

The Extent Hospital Organizational Factors Influence Inpatient Care Delivery: A Case Study Looking at Knee and Hip Replacement Surgery

Health Services Insights
Volume 15: 1–9
© The Author(s) 2022
Article reuse guidelines:
sagepub.com/journals-permissions
DOI: 10.1177/11786329221109303



Julie Ann Sakowski¹  and Paula H Song²

¹Associate Professor of Health Care Management, Appalachian State University, Boone, NC, USA. ²Richard M. Bracken Professor and Chair, Department of Health Administration, Virginia Commonwealth University, Richmond, VA, USA.

ABSTRACT: There is a body of Implementation and Dissemination research describing the importance of “context”—the characteristics describing the setting where a process or innovation occurs—when evaluating delivery, outcomes and cost of health services. These contextual factors, which can occur at the system, organization, or provider level, may either facilitate or erect barriers to the utilization of evidence-based practices and the outcomes achieved. This paper examines the influence of organizational structure and operating environment characteristics of where inpatient health care is delivered, controlling for patient and provider characteristics, on health services delivery and outcomes achieved. We used inpatient cost-of-care to represent the bundle of services provided to patients receiving primary knee and hip replacement procedures. Data includes patient level data from discharge records for 62 140 knee replacements and 42392 hip replacements from the 2015 AHRQ Healthcare Cost and Utilization Project State Inpatient Discharge database and hospital characteristics from the 2015 American Hospital Association survey. Multi-level linear estimation models controlling for patient and payer characteristics were employed to assess the impact of specific organizational and operating environment factors. We found that although patient and payer characteristics significantly impacted the inpatient cost of care, there is significant variation between hospitals and among physicians within a hospital beyond what can be explained by patient, payer and local price effect characteristics. Organizational and physician characteristics that had the most significant impact on cost of care included the volume of services provided, urban location, and for-profit ownership. These factors can inform future policy and program design and evaluation.

KEY WORDS: Practice variation, hospital cost, arthroplasty, organizational culture and climate, knee replacement cost, hip replacement cost

RECEIVED: December 30, 2021. **ACCEPTED:** May 24, 2022.

TYPE: Original Research

FUNDING: The author(s) received no financial support for the research, authorship, and/or publication of this article.

DECLARATION OF CONFLICTING INTERESTS: The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

CORRESPONDING AUTHOR: Julie Ann Sakowski, Department of Nutrition and Health Care Management, Appalachian State University Box 32168, Boone, NC 28608-2168, USA. Email: sakowskija@appstate.edu

Background

Geographical variation in health care practices such as differences in utilization of services, costs of providing services, and how these services are produced has been well documented.¹ In addition, there is an extensive and long-standing history of work examining the sources and implications of health services variation. For example, 30 years ago, Greenfield et al presented findings from the Medical Outcomes Study describing variations in resource utilization among medical specialties and systems of care.² More recently, Birkmeyer et al found that significant regional variation in surgical procedures could be attributed to attitudes and beliefs about the indications for surgery and “preference-sensitive” procedures tend to vary considerably more than procedures for which clinical decisions are constrained to a narrow range of options.³ Other studies have looked at how much variation can be explained by patient preferences versus physician practices.⁴

Purpose

It is widely accepted that observed variation in health services practices, even among physicians within the same organization, exists beyond what can be attributed to patient differences, and that this variation in practice produces little difference in outcomes.⁵ The purpose of this paper is to explore the impact of the organizational and operating environment characteristics

when evaluating variation in practices that contribute to individual (hospital or physician) behavior and, ultimately, the cost of care. This assessment will focus on 2 research questions:

- Do patient level costs vary between and within hospitals after controlling for patient characteristics and local price effects?
- Are organizational and operating environment characteristics associated with cost of care after controlling for local price effects and patient characteristics?

This paper addresses these research questions using an empirical case study to examine the impact of the organization where a physician practices on inpatient health service delivery. Although there is a body of research examining practice setting on provider behavior in the ambulatory physician practice setting, the impact on physician care delivery processes within the hospital setting is less well understood. Considering that hospital expenditures account for about one-third of all health services spending in the United States, understanding variation in how health services are performed within those settings is important for the dissemination of best practices and cost containment. This information will help guide process improvement interventions and policy development to produce higher quality, appropriate, more efficient care.⁶



This study examines routine, primary knee and hip replacement inpatient surgeries to empirically test the influence of patient, provider, and organization level contextual variables on variation in inpatient medical procedure processes. Complete knee and hip replacement procedures are a particularly relevant case study; they are commonly performed, potentially expensive and demonstrate wide variations in practices.⁷ Studies have applied activity-based costing techniques^{8,9} and examined the role of device choice and overall practices on variation in total joint replacement costs.^{8,10-13} This paper builds on this existing literature exploring variation in lower joint replacement processes and outcomes by examining the impact of organizational characteristics and operating environment characteristics such as ownership status, setting, and service volume on the delivery of inpatient knee and hip replacements, as measured by the inpatient cost of care.

