RESEARCH ARTICLE

Correlation between hospital finances and quality and safety of patient care

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Abstract

Background

Hospitals under financial pressure may struggle to maintain quality and patient safety and have worse patient outcomes relative to well-resourced hospitals. Poor predictive validity may explain why previous studies on the association between finances and quality/safety have been equivocal. This manuscript employs principal component analysis to produce robust measures of both financial status and quality/safety of care, to assess our *a priori* hypothesis: hospital financial performance is associated with the provision of quality care, as measured by quality and safety processes, patient outcomes, and patient centered care.

Methods

This 2014 cross-sectional study investigated hospital financial condition and hospital quality and safety at acute care hospitals. The hospital financial data from the Centers for Medicare and Medicaid Services (CMS) cost report were used to develop a composite financial performance score using principal component analysis. Hospital quality and patient safety were measured with a composite quality/safety performance score derived from principal component analysis, utilizing a range of established quality and safety indicators including: risk-standardized inpatient mortality, 30-day mortality, 30-day readmissions for select conditions, patient safety indicators from inpatient admissions, process of care chart reviews, CMS value-based purchasing total performance score and patient experience of care surveys. The correlation between the composite financial performance score and the composite quality/safety performance score was calculated using linear regression adjusting for hospital characteristics.

Results

Among the 108 New York State acute care facilities for which data were available, there is a clear relationship between hospital financial performance and hospital quality/safety performance score (standardized correlation coefficient 0.34, p<0.001). The composite financial performance score is also positively associated with the CMS Value Based Purchasing Total Performance Score (standardized correlation coefficient 0.277, p = 0.002); while it is

negatively associated with 30 day readmission for all outcomes (standardized correlation coefficient -0.236, p = 0.013), 30-day readmission for congestive heart failure (standardized correlation coefficient -0.23, p = 0.018), 30 day readmission for pneumonia (standardized correlation coefficient -0.209, p = 0.033), and a decrease in 30-day mortality for acute myocardial infarction (standardized correlation coefficient -0.211, p = 0.027). Used alone, operating margin and total margin are poor predictors of quality and safety outcomes.

Conclusions

Strong financial performance is associated with improved patient reported experience of care, the strongest component distinguishing quality and safety. These findings suggest that financially stable hospitals are better able to maintain highly reliable systems and provide ongoing resources for quality improvement.

Background/Introduction

Is the financial status of a hospital related to the quality and safety of care delivered? While this simple and straightforward question has attracted considerable attention, it has been remarkably difficult to answer. Efforts to control the high costs of health care in the United States presuppose hospitals can do more with less. Hospitals face considerable pressure to lower costs while maintaining quality outcomes [1, 2]. Initiatives to financially incentivize quality, such as public reporting and value-based payment (VBP), will succeed in improving population health for all only if they are designed to account for the complicated relationship between quality and facility financial stability. Otherwise, these programs run the risk of perpetuating the "rich get richer" history of the American health care system and will continue to penalize safety net hospitals and their underserved populations[3]

Prior literature suggests that some aspects of patient care may be compromised as a hospital's financial condition declines [4–11]. Studies directly examining the correlation between financial status and quality and safety of patient care, however, have been equivocal and the findings uncertain. Lack of clear associations may be due to the poor predictive validity of the measures of finances and of quality. When considering financial performance, many financial distress models relied on specific indicators of stress, including bankruptcy and closure data, which are easier to obtain but do not represent the range of financial health [12]. Other studies used only narrow measures of hospital financial performance (e.g., operating margin), which do not capture the full range of revenue potentially available for investment in quality improvements [13]. Concerning quality performance, studies have generally focused on specific outcomes, such as mortality, or hospital readmission from conditions such as pneumonia, heart failure, or myocardial infarction [14–17]. The expansion of public reporting by the Centers for Medicare and Medicaid Services (CMS), as part of VBP, has widened the pool of measures available for quality analysis.[14, 18].

While most previous studies have used limited approaches in describing the abstract measures representing hospital financial health and quality of care, this paper considers an entire profile of financial characteristics and patient quality and safety measures. We hypothesize that robust measurement of these financial measures and quality and safety measures improve the likelihood of observing the relationship between poor financial health and inferior hospital quality of care and patient safety. We attempted to determine whether a composite financial indicator derived from a machine learning methodology (principle component analysis)

would outperform already established financial indicators used in the literature in examining the correlation with quality and safety of patient care. In the next section, we present a conceptual framework and the contribution of our analysis, followed by summarization of several studies that have assessed issues relevant to the ones we are examining. This is followed by a discussion of study methods and measures and concludes with the presentation of results and policy implications.

