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Do We Get What We Pay For? Examining the Relationship Between Payments and Clinical Outcomes in High-Volume Elective Surgery in a Commercially-Insured Population

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Abstract

Studies evaluating the cost and quality of healthcare services have produced inconsistent results. We seek to determine if higher paid hospitals have higher quality outcomes compared to those receiving lower payments, after accounting for clinical and market level factors. Using inpatient commercial claims from the IBM® MarketScan® Research Databases, we used an ordinal logistic regression to analyze the association between hospital median payments for elective hip and knee procedures and 3 quality outcomes: prolonged length of stay, complication rate, and 30-day readmission rate. Patient-level and market factor covariates were appropriately adjusted. Hospital-level payments were found to be not significantly correlated with hospital quality of care. This research suggests that higher payments cannot predict higher quality outcomes. This finding has implications for provider-payer negotiations, value-based insurance designs, strategies to increase high-value care provision, and consumer choices in an increasingly consumer-oriented healthcare landscape.

Keywords

pay-for-performance, healthcare cost and quality, hospital price variation, healthcare consumerism, price transparency, value-based care

What do we already know about this topic?

Many studies have been undertaken to understand drivers of price variation in healthcare, but to the best of our knowledge, this is a novel research question to investigate whether price signals quality in surgical outcomes at the provider level.

How does this research contribute to the field?

This analysis is an innovative approach to exploring the relationship between payments and quality outcomes in that a time horizon for hospital payments preceding the time horizon for quality outcomes reveals the predictive power of hospital payments on the hospital's quality.

What are the research's implications towards theory, practice, or policy?

The contributions of this study include two new and important findings: (a) differentiation of healthcare products on price may not provide any consistent or significant indication of the quality of those products and (b) price transparency efforts to rein in costs by making prices publicly available may do little to assist individuals in choosing high quality providers. In an increasingly consumer-oriented healthcare market, nuanced understanding of the association between payments and quality in high-volume surgeries informs strategic decision-making by third-party payers and consumers directly, as well as health policy along the value-based payment arrangement continuum and price transparency.

Introduction

Price variation exists between providers and across geographical regions for surgical procedures in the United States.[1-3] Continued research focuses on understanding the drivers and impact of price variation; however, the relationship between price and the quality of care delivered has not been as widely researched. Traditional market theory posits that price is a reasonable signal for quality in many industries. In healthcare, the pervasive knowledge asymmetry and inability to obtain direct patient outcomes leads consumers to depend on other measures, such as reputation, designations as centers of excellence, and price, to distinguish between hospitals in place of their quality.[4-7] With the increased availability of consumer-based price transparency tools, patients have access to hospital charge data and, to a lesser extent, mean reimbursement rates for select procedures. For payers, it is likely hospital-level quality is considered when negotiating reimbursement rates (prices); however, it is unclear if patient consumers rely on price to assess quality (e.g., higher cost hospitals reflect higher quality of care provision) and/or select their hospital provider.[8,9] Existing literature does demonstrate that factors relating to hospital characteristics and market structure are strongly correlated with higher prices. Examples include larger hospital bed-size, teaching status, availability of specialty services, and outsized or growing market share.[2,4,10,11]

Studies evaluating the cost and quality of healthcare services have produced varying results on the direction and/or existence of a relationship between cost and quality. Positive associations presume that hospitals spend more to produce higher outcomes, while negative associations may suggest hospitals achieve lower costs by reducing complications and poor outcomes.[12-19] Further research is needed to better understand the relationship between cost and quality in healthcare services. This is salient given the advent of pay-for-performance and value-based care which has tied the receipt of payment to quality outcomes.[20-23] Furthermore, a fundamental equipoise exists as to the extent to which cost-quality congruence and price signaling are able to exert influence during reimbursement negotiations between payers and providers. Examining the relationship between hospital payments and quality outcomes for select inpatient surgeries may provide insight into the impact of higher payments on quality. This deeper understanding could have implications for how providers and payers approach payment rate negotiations for inpatient procedures in a value-based climate. Lastly, the fact that inpatient services currently account for roughly 30% of overall healthcare spending heightens the salience of our anticipated findings.[24]

The availability of claims data across the United States for patients with elective hip and knee procedures presents a unique opportunity to investigate variations in price and quality outcomes.[25-28] Currently, these procedures are performed in a variety of hospital settings, with variation in the utilization of services, and reimbursement rate deviations across commercial payers and geographical regions.[29-31] This research explores the relationship between elective hip and knee procedure quality outcomes—measured by frequency of clinical complications, readmissions, and prolonged length of stay—and the median hospital-level commercial payments for the hospitalization. Specifically, we seek to determine if higher-paid hospitals have higher quality outcomes compared to those receiving lower payments, after accounting for clinical and market-level factors.

