Is Higher Patient Satisfaction Associated With Better Stroke Outcomes?

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ABSTRACT

OBJECTIVES: To evaluate the association between patient satisfaction and cost, outcomes, and clinical performance of stroke care.

STUDY DESIGN: An ecological study was conducted on all participating hospitals of the Hospital Consumer Assessment of Healthcare Providers and Systems patient survey that reported stroke outcomes.

METHODS: Patient satisfaction measures were grouped into global, environmental, communication, pain control, staff responsiveness, care transition, and discharge information categories. Linear regression models compared risk-adjusted 30-day mortality, 30-day readmission, inpatient costs, and clinical performances by patient satisfaction.

RESULTS: Global patient satisfaction was negatively associated with risk-adjusted 30-day mortality (beta coefficient [β] = –0.39; standard error [SE], 0.16; *P* = .02) and readmission rates (β = –0.30; SE, 0.11; *P* = .006). Satisfaction with discharge information was positively associated with risk-adjusted 30-day mortality rate (β = 0.70; SE, 0.14; *P* <.001) and negatively associated with readmission rate (β = –0.37; SE, 0.09; *P* <.001). Satisfaction with discharge information were positively associated with inpatient management (β = 1.67; SE, 0.43; *P* <.001) and secondary care performance (β = 1.82; SE, 0.47; *P* <.001). The average cost among most satisfied hospitals was $6785, 7.3% higher than that among least satisfied hospitals ($6324). Hospitals with the highest environment satisfaction rating had 7% higher costs compared with the least satisfied hospitals.

CONCLUSIONS: Global patient satisfaction was positively associated with the quality of stroke care; however, improvements in patient satisfaction were linked to higher stroke care costs. In addition, patient satisfaction with discharge information was linked to worse outcomes. As a result, patient satisfaction should be used with caution as a quality indicator for stroke care.

Am J Manag Care. 2017;23(10):e316-e322

With an increasing emphasis on curbing costs while improving healthcare, patient satisfaction has become an essential quality indicator. Patient satisfaction measures are an important component of the Affordable Care Act's financial incentives for hospitals to provide better quality of care.[1] In the Donabedian framework for examining health service and quality, healthcare quality comprises the dimensions of structure, process, and outcomes.[2] Fortunately, the Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS) survey provides an opportunity to capture the patient experience with a variety of quality categories, including environment, communication, pain control, responsiveness, and care continuity in hospitals, allowing us to further explore the role of patient satisfaction in distinct quality aspects.[3]

The HCAHPS measures were built into financial incentives. In 2012, CMS began withholding 1% of reimbursements from hospitals as part of its value-based purchasing (VBP) program. Hospitals are able to earn the payment back by realizing high patient satisfaction scores and care quality standards. Tying patient satisfaction to hospital reimbursements remains controversial, as more satisfied patients do not necessarily receive better medical care or experience superior health outcomes. Moreover, there is a controversy over the efficacy and reliability of patient satisfaction metrics. There is a concern that unnecessary costs may increase in the pursuit of higher scores on these metrics, because doctors may turn to discretional services when their payments are associated with patient satisfaction.[4]

The controversies urged researchers to examine the association between patient satisfaction and healthcare quality in distinct classes of diseases. Stroke is a class of life-threatening cerebrovascular disease that caused 129,000 deaths and cost $20.2 billion in 2010 in the United States.[5] If boosting patient satisfaction can improve stroke care quality without significantly increasing the cost, patients and hospitals will benefit.

So far, empirical studies have studied the association between patient satisfaction and healthcare cost and quality in various diseases. Evidence suggests that hospitals with higher patient

satisfaction scores have lower readmission rates for acute myocardial infarction, heart failure, and pneumonia,[6] and patient satisfaction has also been shown to improve guideline adherence and mortality in acute myocardial infarction.[7] For surgical care, higher patient satisfaction saw shorter inpatient stays and lower readmission and mortality rates.[8] However, higher patient satisfaction was also associated with higher inpatient costs and postdischarge mortality rates on the individual patient level.[4] Moreover, most existing studies have assumed all satisfaction categories to have a similar effect as global satisfaction on care quality. It is well documented that higher global patient satisfaction was associated with better care qualities, yet how the specific aspects of patient satisfaction relate to other structure and process quality measures is still unknown.

TAKEAWAY POINTS

Although previous studies showed that higher patient satisfaction was associated with reduced readmission and mortality rates, it is still not clear whether patient satisfaction can be a quality indicator of stroke care.

- Higher overall patient satisfaction with stroke care was associated with lower readmission and mortality rates.
- Higher patient satisfaction with stroke care discharge information was associated with lower readmission rate and better stroke care performance but higher mortality rates.
- Higher patient satisfaction with stroke care was accompanied by higher costs.

Therefore, we explored the relationship between patient satisfaction and cost, clinical performance, and health outcomes in stroke care at the hospital level. We examined the following research questions: first, whether global satisfaction was associated with better stroke care quality; second, whether the components of satisfaction were independently associated with stroke care performance and outcomes; and finally, we assessed whether improving patient satisfaction resulted in higher stroke care cost and what satisfaction categories accounted for the differences in costs.