Conceptual framework

The hypothesis which posits that financial status and quality/safety are linked has strong construct validity. Profitable hospitals with strong cash flows can pay off debt quicker, which allows them to further invest in capital at lower costs than cash-strapped hospitals. With more capital, these facilities can make sizeable investments in clinical and administrative information technology and monitoring systems, hire better qualified staff, sustain ongoing training programs, initiate evidence-based clinical protocols and quality improvement projects, with the goal and outcome of attracting more market share and increasing profits.[19–21] Financial distress may stem from exogenous factors, such as policy changes or local economy, while it also may be attributable to internal or efficiency issues, such as inferior services or poor management.[19, 20] Given that activities to improve hospital quality and patient safety can entail substantial costs, it is presumed that hospitals facing greater financial pressure from inadequate revenues will limit quality improvements as financial performance declines.[22] A record of hospital financial losses likely will also reduce access to capital and raise the costs of borrowing, further hindering the facility.[23, 24] Previous studies support this expectation, demonstrating declines in hospital staffing, infrastructure investment and critical process of care measures, when financial pressure mounts.[25, 26] Existing literature suggests that the lack of resources prevents safety net facilities from investing in care-improvement initiatives, which can lead to higher rates of mortality and morbidity.[27, 28] These facilities have also been shown to provide costly and overpriced care due to inefficient systems and staffing, all of which have been shown to negatively impact patient care and increase length of hospital stay. [29–32]

Value-based payment initiatives are designed to provide direct return on investment (ROI) for improved outcomes, but often presumes all facilities have comparable baseline financial resources to invest in quality improvement (QI). Actions to install QI can require significant upfront resources, and often requires already having robust financial health to engage in such initiatives.[33, 34] Additionally, many VBP initiatives target specific patient groups and specific outcomes, raising concern about disparity in investment in QI among different inpatient populations. Like VBP, public reporting of quality data is intended to incentivize improvement through connecting consumer choice to quality. Public reporting has the potential to influence reputation and, in turn, affect patient perceptions, demand for hospital services, and market share.[35, 36] Despite general support for public reporting and pay for performance initiatives, critics worry that such efforts may have a deleterious effect on safety-net providers struggling with lower reimbursement rates and higher costs associated with caring for populations with greater medical complications and socioeconomic impediments [37–39]. There is concern that these initiatives negatively target safety-net hospitals with limited resources for quality improvement programs and infrastructure.[40, 41]

In this study, we aim to answer the question of whether quality and patient safety metrics are related to hospital financial performance by examining various measures of financial performance and multiple indicators of patient quality of care and patient safety. This study is unique in that we used principal component analysis to combine multiple measures into

meaningful predictive models, while creating composite and robust measures that are more discriminating in detecting differences in performance across hospitals for both our independent variable of financial health and our dependent variables measuring hospital quality and patient safety.

Literature review

When considering the financial health of hospital facilities, varying financial indicators measuring profitability, liquidity, and solvency represent significant markers of financial health; however, discerning financial health is complicated among hospitals and it is difficult to rank the numerous indicators by importance or predictive power. Additionally, individual indicators do not necessarily capture all aspects of hospital financial health, and their order of importance is unclear since varying studies cite different measures as being the most effective indication of impending fiscal problems. [19, 42–44] Limitations of past studies include utilization of financial data that focused only on specific populations (e.g. Medicare patients), the outsized influence of facilities at the extremes of financial performance, and the employment of gross metrics such as operating margin and total margin. [45–50] Using these limited approaches, several studies have found that poor hospital financial health may lead to increased negative outcomes for some publicly reported outcomes and not others. The equivocal findings are difficult to interpret because hospital margins may be misleading indicators of financial health, and negative margin or net loss are not the sole predictors of financial distress. For instance, despite positive margins, some hospitals may have insufficient liquid assets to meet all current or future obligations surrounding quality improvement. Revenues might be underestimated because of the absence of nonoperating transfers, income from grants, loan forgiveness, or other exclusions from typical accounting reports.[51] Therefore, it is important to consider a range of financial dimensions including measures surrounding liquidity, financial leverage, and physical facilities. Wider ranging financial data that better depicts a hospitals financial health are publicly reported and available at state and federal agencies. This work shows the value of looking beyond the limited measures of hospital financial health previously utilized.

Similarly, quality and safety measures included in previous studies have been limited based on 1) use of distal outcomes such as mortality; 2) including only specific patient populations such as Medicare patients; and 3), including only select conditions, most commonly heart attack (AMI), congestive heart failure (CHF), and pneumonia (PN).[14, 17, 18, 45, 49, 52] These three conditions (AMI, CHF, PN) are among the most common causes of hospitalizations for the US population overall, particularly the elderly. There is scientific evidence supporting associations between mortality and readmission for these conditions with specific clinical care processes, leading to use of these indicators to measure provision of consistent quality of care for these conditions.[53] These mortality and readmission indicators have been used as proxies for hospital quality in many prior research articles.[18, 41, 52–56]