Methods

Study Data

Deidentified patient claims and commercial payment data was obtained from the IBM® MarketScan® Research Databases. The MarketScan® Databases contain demographic, geographic, and clinical data on nearly 50 million beneficiaries who are enrolled in commercial, employer-sponsored health insurance plans. The study sample included patient claims between 2013 and 2017 with elective knee and hip procedures from California, Texas, and Florida. To optimize the sensitivity of procedure-specific quality outcomes in relation to payments, HMO health plans (i.e. capitated reimbursements) were excluded. Also excluded were claims associated with emergent cases, individuals younger than 18 years or older than 65 years, and procedures performed in the ambulatory setting.

Hospital Median Procedure Payments

The MarketScan® Databases contain patients' total hospital payment received for the admission paid by the payer and patient. Total hospital payments are the gross payments to all providers (hospital and physicians) who submitted claims for services rendered during the admission. Hospital median payment was computed for each of the study hospitals over 3 years of data (2013-2015) for uncomplicated hip and knee procedures separately. Median payments were used to obtain a payment metric more robust to outliers among the hospital's patients in the study population. Cases characterized by the occurrence of a post operative complication were excluded because they result in higher hospital prices which are unrelated to the ex-ante pricing practices for a "base case" procedure. To identify the occurrence of complications, we used ICD-9 diagnosis codes for surgical complications in the published literature[32] and cross-walked the

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ICD-9 diagnostic codes to ICD-10 for later years (Appendix Exhibit 2). Hospitals included in the analysis performed a minimum of 5 surgeries from 2013 to 2015 and from 2016 to 2017.

Outcome Variables | Complication Rates, Readmission Rates, and Prolonged Length of Stay

Complication rates, readmission rates, and rates of prolonged length of stay (PLOS) were computed at the hospital level using 2 years of data (2016-2017). Outcomes calculated from 2016 to 2017 were linked to hospital median total payment from 2013 to 2015 using the encrypted provider identifier. Evaluating quality outcomes in the years subsequent to the computed median payment allows for discerning the effect, if any, of price signaling. Hospital-level quality outcomes were computed using aggregated patient claims data for each of the 3 quality outcomes studied: prolonged length of stay (>75th percentile), <30-day all-cause readmission rate, <30-day overall complication rate.[33,34] Hospital-level complication rates were determined as the percent of surgeries with complications, indicated by ICD-10 diagnostic codes. All-cause readmission rates were selected in following with Medicare's Hospital Readmission Reductions Program and were determined by hospitalizations within 30 days of discharge for the index hospitalization. All quality outcome rates were converted into low, medium, high categorical variables in which low indicated the best quality and high indicated the worst quality (higher percentage of patients exceeding the 75th percentile for length of stay, higher complications, and higher readmissions). The low, medium, high categories were created with the following logic to balance the values of our outcome data and our number of observations: low—0% outcomes among the provider's patients; medium—up to the 75th percentile of the outcome distribution; high—75th percentile and above).

Covariate Study Variables and Identification

Hospital-level covariates included geographical state, payer-mix, case-mix, hospital market concentration and the percent of male patients. Hospital payer mix represented the percent of patients in a provider-restricted health plan arrangement (PPO, POS, EPO). Case-mix was the mean Charlson Comorbidity Index (CCI) score for the specified surgery. The CCI was computed in the 2016 to 2017 time horizon using patient comorbidities identified via ICD-10 diagnostic codes as previously described in the literature.[35,36]

Hospital market concentration was designated by a Herfindahl-Hirschman Index (HHI) calculated using a three-digit zip code market boundary. The HHI used hospital discharge volume obtained from American Hospital Association 2016 data. Values range from 0 to 10 000 whereby larger scores indicate higher concentration.[37-39] HHI scores were mapped to patient claim files using the 3-digit zip code of each patient's address. Hospital-level HHI scores were calculated as a weighted average of the HHI scores of each hospital's patients.

Statistical Analysis

Descriptive statistics are provided for all model variables. Ordinal logistic regression was used to analyze the 3 quality outcomes of prolonged length of stay, complication rates, and readmission rates. Hip and knee procedures were modeled separately. In total, 6 ordinal logistic regression models were performed. Stepwise regression with backward elimination was used to create a parsimonious list of covariates. Multicollinearity among the selected variables was examined using variance inflation factors. All analyzes were performed with the statistical software package, STATA. Two-tailed P-values < .05 were considered statistically significant.