METHODS

Data Sources

We obtained hospital-level patient satisfaction measures from the 2015 HCAHPS patient survey database.[9] The average inpatient charges for hospitalized patients who had a stroke came from the 2013 CMS Medicare Provider Cost and Payment Data inpatient file. Outcome measures were selected from the CMS Hospital Compare database, including risk-adjusted 30-day mortality rates and risk-adjusted 30-day unplanned readmission rates. This database was updated between 2014 and 2015 at the time of the study. The clinical performance measures for timely and effective stroke care also came from Hospital Compare database (**eAppendix Table 1** [eAppendices available at **www.ajmc.com**]).[10] We further augmented our data with hospital characteristics from the fiscal year 2016 Inpatient Prospective Payment System final rule file.[11] We obtained the US Census geographic region from the 2014 Area Health Resource File.[12]

Outcome Measures

Health outcomes. Hospital-level mortality and unplanned readmission rates were already adjusted by patient demographic characteristics and CMS condition categories (eAppendix Table 1). Thus, these risk-standardized measures allowed us to compare hospitals with different patient demographics and health status distribution.[13,14]

Cost of acute stroke care. Cost was defined as the cost of care for patients who have had a stroke without major comorbidity. Specifically, we estimated cost by multiplying the charges for Diagnosis-Related Group (DRG) 066 by hospital-specific Cost-to-Charge Ratios (CCRs). We used the CCRs from the fiscal year 2016 file for cost in 2013 because of the 3-year lag period in cost data collection.

Performance measures of stroke care. According to a previous classification of stroke care performance measure, we constructed 3 performance domains, including acute treatment, inpatient management performance, and secondary prevention performance.[15] We generated the domain performance scores (range = 0-100) by averaging the scores of measures that belonged to the same domain (eAppendix Table 1). We used 6 items from a CMS measurement of timely and effective stroke care to indicate clinical performance of stroke care (eAppendix Table 1).[16] "Intravenous thrombolytic therapy" and "patients with atrial fibrillation receiving anticoagulation therapy" were dropped from analysis because of an excessive missing rate (>50%).

Patient Satisfaction

The data from the HCAHPS survey provided us with standardized measures of patient satisfaction with hospital care for all patients at the hospital level and were adjusted for patient-mix and survey mode.[3] CMS classified the HCAHPS survey questions into 2 global items, 2 individual items, and 7 composite measures of patient satisfaction.[9] Patient satisfaction categories in our analyses were selected from this preexisting classification.

The global items were an overall rating of the hospital and the patient's likelihood of recommending the hospital to friends and family. Because these 2 global measures were highly correlated, we only used the recommendation measure for analyses. The patient satisfaction score is the percentage of patients with the highest possible rating on the metric. We averaged the scores in the same category, and then divided these scores into quartiles (eAppendix Table 1).

TABLE 1. Characteristics of Studied Hospitals

Hospital Characteristics	Hospitals With Recorded Cost Information (n = 1422)	Hospitals With Recorded Stroke Outcomes (n = 2530)
Ownership, n (%)		
For-profit	222 (15.61)	463 (18.30)
Nonprofit	1020 (71.73)	1678 (66.32)
Public	179 (12.59)	382 (15.10)
Other	1 (12.59)	7 (0.28)
Regions, n (%)		
Northeast	299 (21.03)	433 (17.11)
Midwest	417 (29.32)	609 (24.07)
South	602 (42.33)	1023 (40.23)
West	104 (7.31)	465 (18.38)
Hospital size, n (%)		
Small	261 (18.35)	561 (22.17)
Middle	436 (30.66)	847 (33.48)
Large	725 (50.98)	1122 (44.35)
Rural, n (%)	216 (15.19)	561 (22.17)
Stroke registry, n (%)	1029 (72.52)	1548 (61.38)
Beds, median (IQR)	235 (149, 365)	176 (102, 306)
Disproportionate share, median (IQR)	0.26 (0.19, 0.33)	0.27 (0.20, 0.35)
Risk-adjusted 30-day mortality rate per 100 patients, median (IQR)	14.70 (13.50, 16.00)	14.70 (13.70, 15.80)
Risk-adjusted 30-day readmission rate per 100 patients, median (IQR)	12.70 (12.00, 13.60)	12.70 (12.00, 13.40)
Cost in US$, median (IQR)	6141(5219, 7246)	–
Acute care performance score, median (IQR)	99.0 (98.0,100.0)	99.0 (98.0,100.0)
Inpatient care performance score, median (IQR)	98.5 (96.0, 99.5)	98.5 (96.0, 99.5)
Secondary care performance, median (IQR)	97.6 (95.0, 99.0)	97.3 (94.2, 99.3)

IQR indicates interquartile range.

Hospital-Level Covariates

Multiple hospital characteristics were included as covariates in the analyses. Hospitals' geographic characteristics included whether they were located in an urban or rural setting and their census region locations (northeast, midwest, west, or south). Teaching status was determined by whether a hospital received a teaching hospital payment adjustment from CMS. Hospital ownership was classified as public, for-profit private, nonprofit private, or other. We classified hospitals as small, medium, or large according to the number of beds, teaching status, and region, following the definition used by the Healthcare Cost and Utilization Project.[17] Disproportionate share hospitals (DSH) were defined by CMS as the sum of the percentage of Medicare and Medicaid days that were attributed to low-income patients who were Supplementary Security Income eligible. We also determined from these data whether or not a hospital participated in a stroke care registry.

Statistical Analysis

We first described the distribution of hospital characteristics in those that reported stroke outcome measures or cost information. Categorical data were presented as counts with percentages and continuous variables were presented as medians with interquartile ranges.

We estimated coefficients (β) and 95% CIs for the association between patient satisfaction and cost, 30-day mortality rate, 30-day readmission rate, and stroke care performance for all hospitals reporting stroke outcome data, using multiple linear regression models. The regression model for cost was performed on hospitals that reported cost information for DRG 066. We applied a log transformation to the cost data. Thus, the β coefficients yielded a percentage difference in cost compared with the reference group. The percentage change of the cost was calculated as $(e^{\beta} - 1) \times 100\%$.