Conceptual model

There is a body of Implementation and Dissemination research describing the importance of “context”—the characteristics describing the setting where a process or innovation occurs—when evaluating delivery, outcomes and cost of health services. These contextual factors, which can occur at the system, organization, or provider level, may either facilitate or erect barriers to the utilization of evidence-based practices and the outcomes achieved.¹⁴ This literature includes various models that offer a framework for understanding the relationship between how technologies, including processes and workflows, are adopted and implemented to produce outcomes. We employ a broad definition of outcomes in this study that includes the cost of care and resources used as opposed to a narrow perspective that just reflects changes in patient health status. Starting with the seminal Rogers model of dissemination that showed how knowledge and perceptions of an innovation are critical to the adoption decision and subsequent work that extended this model to health services delivery practices; these models link external factors and the operating context with what processes are used and the outcomes experienced.¹⁵⁻¹⁹ These implementation and dissemination theories and frameworks identify a variety of organizational and operating environment characteristics that may thus ultimately influence health care delivery practices.

Because the nature of health care delivery is nested; individual patients are treated by a specific physician working within a particular organization, characteristics of the individual patient, treating physician, and organization setting all have been shown to influence health services utilization, processes and outcomes. Work by Robinson et al²⁰ demonstrated the extent that these multi-level characteristics impact the variation in hip and knee replacement implantable device cost. They found that after adjusting for patient characteristics, hospital characteristics (between hospital variation) accounted for 61.0% of the variance for total knee replacement implants and

36.1% of the variance for total hip replacement implants. Residual variance attributed to individual physicians within the hospital (within hospital variation) was 36.5% of total variance for total knee replacement implants and 59.5% of total variance for total hip replacement implants.²⁰ We continue this line of work by exploring the impact of organizational structure and operating environment characteristics on variation in hip and knee replacement total inpatient cost.

Methods

This case study examined the inpatient hospital costs associated with non-emergent primary total hip replacement (THR) and total knee replacement (TKR) procedures. (ICD 9 procedure codes 81.51 and 81.54.) Hospital cost of care is used as a marker to represent the total bundle of goods and services used to provide care during a particular encounter.

Data

Patient level data on patient characteristics, procedures performed, payer, total charges, provider performing the procedure and the hospital where the procedure was performed were collected from the Healthcare Cost and Utilization Project (HCUP) State Inpatient Discharge Database (SID) for the first 9 months of 2015. The Healthcare Cost and Utilization project, sponsored by the United States Agency for Healthcare Research and Quality, is “the largest collection of longitudinal hospital care data in the United States, with all-payer, encounter level information beginning in 1988.”²¹

This analysis utilized inpatient patient discharge records from a convenience sample of 3 states: Florida, New York, and Washington. These states were chosen because their inpatient discharge database files included coded physician identifiers, permitting physician-within-hospital analysis. The first three quarters of 2015 were used to ensure the maximum number of cases without external confounding factors. 2015 was chosen as the study year because a major federal reimbursement policy change was implemented in 2016. Discharge records for the fourth quarter of 2015 were excluded because of the transition to recording procedures using ICD-10, making procedure coding between the 2 time periods inconsistent.

The state-specific files in the HCUP SID contains inpatient discharge record abstracts from participating states that provides complete information on all hospital discharges within geographic areas or states. The SID patient level data was linked with de-identified hospital characteristic information from the 2015 American Hospital Association Hospital (AHA) survey of all AHA member hospitals and includes data on approximately 80% of US hospitals. This SID-AHA linked dataset includes information on all discharges, regardless of payer and includes identifiers that enables clustering of patients by primary physician.

Our dataset contained discharge records for 62 140 patients who had elective knee and 42 392 hip replacements

Table 1. Explanatory variables.