Results

Patient-Level Descriptive Statistics

A total of 1899 inpatient elective hip procedure patients and 3305 elective knee procedure patients were included in the study (Table 1). Greater than half of all patients are from Texas with a mean age of approximately 56 years. The unadjusted patient complication rates in the study population were 1.8% and 2.4% for hip and knee procedures, respectively. A greater proportion of knee procedures patients had prolonged length of stay for their hospitalization (>75th percentile) and a slightly higher readmission rate than patients who underwent a hip procedure.

Hospital-Level Descriptive Statistics

Hospital-level descriptive statistics demonstrated that the mean percent of patients with prolonged length of stay, as well as the percent of complications among procedures, was greater for knee operations (Table 2). The average rate of readmissions at the hospital level was the same for both procedures (4.9%). The average hospital median payment for both operations was about $35 000 and hospitals had comparable case mix, payer mix and market concentrations across both procedures. Additionally, the mean CCI score was less than 1 for both procedures. The largest proportion of hospitals were in Texas. The median rates of prolonged length of stay, complications, and 30-day readmissions were similar between hip and knee procedures in each of the respective outcomes' high, medium, low categories.

The distribution of hospital median payments for the procedures revealed a greater degree of variation in hospital median payment among knee procedures (Figure 1). Hospital median payments for hip procedures range from $8666 to $52 808 with a mean of $35 428. Hospital median payments

Table 1. Patient-Level Descriptive Characteristics by Inpatient Procedure.

	Hip procedure (n = 1899)	Knee procedure (n = 3305)
Patient-level descriptive characteristics		
Sex (% male)	49.80%	41.60%
State (%)		
FL	23.80%	23.20%
TX	55.60%	63.30%
CA	20.70%	13.50%
Age (years)		
Mean (SD)	55.7 (7.4)	57.2 (5.5)
Range	[19, 65]	[22, 65]
Days in hospital		
Mean (SD)	5.1 (4.1)	4.2 (3.0)
Range	[3, 33]	[3, 30]
Complication rate (%)	1.80%	2.40%
Rate of prolonged length of stay (%)	15.90%	21.50%
30-day readmission rate (%)	4.90%	5.50%

for knee procedures range from \$4466 to \$67 064 with a mean of \$34 704.

The distributions of the hospital-level outcomes show right-skewed but consistent distributions between both patient populations (Figure 2). For this research, 72% and 63% of hospitals were identified as having zero complications for elective hip and knee procedures, respectively. The observed range for hospital-level outcomes for hip procedures was 0% to 40.0% complication rate, 0% to 83.3% patients with prolonged length of stay, and 0% to 33.3% 30-day readmission rate. The observed range for hospital-level outcomes for knee procedures was 0% to 30% complication rate, 0% to 100% patients with prolonged length of stay, and 0% to 71.4% 30-day readmission rates (Figure 2).

Hospital-Level Ordinal Logistic Regression Analysis

The ordinal logistic regressions showed hospital-level payments are not significantly associated with quality outcomes, except for complication rates in elective hip procedures (Table 3); however, the coefficient of 0.99 for median hospital payment in that model means that the proportional odds of being in a higher outcomes category (worse quality) due to a unit increase in median hospital payment is essentially 1.0 which is negligible as an odds ratio. Case-mix was associated with quality outcomes in 5 of the 6 models. In elective hip procedures, for every 1 unit increase in case-mix, the proportional odds of being in a higher quality outcome category was 4.00 for prolonged length of stay, 6.49 for complication rate, and 5.66 for readmission rate. In elective knee procedures, for every one-unit increase in case-mix, the proportional odds of being in a higher quality outcome category was 4.4 for prolonged length of stay, 1.40 for complication rate, and 5.47 for readmission rate. The proportional odds of moving up in the quality outcome category due to gender or payer mix was not significant. Hospital market concentration was insignificant in all regression models except 30-day readmission rates for hip procedures, however, it had no practical significance in the model due to the OR of 1. Texas had increased odds of providers having higher readmission rates for hip procedures but lower odds of providers having prolonged length of stay for knee procedures.

