Physician Volume, Specialty, and Outcomes of Care for Patients With Heart Failure

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Background—There is an urgent need to improve outcomes and reduce costs for patients with heart failure (HF). Physician volume is associated with better outcomes for patients undergoing procedures, but its association with outcomes for medically managed diseases, such as HF, is not well understood.

Methods and Results—We used Medicare inpatient data in 2009 to examine all HF admissions to acute care hospitals in the United States. We divided physicians into quintiles according to their volume of patients with HF. We used patient-level regression to compare 30-day risk-adjusted mortality, readmissions, and costs across volume groups, controlling for patient, physician, and hospital characteristics. We examined physician volume within strata of hospital volume and physician specialty. Patients cared for by the high-volume physicians had lower mortality than those by the low-volume physicians (8.9% versus 9.7%; $P<0.001$); this relationship was strongest in low-volume hospitals. In contrast, patients cared for by high-volume physicians had higher readmission rates (25.8% versus 21.5%; $P<0001$); this relationship was similar across hospital volume groups. Finally, costs were higher for the high-volume physicians ($8982 versus $8731; $P=0.002$, a difference that was consistent across hospital volume groups). The relationship between physician volume and mortality was strongest for internists (9.2% versus 10.6%; $P<0.001$) and weakest for cardiologists (6.4% versus 6.7%; $P=0.485$).

Conclusions—Physician volume is associated with lower mortality for HF, particularly in low-volume institutions and among noncardiologist physicians. Our findings suggest that clinician expertise may play an important role in HF care. **(*Circ Heart Fail*. 2013;6:890-897.)**

Key Words: health care costs ■ heart failure ■ patient readmission ■ quality of health care

There is an urgent need to improve clinical outcomes and reduce costs for patients with heart failure (HF), a leading cause of morbidity and mortality in the United States.[1] Unfortunately, despite substantial regional and national efforts, mortality for patients with HF has remained relatively stable[2] and costs continue to rise.[3] Finding ways to improve care and outcomes for patients with HF remains a high clinical and policy priority.

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One possibility is that physician volume may play a role in the care of patients with HF. Previous studies that focused on procedure-based care have shown a consistent relationship between physician volume and outcomes,[4,5] but whether that relationship also exists for conditions that are predominantly medically managed, such as HF, is not well understood. We have indirect evidence that physician volume matters: hospitals that treat a higher volume of patients with HF have better outcomes,[6,7] and patients with HF tend to do better when cared for by cardiologists rather than noncardiologist physicians.[8,9] It is possible that physician experience is actually the key factor underlying each of these associations: high-volume hospitals likely have high-volume physicians, and cardiologists likely have a higher volume of patients with HF than noncardiologist physicians. However, these relationships could be independent of physician volume: high-volume hospitals may achieve better outcomes by having better systems (ie, readily available catheterization laboratories, electronic information systems) in place, and cardiologists might have better outcomes because of their additional training. Empirical evidence on the degree to which provider volume affects patient outcomes would be immensely helpful in terms of designing interventions to improve care for patients with HF.

Given the importance of understanding the role of physician experience and expertise in explaining differences in patient outcomes, we sought to answer 3 questions. First, what is the relationship among physician volume, clinical outcomes, and costs among patients with HF? Second, how do these relationships vary between low- and high-volume hospitals? Finally, given that patients with HF are cared for by a variety of

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different types of physicians, how do the relationships among volume, outcomes, and costs vary by physician specialty?

Methods

Data

We used national Medicare data from the 100% inpatient file of 2009 to identify all Medicare fee-for-service beneficiaries discharged from acute care hospitals in the United States, with a primary discharge diagnosis of HF (*International Classification of Diseases, Ninth Revision, Clinical Modification* [*ICD-9-CM*] codes 398.91, 404.x1, 404.x3, 428.0 to 428.9). We excluded patients discharged from federal hospitals, as well as those from hospitals located outside the 50 US states and the District of Columbia. We assigned each patient to the primary attending physician of record as identified in their Medicare claims. Although many physicians may care for the patient during their stay, Medicare identifies the primary attending physician of record as the physician ultimately responsible for discharging the patient.