FIRST LEVEL (PATIENT LEVEL) COVARIATES	REFERENCE SOURCE
Gender, difference in age from population mean, number of chronic conditions, obesity, primary payer, procedure performed on a single joint or bilaterally	Gioe et al, ¹⁰ Maradit Kremers et al, ¹¹ Riggs et al, ²² Collado, ²³ and Martin ²⁴
Second' Level (physician level) Covariates	
High volume provider, low volume provider Mean patient age diff, mean number of chronic conditions, mean number of patients obese, percentage female, percentage covered by Medicare, percentage covered by Commercial Insurance	Gioe et al ¹⁰ and Maradit Kremers et al ¹¹
Third Level (hospital level) Covariates	
Metropolitan, rural, ownership type, hospital size, critical access hospital, high volume hospital, low volume hospital, medical school affiliation, within a network, participate in group purchasing agreement, location state	Rodriguez et al, ²⁵ Goodwin et al, ²⁶ Lampert et al, ²⁷ and Losina et al ²⁸

as their primary procedure during the first 3 quarters of 2015. Patients whose procedures were performed on a non-scheduled or emergent basis were excluded because they would potentially involve complicating factors such as infection or breaks. We excluded patients who died during their hospital stay from our sample since that may artificially truncate their hospital costs. Facilities that had less than 5 knee or hip replacement discharges during our sample period were not included in our analysis to reduce the potential skewing impact of outliers. This resulted in 51 facilities (305 records) being excluded from the hip replacement analysis and 18 facilities (47 records) from the knee replacement analysis.

Measures

Dependent variable. Our dependent variable of interest is the hospital cost of care associated with elective, uncomplicated primary THR and TKR. Total costs were calculated by multiplying total inpatient facility charges per discharge by the hospital specific cost to charges ratio (CCR). We used the Medicare Geographical Adjustment Factor (GAF) to normalize the inpatient cost of care measure by accounting for local wage and price effects.

$$\text{Normalized cost} = (\text{Inpatient charges} * \text{CCR}) / \text{GAF}$$

Explanatory variables. We included explanatory variables that reflect patient level, physician level and hospital level characteristics (Table 1). Table 1 references the literature that guided our choice of contextual characteristics to include as explanatory variables. These variables include measures of patient characteristics and health status, payer status, hospital location, ownership and medical school affiliation, and quantity of the procedures performed. Hospitals that performed less than 2 procedures per week were categorized as “low” volume hospitals and those that performed more than 10 per week were classified as a “high” volume hospital.

Analysis strategy

Multi-level models. As demonstrated by the Robinson et al work, variation in hip and knee replacement costs vary among patients, between and within hospitals. This demonstrates the nested nature of health services delivery and that there is dependence among individual level cost information for patients treated by a given physician within a particular hospital. Standard Ordinary Least Squares (OLS) regression estimations do not consider this interdependence, thus misestimating the standard errors. Multilevel modeling enables us to include the fixed and random effects from each of the clustering levels, enabling the standard errors to be corrected for intraclass correlation inherent in the clustered data.^{29,30} We followed standard multi-level mixed effects analyses techniques.^{29,30} All analyses were performed using the mixed process in STATA version 15.

The Impact of physician and hospital characteristics on patient level costs. To evaluate the impact of hospital and provider characteristics on individual costs after controlling for patient characteristics and price effects, we performed a 3-level estimation of a random intercept model with level 1, 2, and 3 fixed covariates. Level 1 is patient level characteristics, who are treated by a specific physician (level 2) in a particular hospital (level 3). This included fixed patient level effects, fixed categorical physician descriptors of whether the physician performed <6 (low volume) or more than 100 (high volume) procedures, and fixed hospital characteristics. The intercepts for hospital and physician were assumed to be random. This enabled us to answer how much variation in costs is within hospitals as opposed to between hospitals, controlling for these fixed effects.

The impact of hospital characteristics on physician mean costs. To evaluate the impact of hospital characteristics, we used a 2-level model using physician-within-a-hospital specific mean costs as the dependent variable. Fixed effects included the mean characteristics of the physician's patient population and key hospital characteristics. The hospital was treated as a random coefficient.

The contents of each of these estimating models are summarized in Table 2. Variable name subscripts indicate the

Table 2. Estimation models.