Regression models were adjusted for hospital size, ownership, teaching status, region, rural location, DSH percent, and stroke registry status. For models regarding stroke outcomes, we added stroke performance measures to the adjustment set to examine whether patient satisfaction measures were independently associated with stroke outcomes. To make the results more generalizable to all strokes, even those accompanied by complications and comorbidities, we did a sensitivity analysis combining all stroke DRGs (65 and 66). All statistical analyses were performed using SAS version 9.4 (SAS Institute; Cary, North Carolina).

RESULTS

We identified 2530 hospitals that reported 30-day mortality rates and 30-day readmission rates for stroke and 1422 hospitals that reported an average cost for stroke without major comorbidities and conditions in fiscal year 2013.

Table 1 describes the characteristics of selected hospitals. In hospitals that reported stroke outcomes, 15.1% were publicly owned, 17.1% were located in the northwestern region, 22.2% were small, and 22.2% were located in a rural area. The median 30-day mortality and readmission rate was 14.7 and 12.7 per 100

patients, respectively (interquartile ranges, 2.1 and 1.4, respectively). The median scores for acute treatment, inpatient management, and secondary prevention were 99.0, 98.5, and 97.6 (interquartile ranges, 2.0, 3.5, and 5.1).

Patient Satisfaction and Health Outcomes

We found that the global satisfaction measure ("recommendation of hospital") was related to 30-day outcomes. The 30-day mortality rate comparing the highest quartile to the lowest quartile of global satisfaction was significantly lower (β = 0.39 per 100 patients) (**Table 2**). Similarly, the 30-day readmission rate was also lower in the highest quartile of global satisfaction compared with the lowest quartile (β = 0.34 per 100 patients) (Table 2). The **Figure** (a and b) demonstrated a dose-dependent effect for 30-day readmission across quartiles of global satisfaction, with a negative association between satisfaction and 30-day mortality in the upper 3 quartiles.

Hospitals that ranked the highest in satisfaction with hospital environment had a higher 30-day readmission rate by 0.27 per 100 patients compared with the least satisfied quartile. However, 30-day mortality was not associated with satisfaction with hospital environment. The highest quartile of satisfaction with pain control was associated with lower 30-day mortality rate (β = −0.57 per 100 patients) (Table 2). In contrast, we observed an increase in 30-day mortality rate of 0.70 per 100 patients in the highest quartile of satisfaction with discharge information relative to the lowest quartile. However, readmission rates were lower in hospitals with the highest, versus the lowest, satisfaction with discharge information (β = −0.37 per 100 patients) (Table 2). The full regression results can be found in the **eAppendix Table 2**.

TABLE 2. The Association Between Patient Satisfaction and Cost, Risk-Adjusted 30-Day Mortality, and Risk-Adjusted 30-Day Readmission[a]

	Cost		Risk-Adjusted 30-Day Stroke Mortality Rate		Risk-Adjusted 30-Day Stroke Readmission Rate	
Satisfaction Measures	Beta (SE) n = 1422	*P*	Beta (SE) n = 2530	*P*	Beta (SE) n = 2530	*P*
Global						
Second quartile	0.01 (0.02)	.66	−0.06 (0.1)	.57	−0.09 (0.07)	.19
Third quartile	0 (0.02)	.95	−0.19 (0.13)	.14	−0.12 (0.08)	.14
Highest quartile	0.08 (0.03)	.01	−0.39 (0.16)	.02	−0.30 (0.11)	.006
Environment						
Second quartile	0.02 (0.02)	.22	0.09 (0.09)	.35	0.11 (0.06)	.07
Third quartile	0.05 (0.02)	.02	0.09 (0.11)	.42	0.20 (0.08)	.01
Highest quartile	0.07 (0.03)	.04	0.04 (0.16)	.83	0.27 (0.11)	.01
Communication						
Second quartile	0.01 (0.02)	.66	−0.1 (0.11)	.33	−0.03 (0.07)	.69
Third quartile	−0.03 (0.03)	.26	−0.26 (0.14)	.07	0.04 (0.09)	.68
Highest quartile	−0.03 (0.04)	.43	−0.15 (0.21)	.47	0.23 (0.14)	.10
Pain control						
Second quartile	0.02 (0.02)	.20	−0.24 (0.1)	.02	−0.01 (0.07)	.89
Third quartile	0.04 (0.02)	.11	−0.29 (0.13)	.02	−0.08 (0.08)	.35
Highest quartile	0.01 (0.04)	.71	−0.57 (0.18)	.002	0.03 (0.12)	.83
Staff responsiveness						
Second quartile	−0.03 (0.02)	.14	0.09 (0.1)	.36	−0.12 (0.07)	.07
Third quartile	−0.06 (0.02)	.006	0.11 (0.13)	.36	−0.10 (0.08)	.22
Highest quartile	0.01 (0.04)	.73	0.05 (0.19)	.77	−0.15 (0.12)	.23
Care transition						
Second quartile	0.01 (0.02)	.63	0.09 (0.11)	.38	−0.15 (0.07)	.04
Third quartile	0 (0.03)	.90	0.07 (0.14)	.59	−0.11 (0.09)	.21
Highest quartile	0.01 (0.04)	.84	0.39 (0.19)	.04	−0.21 (0.12)	.09
Discharge information						
Second quartile	−0.03 (0.02)	.15	0.49 (0.09)	<.001	−0.20 (0.06)	.001
Third quartile	−0.04 (0.02)	.05	0.74 (0.12)	<.001	−0.39 (0.08)	<.001
Highest quartile	0.00 (0.03)	.95	0.70 (0.14)	<.001	−0.37 (0.09)	<.001