Discussion

In our study population, we found no practical association between payments made to hospitals and the clinical outcomes of prolonged length of stay, complication rate, and 30-day readmission rate. A significant association exists between hospital median payment and complication rate for hip procedures, but the finding (OR 0.99) is not meaningful clinically. This supports prior research which showed no relationship between healthcare costs and quality.[12] While case-mix showed a strong association with clinical outcomes across the models, the variables for patient sex, payer health plan, market consolidation of hospitals, and geographical state did not demonstrate any meaningful association with the study's quality measures. Although the association between case mix and outcomes affirms prior research[40,41] this was counter to other studies that have found patient sex, health plan, etc. are associated with quality outcomes.[42,43] It is likely there are under-reported and under-studied factors that impact quality outcomes. For example, hospital reputation, hospital incorporation into integrated delivery systems, and proportion of hospitals' reimbursements in a value-based payment arrangement likely influence provider-payer negotiations and are infrequently included in clinical quality studies. Additionally, there is a wealth of published literature on the correlation between nurse staffing and nurse education and quality outcomes[44-46]; analyzes may benefit from adjustments for these factors.

Hospital market concentration was not found to be a predictor for quality outcomes in our study population. Market concentration has been researched in other studies to assess its impact on healthcare costs. Previous studies have found hospital market structure to be correlated with prices for common procedures and asserted market concentration increases cost without providing accompanying benefits in quality.[2,47] However, our research took a novel approach (i.e. establishing payment rates for uncomplicated procedures prior to our time horizon for observing care quality) to explore whether market structure directly influences surgical outcomes independent of the payment for procedures. While our study did not detect a direct association between hospital market competition and surgical outcomes, hospital

Table 2. Hospital-Level Descriptive Characteristics by Inpatient Procedure.

	Hip procedure (n = 99)		Knee procedure (n = 155)	
	Mean	SD	Mean	SD
Hospital-level descriptive characteristics				
Prolonged length of stay	19.27%	16.75%	26.91%	23.01%
Complication rate	2.99%	6.30%	3.50%	6.40%
30-day readmission rate	4.90%	7.39%	4.97%	9.16%
Hospital median payment ($)	35 427	10 056	34 704	11 299
Case-mix (avg. comorbidity index score)	0.5953	0.3424	0.549	0.314
Patient gender mix (% male)	50.10%	17.06%	41.87%	16.97%
Hospital market concentration (HHI)	2138	864	2357	1142
Payer mix (% preferred provider or similar)	82.32%	13.68%	83.97%	14.92%
	Hip procedure		Knee procedure	
	N	Median	n	Median
Proportion of hospitals and median outcome by category				
Total hospitals	99	–	155	–
State				
Florida	26.30%	–	26.50%	–
Texas	48.50%	–	53.50%	–
California	25.30%	–	20.00%	–
Prolonged LOS				
Low	25.30%	0	25.20%	0
Medium	50.50%	0.18	49.70%	0.2
High	24.20%	0.41	25.20%	0.57
Complication rate				
Low	71.70%	0	62.60%	0
Medium	17.20%	0.06	25.80%	0.05
High	11.10%	0.17	11.60%	0.14
Readmission rate				
Low	55.60%	0	58.70%	0
Medium	33.30%	0.08	30.30%	0.08
High	11.10%	0.2	11.00%	0.2

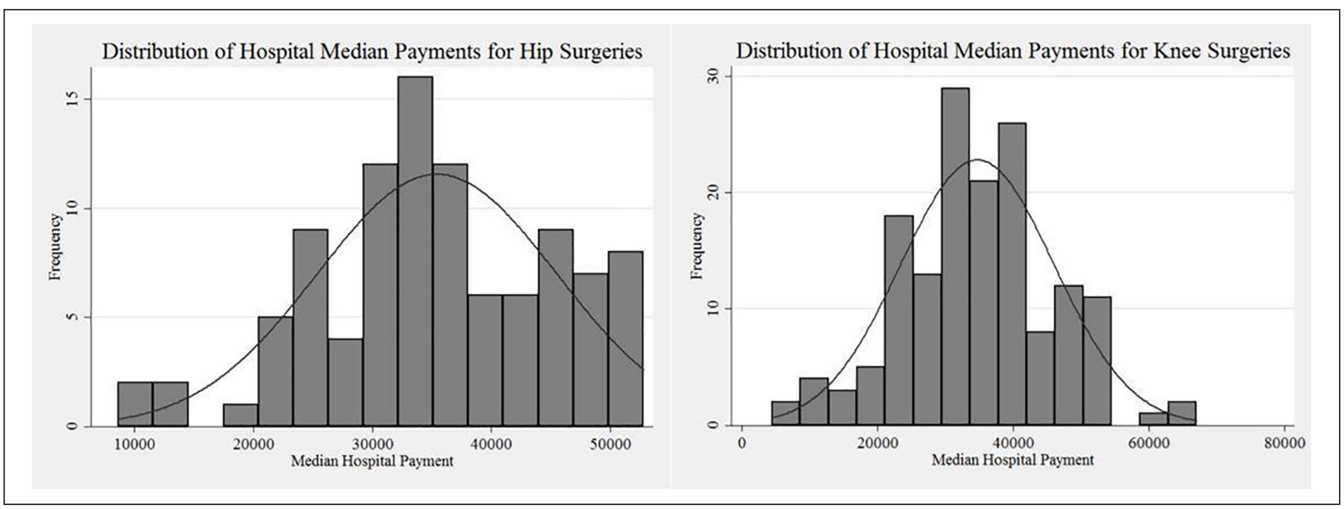

Figure 1. Distributions of hospital-level payments.