We used the National Plan and Provider Enumeration System file from the Centers for Medicare and Medicaid Services to identify physicians by their National Provider Identification number. We linked the National Plan and Provider Enumeration System data to the Healthcare Provider Taxonomy Code Set (also provided by Centers for Medicare and Medicaid Services) to determine physician specialty. We created 3 groups as follows: cardiology (207RC0000X, 207RC0001X, and 207RI0011X), internal medicine (207R00000X and 208M00000X), and family or general medicine (207Q00000X and 208D00000X). Physicians not falling into any of these 7 taxonomies were excluded from our analysis because of their wide heterogeneity. There were 240 distinct taxonomies in the excluded group; the most common omitted specialties were specialist not otherwise specified: nephrology, pulmonary disease, emergency medicine, and thoracic surgery. In total, these physicians cared for 12.2% of patients with HF in 2009. Including them in our analysis did not meaningfully change the results.

We obtained hospital characteristics from the 2009 American Hospital Association annual survey, including hospital size, ownership, membership in the Council of Teaching Hospitals, urban versus rural location, and census region.

Our primary outcomes were 30-day mortality and readmissions, as well as costs per hospitalization. We followed the algorithms used by the Centers for Medicare and Medicaid Services to identify index admissions for HF[10]; consequently, patients could be included in the sample more than once. We identified 30-day mortality using the 100% inpatient file; for mortality calculations, we considered all admissions with a primary diagnosis of HF to be index admissions.

Analysis

We divided the physicians in our sample into quintiles by the number of patients with HF they discharged in 2009. We compared physician characteristics, patient characteristics, and hospital characteristics using χ^2 tests and analyses of variance, as indicated.

Next, we created patient-level hierarchical logistic regression models for 30-day mortality rates and 30-day readmission rates. We accounted for clustering of patients within hospitals; we were not able to account for clustering of patients within physicians because the number of physicians exceeded the maximum clustering capacity of SAS. We adjusted for age, sex, race, and 29 comorbid medical conditions using the Medicare risk-adjustment model developed by the Agency for Healthcare Quality and Research (Appendix Table I in the online-only Data Supplement).[11] We treated the physician volume group as a categorical variable to obtain estimates, but to test for trend, present *P* values from models in which we treated volume group as a continuous variable. We compared mortality and readmission rates across quintiles of physician volume, first adjusted only for patient characteristics and subsequently adjusted for the characteristics of hospitals in which they received care, including size, teaching status, ownership, urban versus rural location, and region, as well as physician specialty.

Each patient's Medicare costs were calculated using an approach we and others have previously described, regressing costs on patient-level factors (age, sex, race, and comorbidities), hospital-level factors that might be expected to cause cost differences but are not within the hospital's control (medicare wage index, income and poverty rate in the community), and the pursuit of costly missions, including teaching (as measured by the intern and resident-to-bed ratio) and caring for the poor (as measured by the disproportionate share hospital index).[12,13] We used linear regression to compare costs across quintiles of physician volume. Again, we first created models adjusted for patient characteristics only, then subsequently added hospital characteristics, annual hospital HF volume, and physician specialty to our models. To further explore potential drivers of any differences in costs that we found, we also conducted linear regression analyses examining length of stay and procedure use within each cohort.

We were specifically interested in the interactions between physician volume and hospital volume and between physician volume and physician specialty and, therefore, decided a priori to stratify our analyses by quartiles of hospital volume and by physician specialty. We repeated the analyses as described above for each of our outcomes within each volume quartile and within each specialty.

A $P<0.05$ was considered statistically significant. All analyses were performed using SAS version 9.2 (Cary, NC). This study was approved by the Office of Human Research Administration at the Harvard School of Public Health.

Results

Physician Characteristics

There were 78 227 physicians in our sample. Medicare HF volume was low for most physicians in our sample: physicians in the high-volume quintile cared for a median of 14 Medicare patients with HF annually compared with 1, 2, 4, and 7 in the low-volume quintiles. High-volume physicians were more often cardiologists or internists than their low-volume counterparts (Table 1). High-volume physicians tended to work at institutions that had somewhat higher annual HF volumes, but they were less likely to work at teaching hospitals.

Patient Characteristics

There were 471 612 patient discharges in our sample. Patients cared for by the high-volume physicians were more often admitted to the hospital on an emergent basis, more likely to be discharged to skilled nursing or rehabilitation facilities, and less likely to be transferred to another hospital (Table 2). There were minimal differences in patient characteristics (age, sex, race, and comorbidities) across the physician-volume quintiles.