Several quality and safety indicators are now publicly reported, including CMS Hospital Compare VBP Total Performance Score (VBP-TPS) and a Five-Star hospital rating system (https://www.medicare.gov/hospitalcompare/Data/Hospital-overall-ratings-calculation.html). These measures, however, were designed for the specific purpose of payment reform and may not be ideal for research purposes. The VBP-TPS includes cost efficiency and year-by-year quality improvement, which may introduce confounding by past financial performance. Cefalu et al. recently reported use of principal component analysis across 25 hospital quality measures, concluding that four factors representing patient experience of care, select process of care measures, and inpatient mortality demonstrated the multidimensionality of hospital quality. [57]

Methods

Population

The study population included general medical/surgical hospitals in New York State (NYS) that participated in the Centers for Medicare and Medicaid Services (CMS) inpatient prospective payment system. All facilities included in this study provided a broad enough range of services to ensure availability of sufficient quality of care indicators and had financial data available in 2014. These requirements lead to the exclusion of specialty hospitals, federal hospitals, and some small hospitals providing limited services (e. g. critical care hospitals). In the situation where there were multiple hospitals in the same network, ancillary facilities without independent financial information from a principal facility were excluded from the analysis. All general medical/surgical hospitals in NYS are nonprofit or government owned.

This study was approved by the NYS Department of Health (NYSDOH) Institutional Review Board (IRB). Informed consent was not required for health services research of administrative health records. Patients were not contacted.

Measurement of hospital quality of care and patient safety

A total of 46 indicators of quality of care and patient safety were incorporated into a composite measure, covering four domains: (1) inpatient quality, (2) patient safety, (3) process of care, and (4) patient experience of care. We call this measure the composite quality/safety performance score.

The inpatient quality domain included two Inpatient Quality Indicators (IQIs) developed by the Agency for Healthcare Research and Quality (AHRQ) and endorsed by the National Quality Forum (NQF): risk adjusted heart failure mortality rate (IQI 16) and risk adjusted pneumonia mortality rate (IQI 20). The IQI mortality rates were obtained from the NYSDOH Open Data website and based on the NYS Statewide Planning and Research Cooperative System (SPARCS) inpatient discharge data for 2014 [accessioned March 27, 2018, IQI version 5.0, March 2015].[58, 59]

The patient safety domain was assessed using 11 AHRQ Patient Safety Indicators (PSIs), also based on SPARCS data from 2014 obtained from the NYSDOH Open Data website [accessioned March 27, 2018, PSI version 6.0, September 2015].[59] The domain encompassed six measures of perioperative and postoperative adverse events. These events included postoperative hip fracture (PSI 08), perioperative hemorrhage or hematoma (PSI 09), postoperative physiologic and metabolic derangements (PSI 10), postoperative respiratory failure (PSI 11), perioperative pulmonary embolism or deep vein thrombosis (PSI 12), postoperative wound dehiscence (PSI 14), pressure ulcers (PSI 03), iatrogenic pneumothorax (PSI 06), central venous catheter-related bloodstream infection (PSI 07), accidental puncture or laceration (PSI 15), and deaths among patients with low-mortality diagnoses (PSI 02). These PSIs, except for PSI 10, are either NQF endorsed or included in the NQF endorsed composite PSI.

The process of care (also known as timely and effective strategies) domain was compiled from the CMS Hospital Inpatient Quality Reporting (IQR) Program indicators derived from chart reviews [accessioned March 27, 2018, HQA 2007, year of admission = 2014]. For each hospital, 21 process of care indicators contributed to the calculation of the composite quality/safety performance score. The five process of care categories include: emergency department throughput (six indicators), preventive care (six indicators), surgical care improvement (six indicators), pneumonia care (two indicators), and stroke care (one indicator).

The Patient Experience of Care domain was assessed via the Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS) Patient's Perspectives of Care Survey, a

nationally standardized publicly reported survey utilized for measuring patients' perceptions of their hospital experience. [60] Eleven HCAHPS measures are publicly reported measures on the Hospital Compare website, including six composite topics, two individual items, and three global items. Composite topics include communication with doctors, communication with nurses, responsiveness of hospital staff, pain management, communication about medications, and discharge information. Individual items include cleanliness and quietness of the hospital environment, while global items include overall rating of the hospital, willingness to recommend the hospital, and care transition—patient understanding of their care at discharge. The 11 measures included in this submission have been endorsed since 2006 and results have been tied to hospital pay for reporting since 2007, and used in pay for performance and VBP since 2012.[61] Survey response rates for hospitals in our analysis range from 10% to 52%. The varying and often low response rates between hospitals led us to perform a sensitivity analysis of our findings with and without the patient experience measures (accessioned March 27, 2018, hospital compare. Data was used from the measure start date of 04/01/2014 till 03/31/2015). [61]

In addition to the four-domain based composite, several individual quality indicators were included in the analysis with a view to performing analysis comparable with published literature. These included the 2014 CMS Value Based Purchasing Total Performance Score (VBP-TPS), all-cause risk-adjusted 30-day readmission and 30-day mortality among adults, as well as risk-adjusted 30-day readmission and 30-day mortality for acute myocardial infarction (AMI), congestive heart failure (HF) and pneumonia (PN). The readmission measures, endorsed by the NQF, were obtained from the Hospital Inpatient Quality Reporting Program during calendar year 2014, and are available on the Hospital Compare website (http://www.hospitalcompare.hhs.gov). NQF endorsements have included the consideration of condition-specific readmission and mortality measures since April 2012 (http://www.qualityforum.org/ProjectDescription.aspx?projectID=73619).

