.79 to 0.81). However, with an annual volume of 70 patients with acute myocardial infarction, increasing the annual volume by 100 would be associated with a 10% reduction (odds ratio, 0.90; 95% CI, 0.89 to 0.92), and with an annual volume of 236 patients with acute myocardial infarction, a 4% reduction (odds ratio, 0.96; 95% CI, 0.95 to 0.97).

For heart failure, increasing the annual volume by 100 patients at a hospital with an annual volume of 42 patients with heart failure would be associated with a 10% reduction in the odds of death within 30 days (odds ratio, 0.90; 95% CI, 0.88 to 0.91), a 4% reduction (odds ratio, 0.96; 95% CI, 0.95 to 0.97) at a hospital with an annual volume of 157 patients, and a 2% reduction (odds ratio, 0.98; 95% CI, 0.97 to 0.99) at a hospital with an annual volume of 422 patients.

For pneumonia, increasing the annual volume by 100 patients at a hospital with an annual volume of 59 patients with pneumonia would be associated with a 5% reduction in the odds of death within 30 days (odds ratio, 0.95; 95% CI, 0.94 to 0.97) and with a 2% reduction (odds ratio, 0.98; 95% CI, 0.97 to 0.99) at a hospital with an annual volume of 179 patients. Such an increase in annual volume was not associated with a significant reduction in the odds of death at a hospital with an annual volume of 405 patients with pneumonia.

VOLUME–MORTALITY THRESHOLD

For all three conditions, we identified a volume threshold above which an increase of 100 patients in the annual volume was no longer significantly associated with a reduction in the risk-adjusted odds of death within 30 days (Fig. 3). The volume threshold was reached once a hospital's annual volume reached 610 patients (95% CI, 539 to 679) with acute myocardial infarction, 500 patients (95% CI, 433 to 566) with heart failure, and 210 patients (95% CI, 142

to 284) with pneumonia. In our analyses, the proportions of patients who were admitted to hospitals with an annual volume that was less than the identified threshold were 57.4% of patients with acute myocardial infarction, 35.8% of those with heart failure, and 7.6% of those with pneumonia.

The identified volume thresholds differed according to the hospital's teaching status and capacity to provide cardiovascular revascularization services. At teaching hospitals, the volume threshold was estimated at 260 patients with acute myocardial infarction, 148 patients with heart failure, and 37 patients with pneumonia; at nonteaching hospitals, the volume thresholds were 629, 385, and 164 patients, respectively. Similarly, at hospitals that provided revascularization services, the volume threshold was estimated at 432 patients with acute myocardial infarction, 256 patients with heart failure, and 66 patients with pneumonia; at hospitals that did not provide revascularization services, the volume thresholds were 586, 303, and 162 patients, respectively.

DISCUSSION

We found that Medicare beneficiaries who were hospitalized for acute myocardial infarction, heart failure, or pneumonia had a reduction in the rate of death if they were admitted to a hospital that handled a large condition-specific volume of patients every year. However, the relationship between volume and lower mortality was attenuated at greater volumes, and we identified a threshold for each condition above which an increase in the hospital volume was no longer associated with lower mortality. Moreover, for all three conditions, once the annual volume reached 100 cases, the curve representing the association between volume and risk-adjusted mortality began to flatten, suggesting that the benefit of an increased volume of patients at a hospital would be most pronounced at low-volume hospitals and would be attenuated as the hospital's volume increased. Because more than 60% of patients were receiving care at large-volume hospitals, whereas approximately 15% were receiving care at small-volume hospitals, a policy aimed at universally increasing hospital volume in order to reduce death rates would not have uniform benefits. Nevertheless, large proportions of patients received care at “below-threshold” hospitals, particularly for acute myocardial infarction.

Despite this association between hospital volume and mortality, we observed heterogeneity among the hospitals. Many patients who were admitted to low-volume hospitals had excellent outcomes, whereas many other patients who were admitted to high-volume hospitals had poor outcomes. For medical conditions, volume alone does not appear to be a proxy for hospital outcome. However, understanding this relationship may help determine whether operator experience accounts for better outcomes, as reported in studies examining PCI¹⁸ and CABG.¹⁹ In turn, strategies may be identified to improve care at small-volume hospitals. For example, large-volume hospitals may be more likely to implement routine treatment algorithms for commonly treated conditions by using reminders in electronic health records or clinical flow charts. Large-volume hospitals may also have an economic scale or the financial capacity to justify employing clinical teams whose sole responsibility is to manage either commonly treated conditions or disease-management and discharge programs, such as home-based follow-up or patient-education seminars, to improve outcomes.