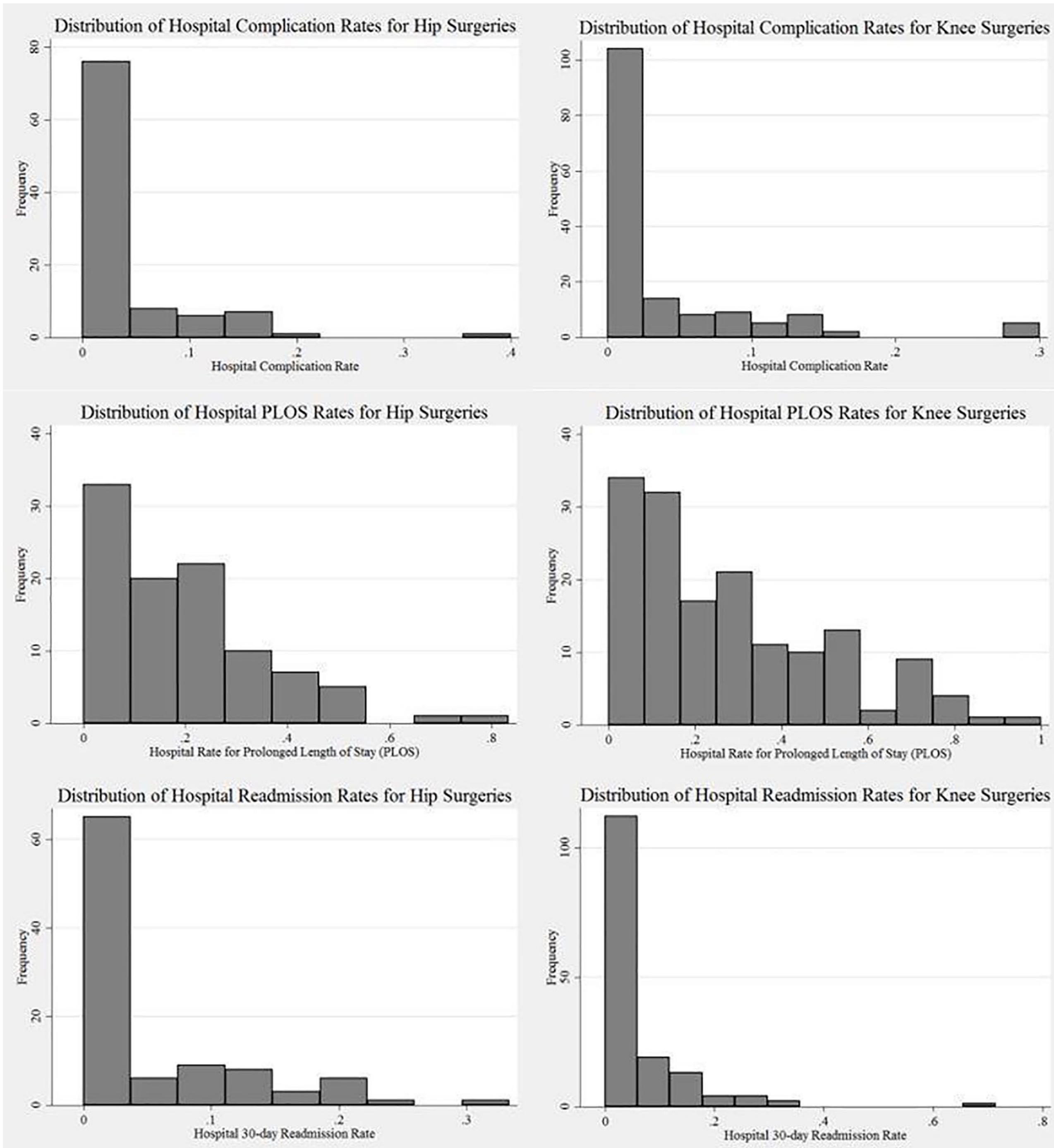

Figure 2. Distributions of hospital-level outcomes.

processes and structures—which are vulnerable to changes resulting from consolidation practices—are demonstrated to impact quality outcomes and are often targets for quality improvement for joint arthroplasty procedures. Our analysis may have been underpowered to detect a relationship between quality outcomes and market factors in this study. Future studies may investigate further whether market concentration truly only influences health care costs or whether, as we speculate, market concentration has alternative pathways to affect quality outcomes.