Measurement of hospital composite financial performance

We examined financial performance using data from CMS costs reports for the 2014 fiscal year and generated a continuous hospital composite financial performance score for each hospital based on a combination of financial measures.[62] Thus, our analyses considered multiple measures of financial health including operating profit or loss, net profit margin, return on total assets, cash flow margin, working capital, current ratio, days cash on hand, net asset position, equity financing, fixed asset financing, debt coverage, total debt ratio, long term debt ratio, salary ratio, total asset turnover, average operating margin and average total margin. These indicators were used to create a composite financial performance score. The CMS cost report data was obtained from the NYSDOH, although comparable data is publicly available from CMS. NYSDOH data were used due to ease of access.

Hospital characteristics and covariates

To describe the hospitals studied and to adjust for potential confounding that may influence the financial performance of hospitals, the following hospital characteristics were utilized: teaching status, bed count, proportion of discharges with Medicare as a payer (Percent-Medicare), proportion of discharges with Medicaid as a payer (Percent-Medicaid), and rural versus urban geography.

Consistent with other research all hospitals were placed into one of three categories based on their response to the American Hospital Association (AHA) survey: major teaching hospitals (those that are members of the Council of Teaching Hospitals [COTH]), minor teaching

hospitals (non-COTH members that had a medical school affiliation reported to the American Medical Association), and nonteaching hospitals (all other institutions) [63, 64]. Bed count assesses the number of short-term acute beds in the hospital, whether staffed or not, obtained from the AHA Annual Survey of Hospitals (Retrieved March 4th, 2016; https://www.ahadataviewer.com/quickreport/). Annual Medicare caseload was defined as the proportion of Medicare discharges divided by the total number of discharges, based on 2014 SPARCS data. Similarly, annual Medicaid caseload was defined as the proportion of Medicaid discharges divided by the total number of discharges based on 2014 SPARCS data. A hospital was considered urban if it was located in a metropolitan statistical area considered nonurban otherwise. This information was obtained from the AHA Annual Survey of Hospitals (Retrieved March 4th, 2016; https://www.ahadataviewer.com/quickreport/).

Statistical analyses

Hospital level composite quality/safety performance scores and composite financial performance scores were developed. For each composite score, principal components analysis was used to synthesize the indicators simultaneously, loading weights were calculated based on indicator variance, and scores were standardized using the SAS Factor Procedure with varimax rotation. The number of factors to retain were determined based on the Scree Plots. The retained factors were used to calculate individual hospital composite scores by summing the individual hospital factor score weighted by the factor eigenvalue (variance explained) [65].

Several linear regression models were developed using the following permutations of dependent and independent variables, as well as with and without adjustment for percent Medicare and percent Medicaid, as follows:

Model 1 Quality
$$= \alpha + \beta_1 \text{Financial} + \beta_2 \text{BedSize} + \beta_3 \text{Minor Teaching} + \beta_4 \text{Non Teaching} + \beta_4 \text{Urban} + \beta_5 \%\text{Medicaid} + \beta_6 \%\text{Medicare}$$

Model 2 Quality
$$= \alpha + \beta_1 \text{Financial} + \beta_2 \text{BedSize} + \beta_3 \text{Minor Teaching} + \beta_4 \text{Non Teaching} + \beta_4 \text{Urban}$$

In order to compare the composite quality/safety performance scores calculated as described above, the following published quality metrics were also modeled: (1) CMS Value Based Purchasing Total Performance Score, (2) risk adjusted 30 day readmission for all patients, (3) risk adjusted 30 day readmission for AMI, (4) risk adjusted 30 day readmission for CHF, (5) risk adjusted 30 day readmission for PN, (6) risk adjusted 30 day mortality for AMI, and (7) risk adjusted 30 day mortality for CHF, (8) risk adjusted 30 day mortality for PN. Similarly, operating margin and total margin were modeled as independent financial variables to compare to the composite financial performance score.

All measures were standardized prior to regression analysis. Standardizing these coefficients allowed comparison of the relative importance of each coefficient in our regression models.[66] The strength of the coefficients based on standardized independent and dependent variables are internally comparable, and the strongest association is theoretically the one with the greatest total effect.[67] Model fit was assessed for influence and outliers in each model.