Mortality

In comparison with patients cared for by the low-volume physicians, and after adjusting for hospital characteristics, including size, ownership, teaching status, location, and region, as well as annual hospital HF volume and physician specialty, patients in the high-volume group had lower risk-adjusted 30-day mortality rates (8.9% versus 9.7%, difference 0.9%; $P<0.001$ for trend across quintiles; Table 3). There was no statistically significant interaction between hospital volume and patient volume ($P=0.155$), but the mortality difference between the high- and low-volume physicians was numerically largest in the low-volume hospitals (8.5% versus 14.0%, difference 5.5%; $P<0.001$ for trend across quintiles, Figure A).

Table 1. Physician Characteristics

	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5	
	Lowest Volume	Low Volume	Medium Volume	High Volume	Highest Volume	*P* Value
Number of physicians	16 735	11 312	21 060	14 140	14 980	n/a
Annual volume of HF patients, median (range)	1 (1–1)	2 (2–2)	4 (3–5)	7 (6–9)	14 (10–191)	<0.001
Specialty						
Cardiologist	17.2%	17.6%	18.0%	18.6%	18.3%	<0.001
Internist	44.2%	44.2%	51.6%	59.1%	66.5%	
Generalist	38.6%	38.6%	30.4%	22.4%	15.2%	
Hospital HF volume, mean	244	248	260	271	303	<0.001
Hospital size						
Small	17.0%	16.9%	16.7%	15.3%	14.9%	<0.001
Medium	49.9%	50.5%	51.7%	54.8%	56.5%	
Large	33.1%	32.7%	31.5%	29.9%	28.6%	
Teaching hospital	22.3%	21.1%	19.3%	16.4%	13.4%	<0.001
Urban location	93.0%	92.8%	92.7%	93.1%	93.9%	<0.001

HF indicates heart failure; and n/a, not applicable.

Readmissions

In comparison with patients cared for by the low-volume physicians, and adjusting for hospital characteristics, annual hospital HF volume, and physician specialty, patients in the high-volume group had higher risk-adjusted 30-day readmission rates (25.8% versus 21.5%, difference 4.3%; $P<0.001$ for trend across quintiles; Table 3). There was no statistically significant interaction between hospital volume and patient volume ($P=0.081$), and the difference between high- and low-volume physicians was similar across hospital volumes (Figure B).

Costs

In comparison with physicians in the low-volume group, and adjusting for hospital characteristics, hospital HF volume, and physician specialty, physicians in the high-volume group had slightly higher risk-adjusted costs per discharge than physicians in the low-volume group ($8982 versus $8731, difference $251, $P=0.002$ for trend; Table 3). The magnitude of this difference was roughly similar across quartiles of hospital volume ($P=0.125$ for interaction; Figure C). After full adjustment, length of stay (6.2 versus 6.0 days, $P<0.001$ for

Table 2. Patient Characteristics

	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5	
	Lowest Volume	Low Volume	Medium Volume	High Volume	Highest Volume	*P* Value
Demographics						
No. of patients	16 375	22 624	81 136	102 840	248 277	n/a
Age, median (Q1–Q3)	81 (74–87)	81 (74–87)	82 (75–87)	82 (75–87)	81 (75–87)	<0.001
Proportion female	44.5%	44.3%	44.6%	44.9%	44.7%	0.39
Race						
White	81.7%	83.0%	84.1%	84.4%	83.9%	<0.001
Black	12.4%	11.6%	11.2%	11.2%	12.4%	
Other	5.9%	5.4%	4.7%	4.4%	3.7%	
Selected comorbidities						
Uncomplicated diabetes mellitus	25.6%	25.7%	25.5%	25.8%	26.2%	<0.001
Hypertension	54.8%	54.4%	53.6%	53.3%	53.3%	<0.001
Chronic kidney disease	28.0%	28.6%	29.1%	29.6%	30.5%	<0.001
Visit characteristics						
Emergent admission	67.5%	67.6%	68.9%	70.1%	73.0%	<0.001
Discharge						
Home	70.1%	69.6%	68.8%	68.2%	67.5%	<0.001
SNF/rehabilitation	22.7%	23.5%	24.4%	25.2%	26.1%	
Hospice	3.3%	3.2%	3.3%	3.3%	3.2%	
Transfer out	3.2%	3.0%	2.9%	2.8%	2.6%	<0.001

Q1–Q3 indicates first quartile to third quartile; and SNF, skilled nursing facility.