Our research supports existing literature suggesting price is not a signal for quality. Hussey et al's[12] systematic review

Table 3. Hospital-Level Ordinal Logistic Regression Results.

	Hip replacement (n = 99)			Knee replacement (n = 155)		
	Prolonged length of stay	Complication rate[a]	Readmission rate[b]	Prolonged length of stay	Complication rate[a]	Readmission rate[b]
Ordinal logistic regression model by inpatient procedure						
Hospital median payment	0.99 (0.00)	0.99 (0.00)*	0.99 (0.00)	1.00 (0.00)	0.99 (0.00)	0.99 (0.00)
Case-mix	4.00 (2.47)*	6.49 (4.44)**	5.66 (3.79)**	4.04 (2.34)*	1.40 (0.77)	5.47 (3.11)
Percent male	0.10 (0.13)	0.24 (0.38)	0.17 (0.23)	0.20 (0.19)	0.16 (0.18)	2.83 (3.00)
Hospital market concentration	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)**	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)
Percent PPO	0.09 (0.14)	0.16 (0.28)	1.15 (1.87)	3.87 (4.22)	0.29 (0.34)	1.36 (1.61)
State						
Florida (ref)	–	–	–	–	–	–
Texas	–	0.80 (0.44)	3.28 (1.79)*	0.68 (0.27)	1.30 (0.53)	1.12 (0.45)
California	–	0.32 (0.23)	1.53 (1.00)	0.33 (0.16)*	0.57 (0.33)	0.65 (0.34)
Model R^2	0.066*	0.098*	0.127**	0.061**	0.049	0.049

Note. Odds ratio (Std Error).
[a]Medical and surgical postoperative complications.
[b]All-cause readmission rate within 30 days of discharge.
*Significant at .05. **Significant at .01.

found that among sixty-one studies the strength of association between quality and cost was small to moderate, with inconsistent findings on the directional impact. The findings of weak correlations, if any, between cost and quality have important implications for value-based frameworks and provider-payer negotiations, for employer-sponsored health insurance plans, and for consumers directly.

The lack of association between hospital payments and quality outcomes substantiates the need for value-based arrangements in which quality demonstration precedes incentive payment. The increasing growth of value-based insurance designs predicates the need to evaluate the assumption that value principles can effectively accomplish the presumed high quality and lower cost objective. Consideration should be given to the ability of a hospital to demonstrate quality improvements before obtaining higher reimbursements; this may be a barrier for hospitals with small profit margins and a lack of capital needed to change structure and process elements. The association, or lack thereof, between higher reimbursements and quality outcomes, has potential consequences for provider-payer negotiations. Without an association, it is difficult to argue that increased/higher reimbursements are warranted without first demonstrating quality improvements. As such, increasing the contracted price for services may be unrelated to the provision of better quality outcomes for inpatient procedures.

Coverage and network decisions for employer-sponsored health insurance plans pose a continual challenge for businesses and employers. These plans, which cover about 49% of all Americans,[48] are well-positioned to strategically choose network providers based on high-quality outcomes and/or lower reimbursement rates. However, the lack of evidence that higher reimbursement rates function as a signal for quality suggests selecting higher-priced hospitals to be in the network, in an effort to dress up benefits packages, does not guarantee better quality for employees. Thus, employers who build networks based on the notion that price is indicative of quality may end up paying more without the benefit of higher quality healthcare provision.

Reference pricing and centers of excellence, which are more commonly used in the private sector and employer-sponsored health plans, gain support as high-value strategies in light of weak associations between health care costs and quality, especially for expensive, high-volume procedures. Reference pricing reduces the likelihood of beneficiaries choosing expensive providers that do not have a return in care quality proportional to their relatively higher cost over other providers. Additionally, the research suggests that centers of excellence for elective surgeries are a beneficial strategy for improving the value of health care as they generally produce higher quality outcomes without a higher price tag. Centers of excellence for hip and knee replacement procedures have demonstrated high-quality surgical outcomes without any significant difference in cost compared to non-designated hospitals.[49,50] Elective orthopedic procedures are high-volume procedures in the United States with wide price variation and are, therefore, priority targets for more widespread use of strategies such as reference pricing and centers of excellence as a means to produce greater value of health care and reduce cost burden on employers.