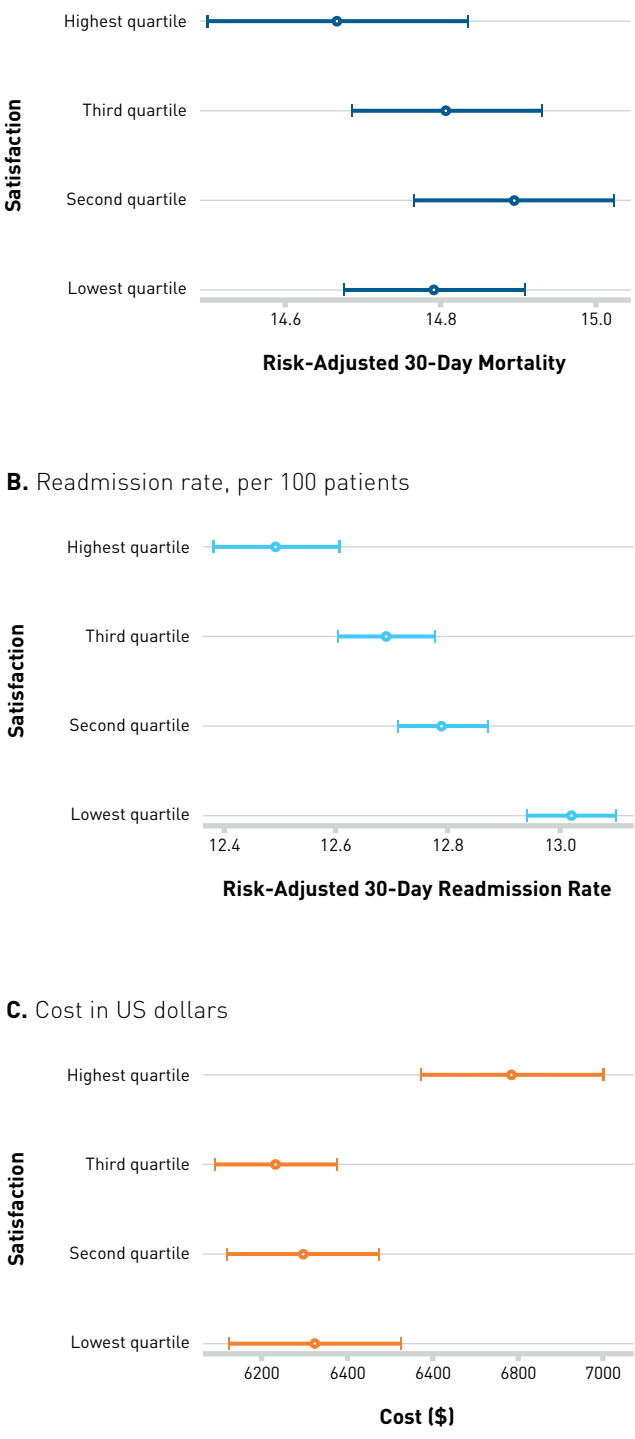
SE indicates standard error.
[a]The lowest quartile was taken as reference group and all models were adjusted for hospital level covariates. The level of significance for *P* values is .05.

Patient Satisfaction and Cost

The average cost in hospitals with the highest global satisfaction was $6785, 7.3% higher than the least satisfied hospitals ($6324) (**Figure** [c]). There is a decreasing trend of cost within the first 3 quartiles of satisfaction, but with no statistical or clinical significance. After adjusting for hospital-level covariates, the cost in hospitals with highest global satisfaction was still 8% higher than the least satisfied hospitals. In addition, compared with hospitals in the least satisfied quartile of environment, the highest quartile had 7% higher costs. Meanwhile, satisfaction with communication, pain control, care transition, and discharge information was not associated with cost (Table 2).

In sensitivity analysis (**eAppendix Table 3**), the hospitals with the highest global satisfaction cost 8% higher than the least satisfied hospitals, even after combining the cost of all patients who had a stroke (with and without major complications).

FIGURE. The Cost of Acute Stroke Care Among Hospitals in Different Quartiles of Global Patient Satisfaction[a]



[a]The measures displayed in the figures are crude numbers without adjustment of hospital characteristics. The average and 95% confidence interval are shown.

Patient Satisfaction and Stroke Care Performance

No association was found between global satisfaction and acute treatment, inpatient management, or secondary prevention performance. Hospitals in the highest quartile of discharge information satisfaction had 1.62 (P <.001) and 1.82 (P <.001) higher scores, on average, with regard to inpatient management and secondary prevention than hospitals in the lowest quartile (**eAppendix Table 4**). Full regression results can be found in **eAppendix Table 5**.

DISCUSSION

Understanding whether patient satisfaction with hospital care is consistent with healthcare quality is critical to current CMS reimbursement policies based on a VBP system.[18] Our findings support the hypothesis that global patient satisfaction can represent the quality of care that hospitals provide. Specifically, we found that the risk-adjusted 30-day mortality rate and readmission rate among patients who have had a stroke decreased, with an increase in global patient satisfaction from the lowest to the highest quartile. Linking patient satisfaction to healthcare quality, our study results suggest that the global patient satisfaction measure is useful for assessing value-based care in the context of stroke.

Our investigation into each satisfaction dimension also challenged the conventional assumptions in existing studies that all satisfaction dimensions have similar effects on care quality. Previous studies found that improving the quality of care continuity, such as care transition, patient education, and discharge planning, was effective in containing unplanned readmission rates.[16] We observed that patient satisfaction with discharge information was associated with a reduced readmission rate. Surprisingly, we also observed higher satisfaction with discharge information associated with higher 30-day mortality rates. A previous systematic review of various diseases showed that discharge planning did not help reduce the mortality rate,[19] leading us to reconsider the role of discharge information in quality improvement.