	ESTIMATION 1	ESTIMATION 2
<i>Dependent variables</i>		
Normalized_cost _{ijk}	X	
Normalized_mean_cost _{jk}		X
<i>Explanatory variables</i>		
Fixed		
Difference_from_pop_mean (in 5 year increments) _{ijk}	X	
Female _{ijk}	X	
Number of chronic conditions _{ijk}	X	
Obese _{ijk}	X	
Primary Payer indicator (compared to Medicare) _{ijk}	X	
Low volume physician _{jk}	X	X
High volume physician _{jk}	X	X
Bilateral Procedure _{ijk}	X	
State indicator (compared to Florida)	X	X
Member of a group purchasing collab _k	X	X
Member of a network _k	X	X
Government controlled _k	X	X
NFP—religious affiliation _k	X	X
For-profit _k	X	X
Contract-managed _k	X	X
Less than 100 beds _k	X	X
Metropolitan facility _k	X	X
Rural indicator _k	X	X
Critical Access Hospital _k	X	X
Medical School Affiliation _k	X	X
Low volume hospital _k (<2 procedures/wk)	X	X
High volume hospital _k (>10 procedures per week)	X	X
Computer Assisted Orthopedic Surgery _k	X	X
Mean cost _{jk}		X
Mean age diff _{jk}		X
Mean number of comorbidities _{jk}		X
Random		
Hospital id (intercept)	X	X
MD within a hospital ID (intercept)	X	

Table 3. Characteristics of patient population in study sample.

	KNEE REPLACEMENT	HIP REPLACEMENT
N	62 140	42 392
Hospitals	322	308
Physician/Hospital Pairs	2879	2296
Avg Cost—Single joint (price effects normalized)	\$15 361	\$16 047
Avg Cost—Bilateral procedure (price effects normalized)	\$24 939	\$26 766
% Procedures bilateral	4%	1%
% Female	64%	55%
Avg age	67	65
Mean number of chronic conditions	5.17	4.90
% Obese	29%	21%
Primary payer	61% Medicare 5% Medicaid 33% Commercial 1% Other	55% Medicare 6% Medicaid 38% Commercial 1% Other

“level” of data. For example, *ijk* indicates data from patient *i* being treated by physician *j* at hospital *k*. Subscript *jk* indicates data on physician *j* practicing in hospital *k*.

Results

Description of patient population

Table 3 describes the characteristics of our study population. The primary payer sources were Medicare and commercial insurance. Of the 62 140 knee replacement procedures performed, 59 585 replaced a single knee and 2 555 were bilateral procedures replacing both knee joints. Patients undergoing knee replacements ranged in age from 12 to 93 and had between 0 and 18 chronic conditions. Of the 42 493 hip replacement procedures, 41 909 involved replacement of a single hip and 483 replaced both hips during the procedure. Patients undergoing hip replacement procedures ranged in age between 11 and 101 and had between 0 and 23 chronic conditions.

Variation in inpatient cost for knee and hip replacement

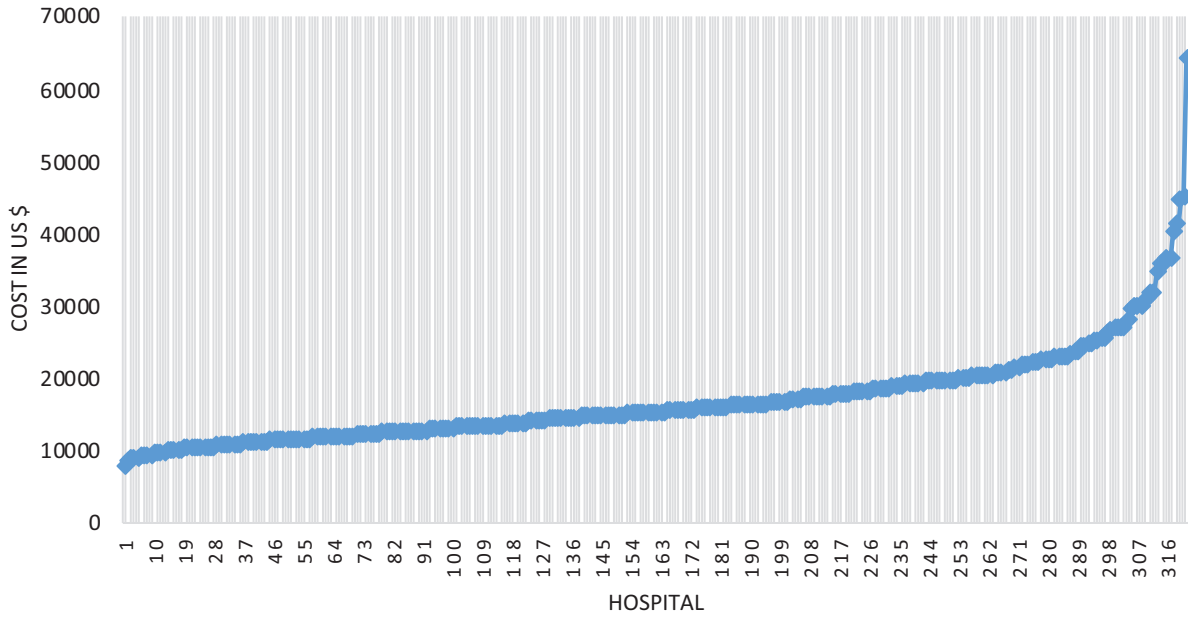
Figure 1 displays the variation in the average inpatient cost of care for providing uncomplicated primary knee and hip replacement procedures for each of the hospitals in our sample. To demonstrate the magnitude of variation in costs incurred between hospitals, these figures are not adjusted for local price effects. As the figures show, there is a significant variation in the cost of care among hospitals. The average hospital inpatient cost for performing a single knee replacement (ie, left or right knee) ranged from \$7860 to \$64 100 and \$8100 to 60 000 for performing a single hip replacement.