Table 3. Relationships Between Physician Volume and Mortality and Costs

Outcome	Quintile 1 Lowest Volume	Quintile 2 Low Volume	Quintile 3 Medium Volume	Quintile 4 High Volume	Quintile 5 Highest Volume	Difference (Highest Minus Lowest Volume)	*P* for Trend
30-Day risk-adjusted mortality	9.7% (2.6%)	9.3% (2.4%)	9.3% (1.3%)	9.2% (1.2%)	8.9% (0.9%)	–0.8%	<0.001
30-Day risk-adjusted readmissions	21.5% (2.2%)	22.1% (1.8%)	23.3% (1.0%)	24.6% (0.9%)	25.8% (0.7%)	4.3%	<0.001
Risk-adjusted costs per hospitalization	$8731 ($88)	$8801 ($80)	$8861 ($57)	$8919 ($54)	$8982 ($54)	$251	0.002

All models are adjusted for patient characteristics, physician specialty, hospital volume, and hospital characteristics, including teaching status, hospital size, urban versus rural location, region of the country, and ownership (public, private nonprofit, and private for-profit). SEs are shown in parentheses.

trend) was higher for patients cared for by high-volume physicians, but procedure use was lower (8.9% versus 10.8% of patients with ≥1 procedure during hospitalization, $P<0.001$ for trend, Appendix Tables II and III in the online-only Data Supplement).

Physician Volume and Specialty

The association between physician volume and mortality was weaker for cardiologists than that for other physicians, even controlling for hospital characteristics and hospital volume. For example, patients cared for by the high-volume cardiologists had similar mortality rates to patients cared for by the lowest volume cardiologists (6.4% versus 6.7%, $P=0.485$ for trend), whereas for internists and generalists, the differences were larger and statistically significant (9.2% versus 10.6%, difference 1.4%, $P<0.001$ for trend; and 10.1% versus 10.8%, difference 0.7%, $P=0.150$ for trend, $P=0.071$ for interaction; Table 4). For readmissions, higher physician volume was associated with higher readmission rates across specialties although the effect was numerically largest in the generalist group (26.4% in the high-volume group versus 20.5% in the low-volume group, difference 5.9%, $P<0.001$ for trend, $P=0.019$ for interaction; Table 4).

Cardiologists had significantly higher costs than internists or generalists. The relationship between volume and costs was positive and significant for both cardiologists and generalists; however, there was no relationship between volume and costs in the internist group; after controlling for hospital characteristics and hospital volume, the difference between the high- and low-volume cardiologists was $1149 ($12 581 versus $11 432, $P=0.001$ for trend across quintiles) versus $38 for internists ($8511 versus $8549, $P=0.166$ for trend across quintiles) and $368 for generalists ($7683 versus $7315, $P<0.001$ for trend across quintiles, $P=0.097$ for interaction; Table 4).

Discussion

We found that patients with HF cared for by high-volume physicians had lower mortality rates, higher readmission rates, and higher costs per hospitalization, relationships that persisted even after accounting for hospital volume and physician specialty. However, hospital volume and specialty maintained significant relationships with outcomes as well, suggesting that each remain important determinants of patient outcomes. These findings suggest that to improve care for patients with HF, we may need new strategies that target quality improvement efforts toward low-volume physicians, particularly at low-volume hospitals and in the case of non-cardiologist physicians.