The results of a recent study show that the hospital-level mortality rates were not associated with the readmission rates, proposing the hypothesis that the 30-day readmission rate and mortality rate are conveying different information about healthcare quality.[17] It should be noted that the 30-day mortality rate was calculated from the moment of inpatient admission and was largely affected by in-hospital care, whereas 30-day readmission rates were calculated only after discharge. There was even an article that casted doubt on the validity of readmission rates, suggesting that it is more an accountability measure than a quality measure.[18] Thus, patient experience measures that are found to be associated with readmission reduction do not necessarily also help to reduce mortality rate.

It is possible that resource abundant hospitals have good quality and accountability and generally have better patient experience. However, hospitals that have to spend substantial efforts on

improving patient education, discharge planning, and outpatient support may have higher patient satisfaction and lower readmission rates; however, such efforts could drive stroke mortality in the opposite direction. In our analysis, patient satisfaction with discharge information was linked to better inpatient management and secondary prophylaxis performance, while the increased performance was not associated with better health outcomes. Thus, the incentive to achieve premium patient experience may be unfair to hospitals that cannot spare enough resources to support all patient satisfaction–promoting activities.

VBP programs are primarily aimed at improving healthcare quality while reducing cost, yet we found that hospitals in the highest quartile of satisfaction provided care that costs 6.9% more than hospitals in the lowest quartile, suggesting that improving patient satisfaction does not help to mitigate inpatient costs. Hospitals that take a large number of patients who have suffered a stroke will spend substantially more money to achieve higher satisfaction. This is an interesting finding, because we observed that the cost rose faster than any improvements in outcomes. The observed improvements in mortality and readmission rates were 3.1% and 2.7%, respectively, which were similar in size to a previous study of patients with acute myocardial infarction, heart failure, and pneumonia.[6] The results of a previous study showed that higher patient satisfaction was linked to higher intensity of inpatient care and drug prescriptions.[4] Yet, these procedures and prescriptions were not necessarily beneficial to patients. This finding suggests that hospitals that invested more money to improve patient satisfaction generated a minimum or even a negative return in stroke care outcome.

Limitations and Strengths

There are several limitations to our study. First, as it is based on CMS data, our results may not be appropriate to generalize to all hospitals because the participating hospitals may be systematically different, in terms of hospital characteristics, compared with nonparticipating hospitals. Another limitation is the ecological design of our study. Our results can only explain the association at the hospital level, not at the patient level. Although we have adjusted for hospital size, teaching status, location, region, and disproportionate share, unobserved factors may still confound our results. For example, hospitals that discharge more patients to their home, rather than a skilled nursing facility, may have higher patient satisfaction and lower readmission rates. Nevertheless, lacking stroke severity information may not be a major confounder because the health outcome measures were risk adjusted in terms of case mix, hospital clustering effect, and comorbidities of patients.[14] The risk adjustment may also explain the lack of variability of mortality and readmission rate among hospitals in our sample. Furthermore, our study cannot determine the direction of causality. HCAHPS surveys were conducted from 48 hours to 6 weeks after discharge. It could be possible that some patients reported low satisfaction because they experienced unfavorable health outcomes during the time after discharge. Finally, without an indicator of stroke severity, we can only provide the evidence of association, instead of causality, between patient satisfaction and stroke care cost.

Despite the limitations, our study also has some strengths. To extend our ability to extrapolate our conclusions to a broader definition of stroke cases, we conducted a sensitivity analysis. In those analyses, global patient satisfaction remained associated with an increased cost of care. In addition, we used both CCR and hospital charge to estimate cost. Specifically, we estimated cost by multiplying the charges for DRG 066 by hospital-specific cost-to-charge ratios. Although we do not have information of the real costs that were incurred, previous researchers have verified that using the CCR produces estimates closest to providers' actual costs.[20-22] There are many other ways to estimate cost, such as using the CMS payments or hospital charges; however, these methods are also subject to limitations. The CMS payments were the reimbursements to the hospitals after adjusting the costs by regional, hospital, and individual characteristics according to published policies.[11] With hospital-level aggregated data, we were not able to disentangle policy adjustment and the real cost from the payments. The charges were the list prices marked by the hospitals, which were usually much higher than the real cost.[23] Thus, standardizing charges by CCR was the best approximation of cost in this context.

CONCLUSIONS

Our study provided important knowledge on the relationship between patient satisfaction and healthcare quality in stroke care. Higher global patient satisfaction scores were associated with improved readmission and mortality rates while discharge information satisfaction domains produced mixed evidence. Our analysis also suggests that improving patient satisfaction will lead to higher stroke care costs and the associated improvements observed in stroke outcomes may not be cost-effective. ■

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Source of Funding: None.

Author Disclosures: The authors report no relationship or financial interest with any entity that would pose a conflict of interest with the subject matter of this article.

Authorship Information: Concept and design (XX, WYX); acquisition of data (XX); analysis and interpretation of data (XX, WYX); drafting of the manuscript (XX, WYX); critical revision of the manuscript for important intellectual content (XX, WYX, REF); statistical analysis (XX); administrative, technical, or logistic support (REF); and supervision (WYX, REF).