Our findings have two clear policy implications. First, policymakers may suggest that acute care be regionalized so that patients requiring hospitalization for acute myocardial infarction, heart failure, or pneumonia are transferred to receive care at “above-threshold” hospitals or at least at a hospital whose size places it on the flattening part of the volume–mortality curve. Although regionalizing care for less-common, elective surgeries may be practical, regionalizing acute care, particularly for common medical conditions, seems both clinically and politically infeasible and may disrupt care for patients.²⁰ Second, policy-makers may

attempt to increase volume at only the smallest-volume hospitals, perhaps by ensuring that small hospitals are not located within close proximity to one another. This could be accomplished through state certificate-of-need regulations or critical-access-hospital programs.

Hospital volume was not independent of certain hospital characteristics, including teaching status and capacity to provide cardiovascular revascularization services. Nevertheless, although volume thresholds differed according to the type of hospital, the attenuating association was consistently observed. In addition, we cannot rule out confounding of hospital volume by other unmeasured characteristics of patients or hospitals.

Our study has several limitations. First, we examined hospitalizations only for acute myocardial infarction, heart failure, and pneumonia. Our results may not be generalizable to acute care for other conditions or to care provided in ambulatory settings. Second, we focused on mortality, not on other important dimensions of quality, such as processes of care or the experience of patients. Third, we determined estimates of hospital volume using hospitalizations of fee-for-service Medicare beneficiaries and did not account for hospitalizations of nonelderly or Medicare Advantage beneficiaries. Fourth, our estimates were based on hospital volume, not physician volume; the latter has been associated with improved outcomes for acute myocardial infarction and diabetes care.^{21,22} However, hospital volume better reflects the joint efforts required of multiple health care professionals to manage medical conditions, including physicians, nurses, and other clinical staff. Finally, we used administrative data, rather than data from medical records, for all our analyses. However, the statistical models that we used had been developed for use with administrative data and produce estimates of hospital- or state-specific risk-standardized mortality that are good surrogates for estimates from a medical-record model.^{8,13-15}

In conclusion, although we found that admission to higher-volume hospitals was associated with lower mortality, this relationship was attenuated at greater volumes, and we identified a volume threshold above which an increase in volume was no longer significantly associated with lower mortality.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1. Frequency Distribution of 30-Day Rates of Death, According to Medical Condition and Hospital Volume

The upper boundaries of the boxes represent the 75th percentile, the white horizontal line within each box represents the median or 50th percentile, and the lower boundaries of the boxes represent the 25th percentile. Individual data points represent outliers. The I bars represent the highest and lowest values within 1.5 times the interquartile range.

A Acute Myocardial Infarction **B Heart Failure** **C Pneumonia**

Figure 2. Relationship between Hospital Condition-Specific Volume and Risk-Adjusted Odds of Death from Any Cause at 30 Days, According to Medical Condition

The dashed line represents the fitted regression analysis for acute myocardial infarction, heart failure, and pneumonia, with each data point representing one hospital. The hospital volume was the annual condition-specific volume of patients who were treated at hospitals, averaged over the 3-year study period.

Figure 3. Predicted Effect of an Increase of 100 Patients in Annual Hospital Volume on the Adjusted Odds of Death from Any Cause at 30 Days and Volume Threshold, According to Medical Condition For each condition, the association between the hospital volume and the patient outcome was attenuated as the hospital's volume increased. For patients with acute myocardial infarction, once the annual volume reached 610 patients, an increase of 100 patients in hospital volume was no longer significantly associated with reduced odds of death. The volume threshold for hospitalization was 500 patients for heart failure and 210 patients for pneumonia.

Table 1
Characteristics of the Patients, According to Medical Condition and Condition-Specific Hospital Volume.*