Do patient level costs vary between and within hospitals after controlling for local price effects?. We performed a regression of the patient level price normalized cost of care dependent variable using hospital and physician as random effects as the sole explanatory variables. The intraclass correlation coefficients from this regression showed that 78% of the variation in price normalized knee replacement costs occurs between and within hospitals. Differences among hospitals account for 46% of the variation in price-normalized costs and the remaining 32% is among physicians operating within the same hospital. Similarly, 84% of the variation in price normalized hip replacement costs is between and within hospitals. Between hospital variation accounts for 36% of the variation and 48% of the variation occurs among physicians operating within the same hospital.

The impact of organizational and operating environment characteristics on inpatient cost of care after controlling for local price effects and patient characteristics. The results of the 3-level estimation of patient level costs including patient, physician and hospital covariates are shown in the between hospital costs columns in Table 4. Patient characteristics influenced total cost of care for both knee and hip replacements. Increasing age had a small negative impact on costs. Medicaid coverage (the government sponsored insurance program for low-income individuals) had a small but positive effect on cost when compared to patients covered by Medicare and commercial insurance. Number of chronic conditions and obesity had a small but positive impact on costs.

Physician procedure volume produced a much greater impact on cost of care than the patient characteristics. The costs for high volume producing physicians (greater than 100 procedures in our sample) were lower, however the physicians

AVERAGE INPATIENT COST FOR A SINGLE KNEE REPLACEMENT BY HOSPITAL



AVERAGE INPATIENT COST FOR A SINGLE HIP REPLACEMENT

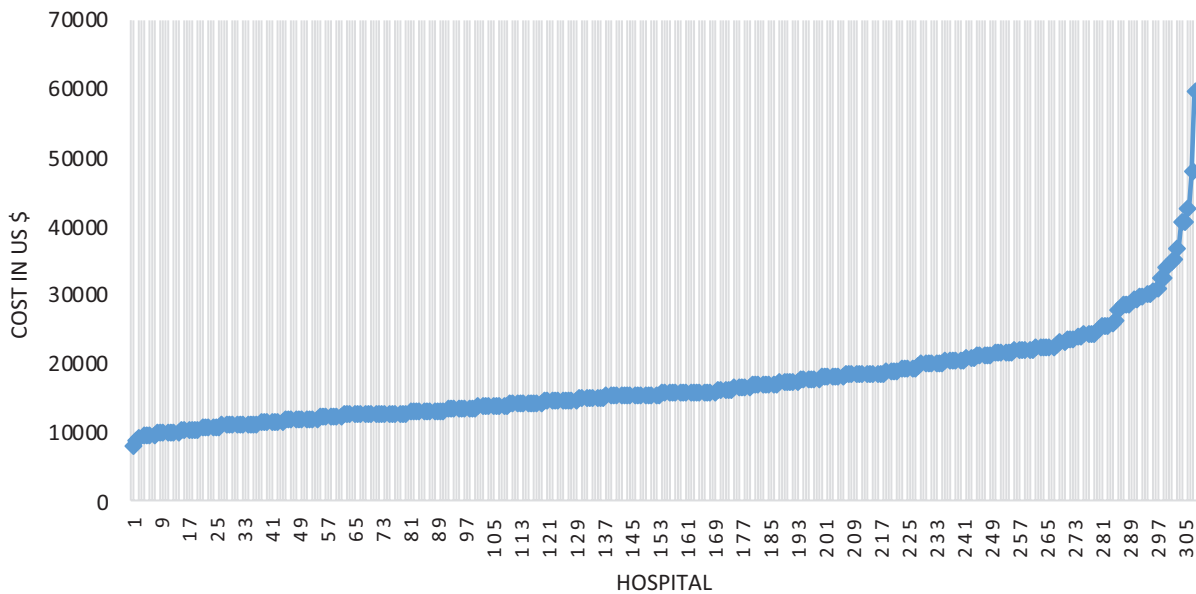


Figure 1. Variation in average cost to perform a joint replacement by hospital.

who performed very few procedures (less than 5) at a hospital had significantly higher costs.