As an alternative to the standardized beta weights, regression tree models were developed using the Classification And Regression Trees (CART) methods.[68] Regression trees consist of recursive partitions of data into subsets according to ranges of ordered values of ordinal covariates or to subsets of values of categorical covariates which are as homogenous as possible

with respect to the composite financial performance score. For all partitions, all observed covariates remain available even if they have been used earlier in the tree, so it is possible for a covariate to reappear at several points in a tree. Unlike traditional linear regression, covariates with similar information are kept in the process and assessed for every partition. CART ranks all covariates based on their contribution to the improvement in homogeneity (even if it does not appear in the tree). This is a measure of how "important" each covariate is based on explanatory power and, in the case of correlated covariates, based on their ability to perform as main splitting criterion. The process of building a regression tree requires a decision to stop partitioning the data. In this study, we stopped the trees when additional partitions did not improve homogeneity. Regression tree models for this study were developed using CART available in the Salford System's Predictive Modeler v8.0. (https://www.salford-systems.com/products/cart)

Results

Of the 214 non-federal acute care hospitals in New York in 2014, 109 (51%) were included in the principal component analysis. Reasons for exclusion were specialty facilities without medical or surgical beds (29), critical access facilities (18), recent closure (2), and ancillary facilities without independent financial information from a principal facility (56). The included hospitals account for 71% of inpatient discharges from non-Veteran's Affairs (VA) NYS Hospitals in 2014.

Composite financial performance score components

Principal component analysis of financial variables revealed seven factors with eigenvalues greater than one, accounting for 87 percent of the variance of the financial health subscale. The factors were interpreted as measuring profitability (38%), asset efficiency (13%), absolute size of assets (11%), debt coverage (9%), capital structure (7%), uncompensated care or unutilized income (5%), and growth (4%) (Table 1). The standardized composite financial performance scores for the 109 hospitals ranged from -3.70 to 3.05, Interquartile range (IQR) -0.45 to 0.38.

Composite quality/patient safety performance components

Principal components analysis of quality variables revealed fourteen factors with eigenvalues greater than one, explaining a total of 77 percent of the variance of the quality/safety subscales. Based on analysis of scree plots, we narrowed the number of components to seven (Table 2), which explained 57 percent of the variance and had a very strong correlation ($r = 0.91$) with the 14-component summary score.

The first component, interpreted as patient experience of care (23%), included all ten subscales derived from the HCAHPS survey. The second component, interpreted as timeliness in surgical care improvement (10%), included process of care subscales predominantly related to reducing poor surgical outcomes including cardiac, venous thromboembolism, and infections. The third component featured timeliness of stroke care and other prophylactic therapies (7%). The next two components were both related to emergency department (ED) process measures: factor four includes measures of ED delays following evaluation (5%) and factor five includes measures of ED quality, including timeliness of pain control and of evaluation. The sixth component included patient safety indicators (4%) and the seventh included inpatient mortality (6%). Additional analysis conducted without the patient experience measures found similar components and proportion of variance explained (43% for 5 factors, data not shown). The standardized composite quality/safety performance scores for the 109 hospitals ranged from -4.45 to 1.86, with an interquartile range (IQR) from -0.59 to 0.76. One facility was identified

Table 1. Proportion of variance explained by principal components analysis of financial indicators, NYS hospitals, 2014.

Factors with key items listed	Proportion of variance explained	Cumulative variance explained
Factor 1: Profitability High Operating margin, net margin, return on assets, cash flow, current ratios, Low debt ratio, average payment period and asset turnover	38%	38%
Factor 2: Asset Efficiency High asset turnover, high margins, Low days cash on hand, current ratio, acid test ratio	13%	51%
Factor 3: Absolute Size High net assets, net assets	11%	62%
Factor 4: Debt Coverage High Capital expense ratio, current asset turnover, and capital expenditure growth rate, Low average payment period, debt ratio	9%	71%
Factor 5: Capital Structure High capital expenditure growth rate, total asset turnover, Low capital expense ratio	7%	78%
Factor 6: Uncompensated Care/ Unutilized Income Low days in patient accounts receivable	5%	83%
Factor 7: Growth High Capital Expenditure Growth Rate, Capital Expense Ratio	4%	87%

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as a low outlier for both the standardized financial score (-3.70) and quality score (-4.45). To provide conservative estimates of association, this outlier was removed from the following regression analyses.

Table 2. Proportion of variance explained by principal components analysis of hospital quality indicators, New York State, 2014.