Variable	Acute Myocardial Infarction				Heart Failure				Pneumonia			
	All Patients	Hospital Volume			All Patients	Hospital Volume			All Patients	Hospital Volume		
		Small	Medium	Large		Small	Medium	Large		Small	Medium	Large
No. of patients (%)	734,972 (100)	74,893 (10.2)	159,104 (21.6)	500,975 (68.2)	1,324,287 (100)	177,882 (13.4)	319,360 (24.1)	827,045 (62.4)	1,418,252 (100)	252,113 (17.8)	367,348 (25.9)	798,791 (56.3)
Age — yr	79.1±7.9	81.5±8.2	79.8±8.0	78.5±7.8	80.5±7.9	81.6±8.0	80.6±7.9	80.2±7.8	80.2±8.0	80.8±8.2	80.1±8.0	80.1±7.9
Female sex — %	51.2	56.6	53.5	49.7	50.8	60.5	59.2	57.0	55.9	55.6	56.2	55.9
Cardiovascular history — % [†]												
PCI	4.7	2.9	4.2	5.2	6.7	4.5	5.9	7.4	3.3	2.5	2.9	3.7
CABG	6.5	7.0	7.4	6.2	11.8	8.4	11.0	12.8	5.4	4.1	5.2	5.9
Heart failure	30.3	38.2	33.9	27.9	73.1	72.1	72.4	73.6	39.1	38.7	38.7	39.5
Myocardial infarction	15.2	16.2	15.7	14.9	9.6	8.1	9.4	9.9	3.7	3.2	3.6	3.9
Unstable angina	11.6	11.0	11.9	11.6	15.2	11.9	14.5	16.1	7.2	5.9	7.0	7.8
Chronic atherosclerosis	73.5	58.0	68.0	77.5	71.0	63.3	69.2	73.4	46.7	42.2	45.8	48.6
Valvular heart disease	18.5	18.1	20.1	18.1	47.0	36.8	45.1	50.0	NA	NA	NA	NA
Coexisting condition — % [‡]												
Hypertension	59.2	57.7	59.3	59.4	82.8	81.7	82.5	83.1	75.4	73.1	75.2	76.1
Stroke	7.0	8.4	7.9	6.5	10.6	9.3	10.3	11.0	10.9	9.7	11.0	11.3
Renal failure	13.2	13.8	14.4	12.7	28.0	22.7	26.5	29.8	14.3	11.5	13.7	15.4
COPD	28.8	30.8	30.4	28.1	47.0	46.0	47.7	46.9	56.1	53.3	56.5	56.8
Pneumonia	12.7	17.0	14.3	11.6	38.5	40.0	38.9	38.0	41.9	40.3	41.8	42.5
Diabetes	39.5	40.9	41.0	38.8	48.7	46.4	48.5	49.2	NA	NA	NA	NA
Dementia	14.5	20.9	17.0	12.8	20.2	21.1	20.6	19.9	27.6	27.1	28.0	27.5
Peripheral vascular disease	20.6	20.1	21.9	20.3	32.1	26.4	30.3	34.0	26.0	22.1	25.2	27.6
Metastatic cancer	3.5	3.5	3.7	3.5	4.0	3.3	3.8	4.3	7.9	6.1	7.5	8.7
Major psychiatric disorder	5.5	7.2	6.3	5.0	8.6	9.1	8.6	8.5	11.3	11.1	11.3	11.3

* Plus-minus values are means ±SD. Risk-adjustment models included age, sex, and the same clinical-characteristic variables used for the risk-standardization measures developed for each condition independently for the Centers for Medicare and Medicaid Services and endorsed by the National Quality Forum for the evaluation of hospital performance. 11,12 The model for acute myocardial infarction includes 10 cardiovascular clinical characteristics and 15 other coexisting conditions; the heart-failure model includes 8 and 14, respectively; and the pneumonia model includes 7 and 22, respectively. Not all variables are shown in the table (for details, see the Supplementary Appendix). Percentages may not total 100 because of rounding. CABG denotes coronary-artery bypass grafting, COPD chronic obstructive pulmonary disease, NA not applicable (because the clinical characteristic was not used for risk standardization for that condition-specific hospitalization), and PCI percutaneous coronary intervention.

[†]Data regarding cardiovascular history and coexisting medical conditions were based on hierarchical condition categories, with the exception of a history of PCI and CABG and anterior, inferior, lateral, or posterior myocardial infarction.

Table 2
Characteristics of the Hospitals, According to Patients' Medical Condition and Condition-Specific Hospital Volume.*

Variable	Acute Myocardial Infarction				Heart Failure				Pneumonia			
	All Patients	Small	Medium	Large	All Patients	Small	Medium	Large	All Patients	Small	Medium	Large
No. of hospitals (%)	4128 (100)	2067 (50.1)	1029 (24.9)	1032 (25.0)	4679 (100)	2341 (50.0)	1170 (25.0)	1168 (25.0)	4673 (100)	2282 (48.8)	1196 (25.6)	1195 (25.6)
Annual admissions for condition — no.		17.0±10.3	69.8±18.6	236.0±141.4		41.6±26.0	156.5±37.8	422.2±203.7		58.5±32.5	178.5±35.5	404.9±170.3
Cardiac procedure provided by hospital — %												
PCI	25.9	5.3	29.5	64.8	23.0	3.6	26.5	58.3	23.0	4.8	26.4	54.5
CABG	24.4	3.1	21.9	69.9	21.7	2.5	20.9	61.0	21.7	4.3	21.4	55.2
PCI or CABG	29.8	5.5	32.8	75.4	26.4	4.3	30.1	67.1	26.4	5.8	29.4	62.9
Public ownership — %	12.7	14.9	11.8	9.3	12.3	12.6	15.0	9.2	12.4	12.7	15.2	8.9
Teaching status — %												
Nonteaching	72.3	92.9	74.0	29.6	75.3	94.4	75.5	36.8	75.3	91.9	74.0	44.9
Affiliated with a residency or fellowship program	20.6	5.8	20.7	50.4	18.5	4.8	19.0	45.3	18.5	6.4	19.5	40.5
Member of Council of Teaching Hospitals	7.0	1.4	5.3	20.1	6.2	0.8	5.6	17.9	6.3	1.7	6.5	14.6

* Plus-minus values are means ±SD. CABG denotes coronary-artery bypass grafting, and PCI percutaneous coronary intervention.