Hospital characteristics did influence the overall cost variation. However, the effect of hospital location and operating environment seemed to have a greater influence than organizational characteristics such as ownership structure, network or medical school affiliation and technology adoption. The

hospital characteristics that produced the largest effects were whether the hospital was located in a metropolitan area (negative impact on cost) and classification as a critical access hospital (positive impact on cost). Hospital ownership status produced mixed results. For-profit ownership had a strong negative effect, but public or religious ownership, network or medical school affiliation did not produce a statistically

significant impact on cost. Lastly, the state where the hospital was located suggests the regional operating environment may impact inpatient costs. Hospitals in the state of Washington experienced significantly higher costs for both knee and hip replacement than both Florida and New York, even after adjusting costs for local price effects using the Medicare geographical adjustment factor.

Organizational characteristics associated with physician specific cost of care. The results of the 2-level model estimating the impact of physician procedure volume, physician patient population characteristics, and hospital characteristics on physician mean total costs are shown in the within hospital variation columns in Table 4. Physician specific costs were significantly driven by the patient characteristics and the volume of procedures performed by the physician. Metropolitan setting and for-profit ownership were associated with significantly lower costs and being a critical access hospital or within Washington had a strong positive impact on cost. A measure used as a proxy for hospital management and technology investment policies - offering computer assisted orthopedic surgery - did not seem to impact physician practices nor costs. This does suggest that, even for correcting for local price effects and patient characteristics, physician behaviors and production choices are impacted by the hospital setting.

Discussion

Variation in health care delivery and possible inefficiencies therein persist despite decades of work documenting and cataloging the variation. Despite recent movements to introduce systematic changes in the delivery of health care by altering incentives and implementing initiatives to curtail the use of practices not supported by evidence (eg, pay for performance, formation of Accountable Care Organizations and medical homes, public campaigns to reduce the use of low value or non-evidence based practices such as “Choosing Wisely”) the change in practice has been slow. Although underlying conceptual models theorize that adoption decisions are influenced by the strength of supporting evidence, the literature provides examples of practices that have either weak supporting evidence or have been disproven that continue to be used. Factors that have been associated with reluctance to de-adopt existing practices include fear of malpractice, lingering consumer preferences, and uncertainty about the evidence.^{31,32}

This study adds to the existing literature documenting variation between and within hospitals on the knee and hip replacement costs by providing insight into the impact of organizational structure and operating environment. A fuller understanding of the factors that contribute to variation will enable us to predict the impact of policy changes and design policies that provide the correct incentives. We chose hip and knee replacement procedures as our case study with the intent to start with the common, to inform production decisions for the innovative.

We found that there is indeed significant variation in the cost of care between hospitals and that hospital characteristics impact the mean cost of providing uncomplicated knee and hip replacement procedures, even after controlling for local price effects and patient characteristics. We find that costs had an inverse relationship with volume of procedures performed, both by the primary physician and the hospital itself. This finding points to possible operating economies of scale or cost efficiencies realized by higher volume providers. Hospital ownership control and setting were also found to have a significant impact on costs. For-profit hospitals and those located in urban markets were found to have lower costs. Critical access hospitals were found to have higher costs, consistent with the incentives under the Medicare cost-based reimbursement model in which critical access hospitals operate.

In addition to variation in cost of care among hospitals, we found significant variation in costs among physicians practicing within an individual hospital. Variation in practice may be expected, and appropriate, depending on patient characteristics, needs and preferences. However, our findings suggest that, even for correcting for local price effects and patient characteristics, physician behaviors and production choices vary, impacting cost of care.

The findings from this study demonstrate the need to consider the broader organizational and management context when designing interventions to influence provider practice and evaluations of health services delivery. As noted health economist and policy expert Uwe Reinhardt wrote, “Understanding what motivates physician behavior is needed to . . . understand what policy levels may be used to influence physician practice.”³³

This is the first step in identifying which factors promote appropriate use, identifying organizational factors that facilitate knowledge transfer and implementation of best practices, which characteristics increase efficiency and improve outcomes.