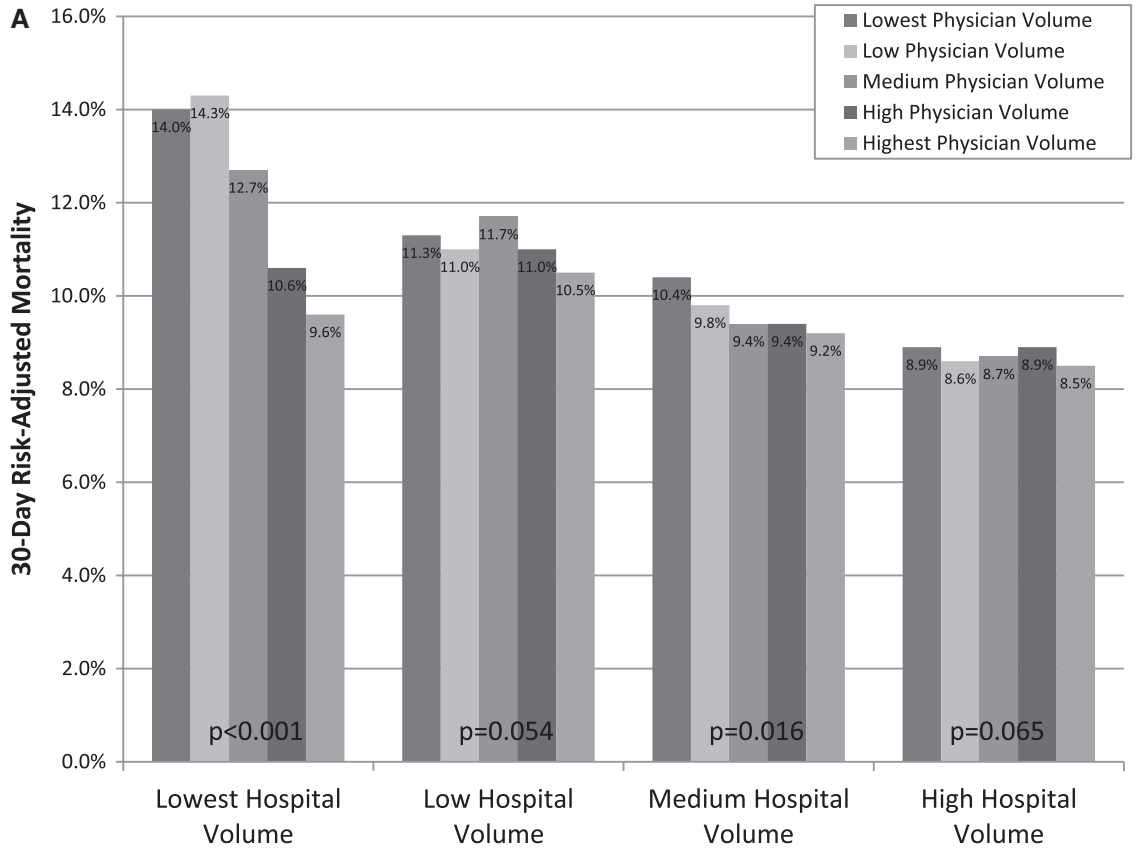
It is unclear why high-volume physicians and cardiologists have lower mortality rates although there are a few possibilities. High-volume physicians or physicians with specific training in HF may be particularly skilled in decision making around diuretic dosing and medication titration, the practice-makes-perfect equivalent for carefully honed surgical skills, or may be particularly consistent about adhering to guideline-based care. Although we were unable to assess guideline adherence in this administrative database, previous studies have suggested that cardiologists, who were slightly overrepresented in the high-volume group, are more likely to adhere to guidelines in the care of patients with HF.[14] Alternatively, high-volume physicians may excel in accurately identifying and treating the many complex medical issues associated with HF, such as chronic kidney disease and diabetes mellitus. Finally, high-volume physicians may be better at identifying when patients are deteriorating or are in need of additional clinical attention, the medical equivalent of avoiding the failure to rescue, which partly explains why high-volume surgeons have better outcomes.[15]