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eAppendix

Table 1. Outcome, Quality and Patient Satisfaction Measures Specification

Selected Measures	**Descriptions**
Health Outcomes	
Mortality	Risk-adjusted 30-day mortality rate
Readmission	Risk-adjusted 30-day readmission rate
Clinical Performance	
Acute treatment performance	Antithrombotic therapy by end of hospital day 2
Inpatient management performance	Deep vein thromboembolism prophylaxis
	Assessed for rehabilitation
Secondary prevention performance	Discharge on thrombolytic therapy
	Discharged on cholesterol-reducing medication
	Stroke education
Patient satisfactions	
Global Satisfaction	Recommend the hospital
Satisfaction with environment	Hospital cleanness
	Hospital quietness
Satisfaction with communication	Communication with nurses
	Communication with doctors
	Communication of medicine
Satisfaction with pain control	Pain control
Satisfaction with responsiveness	Responsiveness of hospital staff
Satisfaction with discharge information	Discharge information
Satisfaction with care transition	Care transition

[a]Clinical performance measures were selected from the "timely and effective care" domain of CMS hospital compare data. "Intravenous thrombolytic therapy" and "patients with atrial fibrillation receiving anticoagulation therapy" were not included due to a large proportion (>50%) of missing data.

Table 2. Full regression results of patient satisfaction on risk-adjusted 30-Day Mortality and Risk-Adjusted 30-Day Readmission

Explanatory Variables	**Risk-adjusted 30-day stroke mortality rate**		**Risk-adjusted 30-day stroke Readmission rate**	
	Beta (SE) N=2530	**P value**	**Beta (SE) N=2530**	**P value**
INTERCEPT	14.33 (0.99)	<0.001	13.6 (0.66)	<0.001
COVARIATES				
Rural	0.31 (0.11)	0.006	-0.25 (0.07)	0.001
Teaching	0.42 (0.08)	<0.001	0.23 (0.05)	<0.001
Hospital Ownership				
Non-for Profit	-0.27 (0.10)	0.008	0.09 (0.07)	0.18
For Profit	-0.29 (0.12)	0.02	0.11 (0.08)	0.16
Other	-1.00 (0.74)	0.18	0.12 (0.49)	0.80
Public	Reference	-	Reference	-
Hospital Size				
Small	-0.23 (0.10)	0.02	-0.26 (0.07)	<0.001
Middle	-0.05 (0.08)	0.53	-0.18 (0.05)	0.001
Large	Reference	-	Reference	-
Regions				
Midwest	0.30 (0.11)	0.007	-0.33 (0.07)	<0.001
South	0.59 (0.11)	<0.001	-0.22 (0.07)	0.003
West	0.65 (0.12)	<0.001	-0.66 (0.08)	<0.001
Northwest	Reference	-	Reference	-
Registered Stroke Center	-0.09 (0.08)	0.29	0.08 (0.05)	0.15
DSH Patient Percent	-0.36 (0.25)	0.16	0.81 (0.17)	<0.001
Acute Treatment	0.00 (0.01)	0.74	-0.01 (0.01)	0.32
Inpatient Management	0.01 (0.01)	0.25	0.00 (0.01)	0.46
Secondary Prevention	-0.01 (0.01)	0.34	0.00 (0.01)	0.68
SATISFACTION				
Global				
Second quartile	-0.06 (0.1)	0.57	-0.09 (0.07)	0.19
Third quartile	-0.19 (0.13)	0.14	-0.12 (0.08)	0.14
Highest quartile	-0.39 (0.16)	0.02	-0.30 (0.11)	0.006
Environment				
Second quartile	0.09 (0.09)	0.35	0.11 (0.06)	0.07
Third quartile	0.09 (0.11)	0.42	0.20 (0.08)	0.01
Highest quartile	0.04 (0.16)	0.83	0.27 (0.11)	0.01

Communication				
Second quartile	-0.1 (0.11)	0.33	-0.03 (0.07)	0.69
Third quartile	-0.26 (0.14)	0.07	0.04 (0.09)	0.68
Highest quartile	-0.15 (0.21)	0.47	0.23 (0.14)	0.10
Pain control				
Second quartile	-0.24 (0.1)	0.02	-0.01 (0.07)	0.89
Third quartile	-0.29 (0.13)	0.02	-0.08 (0.08)	0.35
Highest quartile	-0.57 (0.18)	0.002	0.03 (0.12)	0.83
Staff responsiveness				
Second quartile	0.09 (0.1)	0.36	-0.12 (0.07)	0.07
Third quartile	0.11 (0.13)	0.36	-0.10 (0.08)	0.22
Highest quartile	0.05 (0.19)	0.77	-0.15 (0.12)	0.23
Care transition				
Second quartile	0.09 (0.11)	0.38	-0.15 (0.07)	0.04
Third quartile	0.07 (0.14)	0.59	-0.11 (0.09)	0.21
Highest quartile	0.39 (0.19)	0.04	-0.21 (0.12)	0.09
Discharge information				
Second quartile	0.49 (0.09)	<0.001	-0.20 (0.06)	0.001
Third quartile	0.74 (0.12)	<0.001	-0.39 (0.08)	<0.001
Highest quartile	0.70 (0.14)	<0.001	-0.37 (0.09)	<0.001

Note: The lowest quartile was taken as reference group. The level of significance for P values is 0.05.