There are some important limitations of this data and our analyses. The SID provides discharge data for services provided on an inpatient basis. Thus, we are unable to compare joint replacement costs performed in the ambulatory versus inpatient setting. Our dataset contains limited information on specific physician characteristics, such as years in practice and hospital specific managerial and governance policies. This leaves substantial within-hospital variation still unexplained and additional nuances to be explored. We do not have data on outcomes, so we cannot draw any conclusions on the differences in costs and “appropriateness” of variation. Drawing conclusions on what variation is “appropriate” is beyond the scope of this study but should be the focus of future work. Lastly, our analysis focused on the patient’s primary physician while in the hospital. There may be multiple providers ordering services for the patient. Isolating the impact of the decisions made by “primary” provider from decisions made by other treating physicians is beyond the scope of this study.

Table 4. Multilevel predictors of knee and hip replacement cost.

DEPENDENT VARIABLE	KNEE REPLACEMENT			HIP REPLACEMENT		
	BETWEEN HOSPITAL VARIATION (ESTIMATION 1)		WITHIN HOSPITAL VARIATION (ESTIMATION 2)	BETWEEN HOSPITAL VARIATION (ESTIMATION 1)		WITHIN HOSPITAL VARIATION (ESTIMATION 2)
	PRICE NORMALIZED PATIENT LEVEL COST OF CARE	P > Z	PRICE NORMALIZED PHYSICIAN MEAN COST	PRICE NORMALIZED PATIENT LEVEL COST OF CARE	P > Z	PRICE NORMALIZED PHYSICIAN MEAN COST
B		B	B	B	B	B
Bilateral Procedure	9056.2	<.01	3251.1	10656.5	<.01	10469.6
Female	-173.8	<.01	-	-30.8	.39	-
5 year difference age > mean	-116.4	<.01	-	-115.6	<.01	-
Number of chronic conditions	203.9	<.01	-	199.5	<.01	-
Obese	111.5	<.01	-	214.6	<.01	-
Medicaid	294.6	<.01	-	227.3	.01	-
Commercial insured	5.13	.89	-	-33.36	.45	-
Self-pay	103.7	.54	-	272.8	.12	-
Discharged to another HC facility	903.1	<.01	-	1238.1	<.01	-
Low volume physician	2516.7	<.01	2257.6	2874.5	<.01	2652.3
High volume physician	-744.7	.09	-749.6	-1436.9	.03	-1369.6
Florida	-682.9	.30	-192.3	-679.8	.38	-687.3
Washington	3869.4	<.01	3998.8	4173.4	<.01	3940.4
Public hospital	-1381.1	.09	-1378.4	-1018.1	.30	-1040.4
Religious-affil. hospital	-1628.5	.04	-1780.1	-1280.4	.17	-1321.9
For-profit	-3956.9	<.01	-3402.5	-2654.9	.01	-1990.3
Network member	-705.1	.22	-838.9	-563.9	.40	-562.8
Contract managed	1518.9	.28	1427.9	753.8	.65	989.9
Small hospital	46.3	.95	409.1	39.0	.89	203.1
Metropolitan setting	-3674.6	<.01	-3107.3	-4715.1	<.01	-4354.5
Rural setting	-4487.5	.06	-3751.7	418.3	.87	392.4
Critical Access hospital	9555.2	<.01	9701.7	6358.9	<.01	7332.6
Medical School Affil.	336.9	.55	387.2	61.6	.93	-250.8
Low volume hospital	2285.9	<.01	2326.3	353.7	.60	477.8
High volume hospital	57.8	.94	-32.5	348.5	.29	607.2
Hospital has computer assist. Ortho surg	377.1	.64	321.5	815.9	.23	927.3
Mean # chronic conditions in practice	-	-	980.6	-	-	959.0
Mean age difference in practice	-	-	-91.6	-	-	24.8
Percentage practice Medicare insured	-	-	43.7	-	-	-6817.2
Percentage practice Commercial Insured	-	-	-458.4	-	-	-6528.3
Percentage female in practice	-	-	-1025.7	-	-	-253.3
Percentage obese	-	-	-1179.7	-	-	-103.7
Constant	18370.8	<.01	14997.9	19721.4	<.01	22139.2

Statistically significant variables with a P < 0.05 are highlighted in bold.

Conclusions

This line of research provides an exploratory look at the factors that may be influencing the variation in inpatient hospital cost of care. These findings provide a foundation for understanding the organizational structure and operating environment on health services delivery. The findings presented in this study provide useful insight into the high-level organizational characteristics on physician care delivery choices and patient costs. Our findings underscore the importance of considering organizational factors in future policy and program design.