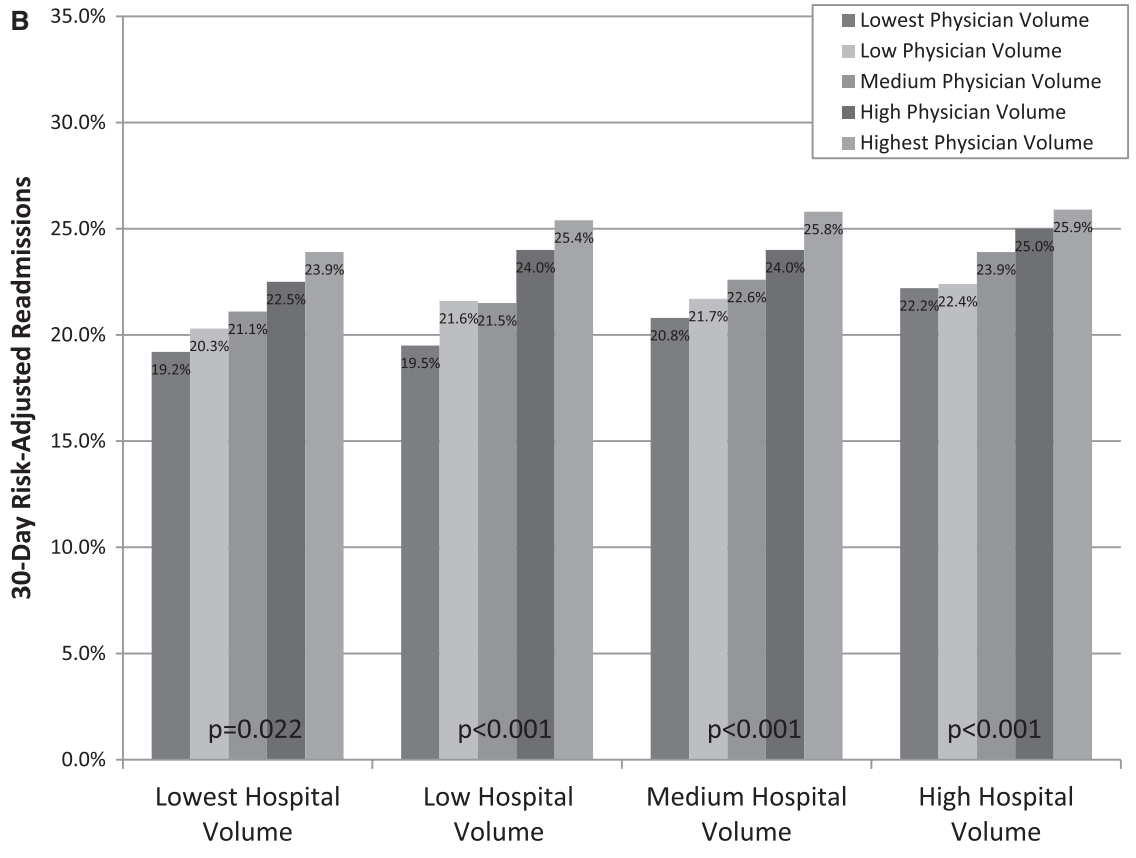
Our finding that the mortality differences between low- and high-volume physicians were numerically largest in the low-volume hospitals suggests that the impact of physician experience may be greatest when there are few systems in place or when care is less uniform. Both physician factors and system factors are likely key components of achieving optimal patient outcomes.

Readmissions followed a different pattern than mortality, with high-volume physicians demonstrating higher readmission rates. This inverse relationship has been demonstrated previously in HF[16] and may suggest that readmission and mortality measure different aspects of patient care both during and after hospitalization.

Patients cared for by the high-volume physicians also had the highest costs per discharge although the differences were relatively small between the high-volume and low-volume groups. The length of stay was slightly higher in the high-volume group, which may have contributed to these higher costs, although the use of procedures was actually slightly lower. We also found that costs were significantly higher among cardiologists, irrespective of volume, who have been demonstrated in previous work to use more high-cost, high-technology adjunct therapies.[17] Whether this additional spending is cost-effective, and whether the higher short-term costs would be offset by lower long-term costs, is unclear but may warrant future study.

Understanding the mechanisms underlying the volume–outcome relationship in HF may offer new avenues for improving outcomes for this vulnerable patient population, particularly