Consumer-driven and high-deductible health plans have grown dramatically in recent years. These health plans incentivize patients to weigh costs and quality but with little guidance. As consumers take on a larger role in health care decisions to choose their provider for health services, a better understanding of the true association between cost and quality of certain health services will be informative for health care decisions for consumers directly. This analysis suggests that it may benefit consumers to explore better proxies for provider quality than price, and prioritize those factors, such as reputation or designations, to inform their decisions about provider selection.

The provider-level analyzes used in this study investigated the effect of hospital payments on quality outcomes; however, this level of analysis did not allow for variation and sample size consideration that a patient-level analysis may provide. Additionally, this study focused on elective hip and knee procedures, however, other high volume, elective surgeries such as abdominal aortic aneurysm (AAA), coronary artery bypass grafting (CABG), colectomy, and bariatric surgery are high priority targets for understanding the association, if any, between payments and quality. Future studies using a patient-level analysis, inclusive of more surgical procedures, are needed to further unpack the healthcare cost-quality relationship.

A limitation of this study is the inability to include total hospital surgical volume as a covariate in the analyses. Hospital surgical volume is widely recognized as an important factor impacting surgical outcomes.[51] The MarketScan® Databases contain only a subset of a hospital's patients and this subset may not be representative of hospitals' entire surgical patient volume. Because it is impossible to know what percentage of a hospital's surgical patients are included in this database, we cannot ascertain hospitals' true surgical volume. This is germane because a volume-outcome relationship has been established for length of stay, readmissions, complication rates and costs associated with hip and knee replacement.[52-55] However, there is to the best of our knowledge, no consensus on the optimum volume thresholds for either procedure and whether this variation is predominantly driven by surgeon or hospital-level performance. Further studies exploring the association between price and quality in the inpatient setting should include a volume metric. An additional limitation of this analysis is that the outcome metric for readmissions contains only those patients who return to the hospital and become an inpatient, opposed to observation patients or patients presenting to the ED who are not admitted but may require some level of post-operative treatment. We suspect that this is not a significant proportion of surgical patients in the commercially-insured population, but as the dataset contained only inpatient files, we were unable to ascertain that prevalence. A final limitation to this study is the possibility that the movement of elective joint procedures to the ambulatory surgical setting during the study period may result in some amount of adverse selection toward sicker patients in our inpatient-only analysis since only those deemed low-risk are typically eligible for surgery in the ambulatory setting. We believe that the case-mix adjustment in the analysis mitigates any impact of this surgical setting trend on the relationship of interest.

Despite these limitations, our results expand the extant literature and lend support to the conclusion that hospital reimbursements may not be associated with the hospital's ability to produce higher quality outcomes. Additional research is needed to provide clarity on the implications suggested here that the lack of functional price signaling has consequences for current payment arrangements and strategies utilized in the industry to produce higher-value healthcare in the United States.

Conclusion

With increasing ties between hospital financials and demonstrated quality of care, an increased understanding of their relationship to one another is critical for industry efficiency and effectiveness. This research suggests that higher payments cannot predict higher quality outcomes. This finding has implications for provider-payer negotiations, value-based insurance designs, strategies to increase high-value care provision, and consumer choices in an increasingly consumer-oriented healthcare landscape. As value-based arrangements continue to be maintained or grow in popularity in the healthcare industry, special attention to feasibility and time to adapt must be kept in mind.

Appendix

Exhibit 1: ICD-9/10 PCS Codes for Hip and Knee Procedures

Elective Hip Procedure Codes. ICD-9: 81.40, 81.51, 81.52, 81.53;
ICD-10-PCS 0SR90XX, 0SRA0XX, 0SRB0XX, 0SRE0XX, 0SRR0XX, 0SRS0XX.

Elective Knee Procedure Codes. ICD-9: 81.44, 81.54, 81.46, 81.47, 81.54, 81.55;
ICD-10-PCS 0SRC0XX, 0SRD0XX, 0SRT0XX, 0SRU0XX, 0SRV0XX, 0SRW0XX.