Table 3. The Full Regression Results of the Sensitivity Analysis for Patient Satisfaction and Stroke Care Costs

Explanatory variables	**DRG 66**		**All stroke DRGs**	
	Beta (SE) N=1800	**P value**	**Beta (SE) N=1800**	**P value**
INTERCEPT	8.81 (0.04)	<0.001	8.92 (0.04)	<0.001
COVARIATES				
Rural	-0.08 (0.02)	<0.001	-0.04 (0.02)	0.05
Teaching	-0.02 (0.01)	0.12	-0.02 (0.02)	0.25
Hospital Ownership				
Non-for Profit	-0.04 (0.02)	0.07	-0.05 (0.02)	0.01
For Profit	-0.11 (0.02)	<0.001	-0.11 (0.02)	<0.001
Other	-0.01 (0.23)	0.96	0.02 (0.16)	0.89
Public	Reference	-	Reference	-
Hospital Size				
Small	0.00 (0.02)	0.91	0.01 (0.02)	0.57
Middle	-0.01 (0.01)	0.41	-0.01 (0.02)	0.42
Large	Reference	-	Reference	-
Regions				
Midwest	-0.14 (0.02)	<0.001	-0.16 (0.02)	<0.001
South	-0.26 (0.02)	<0.001	-0.27 (0.02)	<0.001
West	-0.10 (0.03)	<0.001	-0.15 (0.03)	<0.001
Northwest	Reference	-	Reference	-
Registered Stroke Center	0.05 (0.02)	<0.001	0.07 (0.02)	<0.001
DSH Patient Percent	0.33 (0.05)	<0.001	0.37 (0.05)	<0.001
SATISFACTION				
Global				
Second quartile	0.01 (0.02)	0.66	0.02 (0.02)	0.35
Third quartile	0.00 (0.02)	0.95	0.00 (0.02)	0.87
Highest quartile	0.08 (0.03)	0.01	0.08 (0.03)	0.009
Environment				
Second quartile	0.02 (0.02)	0.22	0.02 (0.02)	0.33
Third quartile	0.05 (0.02)	0.02	0.04 (0.02)	0.05
Highest quartile	0.07 (0.03)	0.04	0.05 (0.03)	0.10
Communication				
Second quartile	0.01 (0.02)	0.66	0.00 (0.02)	0.94
Third quartile	-0.03 (0.03)	0.26	-0.02 (0.03)	0.44

Highest quartile	-0.03 (0.04)	0.43	-0.03 (0.04)	0.49
Pain control				
Second quartile	0.02 (0.02)	0.20	0.01 (0.02)	0.62
Third quartile	0.04 (0.02)	0.11	0.01 (0.02)	0.55
Highest quartile	0.01 (0.04)	0.71	-0.01 (0.04)	0.88
Staff responsiveness				
Second quartile	-0.03 (0.02)	0.14	-0.02 (0.02)	0.30
Third quartile	-0.06 (0.02)	0.006	-0.04 (0.02)	0.11
Highest quartile	0.01 (0.04)	0.73	0.02 (0.04)	0.54
Care transition				
Second quartile	0.01 (0.02)	0.63	0.01 (0.02)	0.48
Third quartile	0.00 (0.03)	0.90	0.03 (0.03)	0.34
Highest quartile	0.01 (0.04)	0.84	0.05 (0.04)	0.20
Discharge information				
Second quartile	-0.03 (0.02)	0.15	-0.03 (0.02)	0.1
Third quartile	-0.04 (0.02)	0.05	-0.06 (0.02)	0.006
Highest quartile	0.00 (0.03)	0.95	-0.02 (0.03)	0.41

Note: The lowest quartile was taken as reference group. The level of significance for P values is 0.05.

Table 4. The Association Between Patient Satisfaction and Acute, Inpatient, and Secondary Stroke Care Performance

Satisfaction Measures	**Acute Treatment Performance**		**Inpatient Management Performance**		**Secondary Prevention Performance**	
	Beta (SE) N=2530	***P***	**Beta (SE) N=2530**	***P***	**Beta (SE) N=2530**	***P***
Global						
Second quartile	0.04 (0.25)	0.87	0.07 (0.32)	0.84	0.33 (0.35)	0.34
Third quartile	0.14 (0.31)	0.66	0.5 (0.39)	0.2	0.75 (0.43)	0.08
Highest quartile	-0.05 (0.4)	0.89	0.16 (0.5)	0.75	0.15 (0.55)	0.78
Environment						
Second quartile	0.43 (0.22)	0.05	0.35 (0.29)	0.22	0.75 (0.31)	0.01
Third quartile	0.44 (0.28)	0.11	0.44 (0.35)	0.21	0.56 (0.38)	0.14
Highest quartile	-0.23 (0.39)	0.56	0.02 (0.5)	0.97	0.38 (0.55)	0.49
Communication						
Second quartile	-0.01 (0.26)	0.98	0.1 (0.33)	0.77	0.12 (0.36)	0.74
Third quartile	0.06 (0.34)	0.86	-0.07 (0.44)	0.86	-0.09 (0.48)	0.86
Highest quartile	0.88 (0.51)	0.08	0.16 (0.64)	0.8	0.48 (0.7)	0.5
Pain control						
Second quartile	-0.11 (0.24)	0.64	-0.43 (0.3)	0.16	-0.36 (0.33)	0.27
Third quartile	0.03 (0.30)	0.93	-0.26 (0.38)	0.49	0.08 (0.42)	0.85
Highest quartile	0.13 (0.44)	0.78	-0.21 (0.56)	0.71	0.89 (0.61)	0.15
Staff responsiveness						
Second quartile	0.43 (0.24)	0.07	0.7 (0.3)	0.02	0.35 (0.33)	0.28
Third quartile	0.11 (0.30)	0.72	0.45 (0.38)	0.24	-0.06 (0.42)	0.89
Highest quartile	-0.59 (0.45)	0.19	0.13 (0.57)	0.82	-0.51 (0.62)	0.41
Care transition						
Second quartile	0.03 (0.26)	0.91	-0.31 (0.33)	0.35	-0.03 (0.36)	0.92
Third quartile	0.07 (0.33)	0.83	-0.14 (0.42)	0.75	0.02 (0.46)	0.97
Highest quartile	0.35 (0.45)	0.44	0.41 (0.57)	0.47	0.28 (0.62)	0.65
Discharge information						
Second quartile	0.12 (0.22)	0.58	0.98 (0.29)	0.001	1.11 (0.31)	<0.001
Third quartile	0.39 (0.28)	0.15	1.35 (0.35)	<0.001	1.46 (0.38)	<0.001
Highest quartile	0.44 (0.34)	0.20	1.67 (0.43)	<0.001	1.82 (0.47)	<0.001

SE indicates standard error.