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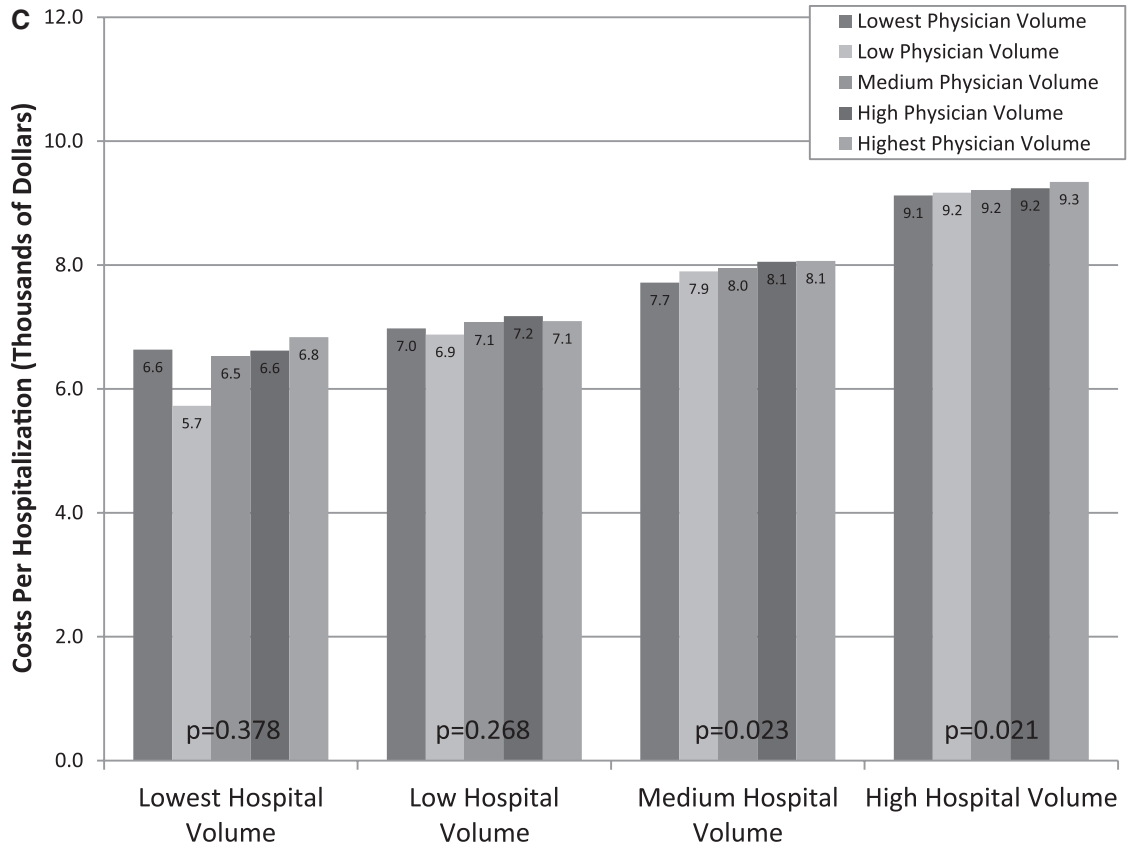

Figure. **A**, Relationship between physician volume and 30-day risk-adjusted mortality, stratified by hospital volume: adjusted for patient characteristics, physician specialty, and hospital characteristics including teaching status, hospital size, urban vs rural location, region of the country, and ownership (public, private nonprofit, private profit). **B**, Relationship between physician volume and 30-day risk-adjusted readmissions, stratified by hospital volume: adjusted for patient characteristics, physician specialty, and hospital characteristics, including teaching status, hospital size, urban vs rural location, region of the country, and ownership (public, private nonprofit, private profit). **C**, Relationship between physician volume and costs per hospitalization, stratified by hospital volume: adjusted for patient characteristics, physician specialty, and hospital characteristics, including teaching status, hospital size, urban vs rural location, region of the country, and ownership (public, private nonprofit, private profit).

those cared for by low-volume, noncardiologist physicians. Because roughly half of the patients in our study were cared for by physicians who were not in the high-volume group, and ≈82% were cared for by noncardiologist physicians, this could potentially have significant national impact. If high-volume physicians use different diagnostic tests or alternative treatment

Table 4. Relationships Between Physician Volume and Mortality and Costs, Stratified by Physician Specialty

Hospital Volume	Quintile 1 Lowest Physician Volume	Quintile 2 Low Physician Volume	Quintile 3 Medium Physician Volume	Quintile 4 High Physician Volume	Quintile 5 Highest Physician Volume	Difference (Highest minus Lowest Volume)	*P* for Trend
30-Day risk-adjusted mortality rates (*P*=0.071 for interaction)							
Cardiologists	6.7%	5.8%	6.1%	6.5%	6.4%	–0.3%	0.49
Internists	10.6%	9.9%	9.7%	9.5%	9.2%	–1.4%	<0.001
Generalists	10.8%	10.9%	10.9%	10.9%	10.1%	–0.7%	0.015
30-Day risk-adjusted readmission rates (*P*=0.019 for interaction)							
Cardiologists	21.0%	21.1%	22.4%	22.9%	23.6%	2.6%	<0.001
Internists	22.5%	22.5%	23.8%	25.1%	26.3%	3.8%	<0.001
Generalists	20.5%	21.9%	22.9%	24.8%	26.4%	5.9%	<0.001
Risk-adjusted costs per hospitalization (*P*=0.097 for interaction)							
Cardiologists	$11 432	$11 929	$12 095	$12 241	$12 581	$1149	0.017
Internists	$8549	$8393	$8414	$8474	$8511	–$38	0.21
Generalists	$7315	$7532	$7536	$7629	$7683	$368	0.009