Factors with items listed in order	Proportion of variance explained	Cumulative variance explained
Factor 1: Patient Experience of Care Overall Rating (H-HSP-RATING), Care Transition (H-COMP-7), Willingness to Recommend (H-RCMND), Pain Management (H-COMP-4), Nurse Communication (H-COMP-1), Communication about Medicines (H-COMP-5), Responsiveness of Staff (H-COMP-3), Doctor Communication (H-COMP-2), Discharge Information (H-COMP-6), Cleanliness (H-CLEAN-HSP), Quietness (H-QUIET-HSP)	23%	23%
Factor 2: Timeliness of care–Surgical Care Improvement Prophylactic Antibiotic Received within 1 hour prior to surgical incision (SCIP-INF-1), Prophylactic antibiotic selection (SCIP-INF-2), Venous Thromboembolism Prophylaxis within 1 day of surgery (SCIP-VTE-2), Perioperative Beta Blocker if needed (SCIP-CARD-2), Influenza Immunization (IMM-2), Postoperative discontinuation of prophylactic antibiotics (SCIP-INF-3), Postoperative Urinary Catheter Removal (SCIP-INF-9)	10%	33%
Factor 3: Timeliness of care–Stroke Care and DVT prevention DVT prophylaxis within 1 day of admission or surgery (VTE-1), DVT treatment within 2 days of arrival for stroke patients (STK-1), DVT prophylaxis within 1 day of admission to ICU (VTE-2), Initial antibiotic selection for community acquired pneumonia patients (PN-6), Stroke patients assessed for rehabilitation services (STK-10)	7%	39%
Factor 4: Timeliness of care–Emergency Department Delays Median Time from ED Arrival to Admission for inpatient admissions (ED-1b), Median time to admission after decision to admit was made (ED-2b), Median Time from ED Arrival to ED Departure for Discharged Patients (OP-18b)	5%	45%
Factor 5: Timeliness of care–Emergency Department Care Median Time to pain medication for ED patients with bone fractures (OP-21), Percent of Patients that left ED without being seen (OP-22), Median Time from arrival to Diagnostic Evaluation (OP-20)	5%	49%
Factor 6: Patient Safety Accidental Puncture or Laceration (PSI-15), Wound Dehiscence (PSI-14), Postoperative Respiratory Failure Rate (PSI 11)	4%	53%
Factor 7: Inpatient Mortality Heart Failure Mortality Rate (IQI 16), Pneumonia Mortality Rate (IQI-20), Perioperative Hemorrhage or Hematoma (PSI-09), Stroke Patients receive antithrombotic therapy by end of hospital day 2 (STK-5).	4%	57%

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Table 3. Relationship between New York State hospital financial indicators and quality outcomes, without adjustment for percent medicare and percent medicaid (model1).

	Composite Financial Performance Score		Operating Margin		Total Margin	
	Parameter	p-value	Parameter	p-value	Parameter	p-value
Composite Quality/Safety Performance Score	*0.340*	*<0.001*	*0.215*	*0.02*	*0.212*	*0.02*
CMS Value Based Purchasing Total Performance Score	*0.277*	*0.002*	*0.218*	*0.02*	0.165	0.07
30 Day Readmissions for All Outcomes	*-0.236*	*0.013*	0.132	0.16	0.069	0.47
30 Day Readmissions for Congestive Heart Failure	*-0.229*	*0.02*	0.179	0.06	0.113	0.25
30 Day Readmissions for Pneumonia	*-0.209*	*0.033*	*0.214*	*0.03*	0.184	0.06
30 Day Readmissions for Acute Myocardial Infarction	-0.034	0.74	0.006	0.96	-0.013	0.91
30 Day Mortality for Acute Myocardial Infarction	*-0.211*	*0.027*	0.041	0.67	0.104	0.27

All parameters are standardized, and all models were adjusted for Bed Size, Teaching Hospital Status, and Urban/Rural Status. One outlier hospital excluded.

Associations between hospital financial status and hospital quality of care

Stronger hospital financial standing, as measured using the composite financial performance score, was positively associated with better quality of care and service delivery as measured by the composite quality/safety performance score. (Table 3) Additionally, strong hospital financial standing also was associated with the CMS Value Based Purchasing Total Performance Score (VBP-TPS). The composite financial performance score was negatively associated with hospital wide 30-day readmission and 30-day readmission for heart failure and pneumonia, along with 30-day mortality from acute myocardial infarction (Table 3).

Overall, adjustment for Percent-Medicare coverage and Percent-Medicaid coverage attenuated the associations (Table 4). The composite quality/safety performance score, VBP-TPS and 30-day readmission for CHF remained statistically significant after adjustment for percent Medicaid and Medicare. The association between the composite financial performance score and a composite quality/safety performance score without patient experience measures was weaker (unadjusted for Medicare and Medicaid coverage: 0.169, p = 0.09; adjusted for Medicare and Medicaid coverage: 0.171, p = 0.12).

The composite quality/safety performance score regressed against the composite financial performance score with adjustment for percent Medicare and percent Medicaid had the best

Table 4. Relationship between New York State hospital financial indicators and quality outcomes, with adjustment for percent medicare and percent medicaid (model2).