Exhibit 2: ICD-9/10 Diagnostic Codes for Perioperative Complications

Pulmonary Failure. ICD-9-D-51881, ICD-9-D-5184, ICD-9-D-5185, ICD-9-D-51851, ICD-9-D-5188;
ICD-10-D-J9600, ICD-10-D-J9602, ICD-10-D-J95821

Pneumonia. ICD-9-D-481, ICD-9-D-4820:ICD-9-D-4822, ICD-9-D-48230:ICD-9-D-48239, ICD-9-D-48240:ICD-9-D-48249, ICD-9-D-48281:ICD-9-D-48289, ICD-9-D-4829, ICD-9-D-5070;
ICD-10-D-J13, ICD-10-D-J14, ICD-10-D-J150, ICD-10-D-J151, ICD-10-D-J1520, ICD-10-D-J15211, ICD-10-D-J15212, ICD-10-D-J1529, ICD-10-D-J153:ICD-10-D-J159

Myocardial Infarction. ICD-9-D-41000:ICD-9-D-41002, ICD-9-D-41010:ICD-9-D-41012, ICD-9-D-41020:ICD-9-D-41022, ICD-9-D-41030: ICD-9-D-41032, ICD-9-D-41040:ICD-9-D-41042, ICD-9-D-41050:ICD-9-D-41052, ICD-9-D-41060:ICD-9-D-41062, ICD-9-D-41070:ICD-9-D-41072, ICD-9-D-41080:ICD-9-D-41082, ICD-9-D-41090:ICD-9-D-41092;
ICD-10-D-I2101, ICD-10-D-I2102, ICD-10-D-I2109, ICD-10-D-I2111, ICD-10-D-I2119, ICD-10-D-I2121, ICD-10-D-I2129, ICD-10-D-I213, ICD-10-D-I214, ICD-10-D-I219, ICD-10-D-I21A1, ICD-10-D-I21A9

Deep Venous Thrombosis/Pulmonary Embolism. ICD-9-D-41511, ICD-9-D-41519, ICD-9-D-45119, ICD-9-D-4512, ICD-9-D-45181, ICD-9-D-4518;
ICD-10-D-I2609, ICD-10-D-I2699, ICD-9-D-45340, ICD-9-D-45341, ICD-9-D-45342, ICD-10-D-I82401:ICD-10-D-I82409, ICD-10-D-I82411:ICD-10-D-I82419, ICD-10-DI82431:ICD-10-D-I82439, ICD-10-D-I82441:ICD-10-D-I82449, ICD-10-D-I824Y1:ICD-10-D-I824Y9, ICD-10-D-I824Z1:ICD-10-D-I824Z9

Acute Renal Failure. ICD-9-D-584;
ICD-10-D-N17

Hemorrhage. ICD-9-D-9981;
ICD-10-D-R58

Surgical Site Infection. ICD-9-D-9583, ICD-9-D-99811, ICD-9-D-99812, ICD-9-D-99813, ICD-9-D-99830, ICD-9-D-99831, ICD-9-D-99832, ICD-9-D-99883, ICD-9-D-99850, ICD-9-D-99851, ICD-9-D-99859, ICD-10-D-L7622, ICD-10-D-L7632, ICD-10-D-L7634, ICD-10-D-T8130, ICD-10-D-T8131, ICD-10-D-T8132, ICD-10-D-T8140, ICD-10-D-T8141, ICD-10-D-T8142

Gastrointestinal Bleeding. ICD-9-D-53082, ICD-9-D-53100-53121, ICD-9-D-53140, ICD-9-D-53141, ICD-9-D-53160, ICD-9-D-53161, ICD-9-D-53200: ICD-9-D-53221, ICD-9-D-53240, ICD-9-D-53241, ICD-9-D-53260, ICD-9-D-53261, ICD-9-D-53300: ICD-9-D-53321, ICD-9-D-53340, ICD-9-D-53341, ICD-9-D-53360, ICD-9-D-53361, ICD-9-D-53400: ICD-9-D-53421, ICD-9-D-53440, ICD-9-D-53441,ICD-9-D-53460,ICD-9-D-53461,ICD-9-D-53501,ICD-9-D-53511, ICD-9-D-53521, ICD-9-D-53531, ICD-9-D-53541, ICD-9-D-53551, ICD-9-D-53561, ICD-9-D-5789);
ICD-10-D-K922, ICD-10-D-K250, ICD-10-D-K251, ICD-10-D-K252, ICD-10-D-K254, K ICD-10-D-256, ICD-10-D-K260, ICD-10-D-K261, ICD-10-D-K262, ICD-10-D-K264, ICD-10-D-K266, ICD-10-D-K270, ICD-10-D-K271, ICD-10-D-K272, ICD-10-D-K274, ICD-10-D-K276, ICD-10-D-K280, ICD-10-D-K281, ICD-10-D-K282, ICD-10-D-K284, ICD-10-D-K286, ICD-10-D-K2901, ICD-10-D-K2921, ICD-10-D-K2961, ICD-10-D-K2991, ICD-10-D-K2981

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