All models are adjusted for patient characteristics, hospital volume, and hospital characteristics including teaching status, hospital size, urban versus rural location, region of the country, and ownership (public, private nonprofit, private for-profit).

strategies, identifying those and finding ways to increase their use among low-volume physicians would be helpful. On the contrary, if the differences are attributable simply to better clinical judgment, then achieving minimum volume thresholds may be the most effective approach to improve care. In institutions with at least a moderate volume of patients, this could be achieved simply by concentrating patients with HF among a smaller group of clinicians. In institutions where the overall volume is low (ie, small, rural hospitals), the solutions might include greater use of consultative services or telemedicine to involve more experienced HF clinicians in patient care.

Our study adds to an emerging body of literature examining the association between physician volume and patient outcomes for medical illness. Tu et al[18] showed that physician volume was strongly related to 30-day and 1-year mortality rates for acute myocardial infarction. Lin et al[19] found that Taiwanese physicians who cared for a higher volume of severely ill patients with pneumonia in an intensive care unit had better outcomes than those who cared for a lower volume of patients. However, the data costs are less robust and have been less consistent. For example, other work from Taiwan has demonstrated that higher physician volume is associated with lower costs for patients with pneumonia[19,20] and stroke.[21] However, others have found no relationship between physician volume costs for patients undergoing complex cancer surgery.[22]

There are limitations in our study. We used administrative data for risk adjustment and therefore were unable to account for differences in severity of illness that might be more accurately represented in clinical data sets. Imperfect risk adjustment here would likely bias us toward finding no effect because it is likely that the sickest patients are concentrated in the high-volume centers with the high-volume physicians. We only assessed each clinician's Medicare HF volume; although Medicare patients make up a significant proportion of HF admissions and we have no reason to think that volume patterns would differ across payers, this could decrease the precision of our volume estimates. We were also unable to account for differences in physicians' length of time in practice, which could impact their cumulative experience and lead to some degree of misclassification. However, these issues would likely bias us against finding a relationship between volume and outcomes; thus, our findings may underestimate the true magnitude of the association. Patients may be seen by multiple physicians while they are hospitalized, and we only considered the discharging attending of record; therefore, if a patient saw a high-volume clinician or a cardiologist in consultation only, we would not have captured this. However, our choice to limit the analysis to a single attending would likely bias against finding a relationship; again, our findings may underestimate the associations. Finally, although we controlled for hospital characteristics, such as size, teaching status, and location in an effort to account for potential differences in ancillary services available to the patients in our study, there may be a degree of residual confounding in this area.

Conclusions

In summary, we found that patients with HF cared for by high-volume physicians had lower mortality rates and higher readmission rates, independent of hospital volume. They also had higher costs per hospitalization. These effects were particularly pronounced among internists and generalists, who care for the majority of patients with HF in the United States. These findings open a new venue for strategies to improve mortality for this population: targeting quality improvement efforts toward low-volume physicians, particularly noncardiologist physicians at low-volume institutions. Although systems-level factors surely matter in the care of the patient with HF, our findings suggest that clinician expertise also plays an important role.

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Disclosures

None.

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CLINICAL PERSPECTIVE

Physician volume is associated with better outcomes for patients undergoing procedures, but its association with outcomes for medically managed diseases such as HF is not well understood. In this study, we studied HF admissions for Medicare patients in 2009. We divided patients into 5 groups based on the volume of patients with HF their attending of record saw in 2009. We found that patients cared for by the high-volume physicians had lower mortality than patients cared for by the low-volume physicians (8.9% versus 9.7%); this relationship was strongest in low-volume hospitals. In contrast, patients cared for by high-volume physicians had higher readmission rates (25.8% versus 21.5%); this relationship was similar across hospital volume groups. Finally, costs were higher for the high-volume physicians ($8982 versus $8731, which was consistent across hospital volume groups). The relationship between physician volume and mortality was strongest for internists (9.2% versus 10.6%) and weakest for cardiologists (6.4% versus 6.7%). In summary, we found that higher physician volume is associated with lower mortality for HF, particularly in low-volume institutions and among noncardiologist physicians. There was not an apparent relationship between volume and readmissions. Our findings suggest that clinician expertise may play a role in influencing the outcomes of HF care.