	Composite Financial Performance Score		Operating Margin		Total Margin	
	Parameter	p-value	Parameter	p-value	Parameter	p-value
Composite Quality/Safety Performance Score	*0.239*	*0.01*	0.106	0.25	0.112	0.23
CMS Value Based Purchasing Total Performance Score	*0.215*	*0.03*	*0.179*	*0.05*	0.098	0.29
30 Day Readmissions for All Outcomes	-0.162	0.10	0.044	0.64	-0.014	0.88
30 Day Readmissions for Congestive Heart Failure	*-0.230*	*0.02*	0.129	0.18	0.088	0.36
30 Day Readmissions for Pneumonia	-0.177	0.09	0.160	0.11	0.149	0.14
30 Day Readmissions for Acute Myocardial Infarction	-0.013	0.91	-0.023	0.84	-0.043	0.71
30 Day Mortality for Acute Myocardial Infarction	-0.162	0.12	0.004	0.97	0.048	0.62

All parameters are standardized, and all models were adjusted for Bed Size, Teaching Hospital Status, Urban/Rural Status, %Medicaid, and %Medicare. One outlier hospital excluded.

fit of all models, with an R-square of 0.29, p<0.0001. The model correlating VBP-TPS with the composite score including percent Medicare and percent Medicaid had an R-square of 0.27, p<0.0001. In the model of the composite quality score regressed against the composite financial without adjustment for percent Medicare and percent Medicaid the R-square was 0.21, p<0.0001.

Both operating margin (p = 0.02) and total margin (p = 0.02) demonstrated a statistically significant association with the composite quality score when the model was not adjusted for percent Medicare and percent Medicaid. With adjustment for percent Medicare and percent Medicaid, operating margin and total margin were not significantly associated with any of the quality metrics, except for one instance with operating margin associated with total VBP-TPS (Table 4). None of the financial measures used demonstrated a significant correlation with adjusted 30-day mortality for pneumonia and for congestive heart failure (data not shown).

Decision-tree analyses

The results from regression tree models supported the findings from the traditional weighted linear regression models. The composite financial performance scores outperformed the total margin and the operating margin in predicting quality of care in NYS acute care hospitals. The composite financial performance score contributed with the largest reduction in mean squares in a regression tree model. The operating revenue margins contributed with a reduction less than half that of the composite financial performance score and the total margins was approximately 10% that of the composite financial score. This ranking remained similar when other predictors were added to the regression tree model. As more covariates were introduced in the regression tree model, the total margin and the operating revenue margin ended up as the weakest predictors of quality of care. However, the composite financial performance score had a similar performance as the total margin and clearly outperformed the operating margin when predicting the composite quality/safety performance score. The composite financial performance score contributed 83% reduction in mean squares compared to total margin and both measures clearly outperformed the operating margin which only contributed 32% reduction in mean squares. All three measures showed weak associations with the readmission measure.

Discussion

Our analyses found strong evidence, as hypothesized, that financially stable hospitals have better patient experience, lower readmission rates, and show evidence of decreased risk of adverse patient quality and safety outcomes for both medical and surgical patients. Hospitals that are better off financially can maintain highly reliable systems and provide ongoing resources for quality improvement, as measured predominantly by patient experiences and better performance on process of care initiatives, while financially distressed facilities struggle in these categories. These superior outcomes in financially stable hospitals persisted after adjusting for public payer caseload and hospital characteristics, suggesting that underlying qualities of financially well-off facilities lead to medical and surgical care that is superior. A small number of studies have suggested a limited association between improved hospital financial performance and improved quality of care and patient safety in specific scenarios.[14, 17, 18, 48, 52] We improve on previous cross-sectional snapshots by developing financial and quality/safety composite measures that have improved predictive validity. The results suggest that money does matter.

In studying this relationship, we also recognize that measurement matters. The strength of the relationship between finances and quality in this report varies across the indicators used in

these regression analyses. Financial health and quality/patient safety are complicated concepts that can be measured along many dimensions. Challenges arise when attempting to find elusive indicators for abstract, broad, and complicated measures, such as the financial health of organizations and/or quality of care of health facilities. Financial health can be measured considering capital structure, cost, profitability, liquidity and efficiency; while patient safety/quality care can range from hospital regulations adherence to patient perspectives on care.[62] The findings from previous studies on this topic are equivocal and have varying limitations [14, 25, 45–47, 50, 69–75]. This report attempts to overcome prior limitations related to measurement by integrating a broader spectrum of existing data routinely collected.

All measures were standardized prior to regression analysis. With standardization, the interpretation of the regression coefficients is the standard deviation change in the dependent variables per standard deviation change in independent variable. This technique preserves internal validity, but the standardized coefficients are only generalizable to other populations with similar variable distributions. Standardized coefficients also facilitate comparison between equations that use the same independent variable set.[66, 67] When comparing the various financial indicators and utilizing the model without adjustment for percent Medicare and Medicaid, the composite quality/safety performance score had the largest strength of effect followed by VBP-TPS and then various subsets of 30 day readmissions. Thirty-day mortality for acute myocardial infarction was also found to be significantly associated with financial health using this model, however none of the other indicators of mortality were significant in either model. The same pattern held when percent Medicare and percent Medicaid were included in the model, though strength was attenuated and fewer associations were significant.