Note: The lowest quartile was taken as reference group and all models were adjusted for hospital level covariates. The level of significance for *P* values is 0.05.

Table 5. The Full Regression Results Between Patient Satisfaction and Acute, Inpatient, and Secondary Stroke Care Performance

Explanatory Variables	**Acute treatment performance**		**Inpatient management performance**		**Secondary prevention performance**	
	Beta (SE) N=2530	**P value**	**Beta (SE) N=2530**	**P value**	**Beta (SE) N=2530**	**P value**
INTERCEPT	97.75 (0.47)	<0.001	93.92 (0.6)	<0.001	91.92 (0.66)	<0.001
COVARIATES						
Rural	-0.52 (0.27)	0.05	-1.38 (0.34)	<0.001	-2.06 (0.37)	<0.001
Teaching	0.29 (0.20)	0.15	0.94 (0.25)	<0.001	0.54 (0.27)	0.05
Hospital Ownership						
Non-for Profit	0.83 (0.24)	0.001	0.93 (0.31)	0.003	0.85 (0.33)	0.01
For Profit	1.26 (0.29)	<0.001	1.98 (0.37)	<0.001	2.60 (0.40)	<0.001
Other	2.33 (1.63)	0.15	2.15 (1.94)	0.27	3.21 (2.47)	0.19
Public						
Hospital Size						
Small	-0.81 (0.24)	0.001	-1.36 (0.31)	<0.001	-1.21 (0.34)	<0.001
Middle	-0.27 (0.19)	0.16	-0.70 (0.25)	0.005	-0.77 (0.27)	0.004
Large						
Regions						
Midwest	-1.00 (0.27)	<0.001	-0.05 (0.34)	0.89	-0.42 (0.37)	0.26
South	-0.63 (0.27)	0.02	-0.13 (0.34)	0.72	-0.21 (0.37)	0.57
West	-0.27 (0.29)	0.35	0.10 (0.36)	0.79	-0.18 (0.40)	0.65
Northwest						
Registered Stroke Center	0.42 (0.19)	0.03	1.78 (0.24)	<0.001	2.95 (0.26)	<0.001
DSH Patient Percent	-1.81 (0.61)	0.003	-0.55 (0.78)	0.48	-0.75 (0.85)	0.37
Global						
Second quartile	0.04 (0.25)	0.87	0.07 (0.32)	0.84	0.33 (0.35)	0.34
Third quartile	0.14 (0.31)	0.66	0.5 (0.39)	0.2	0.75 (0.43)	0.08

Highest quartile	-0.05 (0.4)	0.89	0.16 (0.5)	0.75	0.15 (0.55)	0.78
Environment						
Second quartile	0.43 (0.22)	0.05	0.35 (0.29)	0.22	0.75 (0.31)	0.01
Third quartile	0.44 (0.28)	0.11	0.44 (0.35)	0.21	0.56 (0.38)	0.14
Highest quartile	-0.23 (0.39)	0.56	0.02 (0.5)	0.97	0.38 (0.55)	0.49
Communication						
Second quartile	-0.01 (0.26)	0.98	0.1 (0.33)	0.77	0.12 (0.36)	0.74
Third quartile	0.06 (0.34)	0.86	-0.07 (0.44)	0.86	-0.09 (0.48)	0.86
Highest quartile	0.88 (0.51)	0.08	0.16 (0.64)	0.8	0.48 (0.7)	0.5
Pain control						
Second quartile	-0.11 (0.24)	0.64	-0.43 (0.3)	0.16	-0.36 (0.33)	0.27
Third quartile	0.03 (0.30)	0.93	-0.26 (0.38)	0.49	0.08 (0.42)	0.85
Highest quartile	0.13 (0.44)	0.78	-0.21 (0.56)	0.71	0.89 (0.61)	0.15
Staff responsiveness						
Second quartile	0.43 (0.24)	0.07	0.7 (0.3)	0.02	0.35 (0.33)	0.28
Third quartile	0.11 (0.30)	0.72	0.45 (0.38)	0.24	-0.06 (0.42)	0.89
Highest quartile	-0.59 (0.45)	0.19	0.13 (0.57)	0.82	-0.51 (0.62)	0.41
Care transition						
Second quartile	0.03 (0.26)	0.91	-0.31 (0.33)	0.35	-0.03 (0.36)	0.92
Third quartile	0.07 (0.33)	0.83	-0.14 (0.42)	0.75	0.02 (0.46)	0.97
Highest quartile	0.35 (0.45)	0.44	0.41 (0.57)	0.47	0.28 (0.62)	0.65
Discharge information						
Second quartile	0.12 (0.22)	0.58	0.98 (0.29)	0.001	1.11 (0.31)	<0.001
Third quartile	0.39 (0.28)	0.15	1.35 (0.35)	<0.001	1.46 (0.38)	<0.001
Highest quartile	0.44 (0.34)	0.20	1.67 (0.43)	<0.001	1.82 (0.47)	<0.001

Note: The lowest quartile was taken as reference group. The level of significance for P values is 0.05.