When hospitals are compared to one another based on patient outcomes, concerns inevitably arise about risk-adjustment and statistical heterogeneity due to small numerators. To improve measurement, intermediate process and performance metrics have been added to the measure sets, raising concern of whether these measures appropriately inform meaningful health outcomes. [76] While there is modest evidence connecting many surrogate endpoints, such as risk-factor control or care processes, these metrics may be chosen because they are easy to access and measure, rather than being meaningful, patient-centered outcomes [76, 77]. With payment at stake, clinicians and health organizations may feel compelled to engage in gaming, in over-testing and overtreatment, or in devoting disproportionate effort to patients that improve these surrogate endpoints rather than focusing on those at highest risk [76, 77]. Furthermore, the availability and influence of these markers interferes with opportunities to establish more thoughtful interventions and individualized approaches to clinical complications such as social determinants and multimorbidity. [76, 78–82] We attempted to address these concerns by creating and using global risk measures representing both financial health and quality of care, as decisions for entire hospitals and health systems often rely on hospital level indicators. Global measures are more robust and are preferable to individual risk factors, as they are more likely to indicate highly reliable organizations by reducing the influence of gaming and interventions focused on improvement of individual metrics [76, 83, 84].

Variables chosen for adjustment in our models are well chronicled in the literature. It is well documented that greater dependence on government payers, such as Medicare and Medicaid are associated with a higher probability of financial distress because these payers typically do not pay the average full cost of care.[85–91] The analyses were adjusted for teaching hospital status as prior studies associated teaching hospitals with lower financial performance, considering they often support more labor-intensive staff and offer a wide array of costly medical services. The sheer size of a hospital, measured by the number of beds, allows a hospital to withstand costly outliers which could more likely have adverse effects on smaller facilities.[92] The mixture of operational and market factors influencing the financial condition of hospitals

differently in urban versus non-urban areas is well documented.[19] Non-urban hospitals tend to be smaller and offer fewer services than urban hospitals. Finally, the outcome-based metrics used for the quality composite score were all based on published risk-adjustment methodology.[93, 94]

Policy implications

Federal and State policy also matters as deficits in the quality of care can be systemic, requiring systems level modifications to produce the desired changes and results. As policy makers consider action to achieve the triple aim, the interrelatedness of cutting healthcare costs and achieving quality needs to be addressed, particularly as it affects the ability of fiscally distressed facilities serving vulnerable patients to engage in quality improvement.

This study has policy implications for the millions of patients who gained Medicaid coverage beginning in 2014 from the Affordable Care Act and for the future of the Medicaid program, in general. The attenuation of the association observed here when controlling for public payer are consistent with previous studies that found that hospitals with high Medicaid case-mix had worse quality of care than other hospitals.[56, 95–100] Research on nursing homes also suggest a link between lower Medicaid reimbursement levels and lower quality.[101–104] Despite this association, powerful evidence has been published suggesting that Medicaid has a positive impact on access to care, financial security, and self-reported health.[105, 106] At the same time, under the veil of deficit reduction, future expected cutbacks could lead to reduced access to high quality care. Our findings suggest that any cost-cutting efforts by Medicare, Medicaid, and private payers needs to be carefully designed and managed so that patient safety and patient centered care are not compromised.

Since our analysis was performed with hospital level data, we cannot examine variation in individual patient care within each hospital. Patient level analysis would be relevant if the disparity in quality that arises from financial distress contributed to disparities in outcomes that have been observed for vulnerable patient populations, including older and poorer patients, those covered by Medicaid or Medicare, those with complex comorbidities, and medically disadvantaged groups such as racial and gender minorities.[107, 108] [109–114] Evaluating performance on the hospital level of analysis, however, is relevant since systems and policy decisions are most commonly determined either at the hospital, state, or federal level [57]. Further, there is no current source of individual level data on patient experience of care, which the analysis presented here confirms accounts for the most variability across the hospital healthcare system. The results presented here represents the state of affairs in New York prior to the launch of the Delivery System Reform Incentive Payment (DSRIP) Program funded by the Section 1115 Demonstration Waiver [115]. Repeating these analyses at the end of New York's five-year demonstration will identify if systemic changes have reduced the chasms in quality of care, or made them deeper.[116]

Our findings support the notion that hospitals under greater financial distress have less favorable patient experience of care, higher readmission rates, and increased risk of adverse patient quality and safety outcomes for both medical and surgical patients. These substandard outcomes in financially distressed hospitals persisted after adjusting for public payer caseload and hospital characteristics. This suggests that underlying qualities of poorer facilities can lead to medical and surgical care that is inferior as well as an inferior experience for patients. This study provides composite measures that optimized the estimated correlation between financial status and quality/patient safety outcomes. These findings suggest that it is imperative to address financial disparities when incentivizing health care quality through value-based purchasing in order to ensure financial stability and quality of care in safety net facilities.

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