Author Contributions

Dr. Sakowski was responsible for study design, data collection & analysis, interpretation and manuscript preparation. Dr. Song contributed to the study design, data collection, interpretation and manuscript preparation.

ORCID iD

Julie Ann Sakowski  <https://orcid.org/0000-0001-9740-4180>

REFERENCES

- Reschovsky JD, Hadley J, O'Malley AJ, Landon BE. Geographic variations in the cost of treating condition-specific episodes of care among Medicare patients. *Health Serv Res.* 2014;49:32-51.
- Greenfield S, Nelson EC, Zubkoff M, et al. Variations in resource utilization among medical specialties and systems of care. Results from the medical outcomes study. *JAMA.* 1992;267:1624-1630.
- Birkmeyer JD, Reames BN, McCulloch P, Carr AJ, Campbell WB, Wennberg JE. Understanding of regional variation in the use of surgery. *Lancet.* 2013;382:1121-1129.
- Cutler D, Skinner J, Stern AD, Wennberg D. Physician beliefs and patient preferences: a new look at regional variation in health care spending. *National Bureau of Economic Research Working Paper 19320*, August 2013, Revised December 2017.
- Zuckerman S, Waidmann T, Berenson R, Hadley J. Clarifying Sources of geographic differences in Medicare spending. *N Engl J Med.* 2010;363:54-62.
- Paxton EW, Inacio MC, Khatod M, Yue EJ, Namba RS. Kaiser Permanente National Total Joint Replacement Registry: aligning operations with information technology. *Clin Orthop Relat Res.* 2010;468:2646-2663.
- Schwartz AM, Farley KX, Guild GN, Bradbury TL Jr. Projections and epidemiology of revision hip and knee arthroplasty in the United States to 2030. *J Arthroplasty.* 2020;35:S79-S85.
- Haas DA, Kaplan RS. Variation in the cost of care for primary total knee arthroplasties. *Arthroplast Today.* 2017;3:33-37.
- Akhavan S, Ward L, Bozic KJ. Time-driven activity-based costing more accurately reflects costs in arthroplasty surgery. *Clin Orthop Relat Res.* 2016;474:8-15.
- Gioe TJ, Sharma A, Tatman P, Mehle S. Do "premium" joint implants add value?: analysis of high cost joint implants in a community registry. *Clin Orthop Relat Res.* 2011;469:48-54.
- Maradit Kremers H, Visscher SL, Moriarty JP, et al. Determinants of direct medical costs in primary and revision total knee arthroplasty. *Clin Orthop Relat Res.* 2013;471:206-214.
- Haas DA, Bozic KJ, DiGioia AM, Song Z, Kaplan RS. Drivers of the variation in prosthetic implant purchase prices for total knee and total hip arthroplasties. *J Arthroplasty.* 2017;32:347-350.e343.
- Song PH, Reiter KL, Yu W. High-tech versus high touch: components of hospital costs. *ASHEcon 2014 Biennial Meeting, June 24, 2014*; Los Angeles, CA.
- Wolk CB, Powell BJ, Beidas RS. Contextual influences and strategies for dissemination and implementation in Mental Health. *Oxford Handbooks Online.* Oxford University Press; 2015.
- Kitson A, Harvey G, McCormack B. Enabling the implementation of evidence based practice: a conceptual framework. *Qual Health Care.* 1998;7:149-158.
- Krein SL, Olmsted RN, Hofer TP, et al. Translating infection prevention evidence into practice using quantitative and qualitative research. *Am J Infect Control.* 2006;34:507-512.
- Damschroder LJ, Aron DC, Keith RE, Kirsh SR, Alexander JA, Lowery JC. Fostering implementation of health services research findings into practice: a consolidated framework for advancing implementation science. *Implement Sci.* 2009;4:50.
- Rogers EM. *The Diffusion of Innovations.* 5th ed. Free Press; 2003.
- Tomoaia-Cotisel A, Scammon DL, Waitzman NJ, et al. Context matters: the experience of 14 research teams in systematically reporting contextual factors important for practice change. *Ann Fam Med.* 2013;11:S115-123.
- Robinson JC, Pozen A, Tseng S, Bozic KJ. Variability in costs associated with total hip and knee replacement implants. *J Bone Joint Surg Am.* 2012;94:1693-1698.
- HCUP Overview. Healthcare cost and utilization project (HCUP). Published 2022. Accessed February 5, 2022. www.hcup-us.ahrq.gov/overview.jsp
- Riggs RV, Roberts PS, Aronow H, Younan T. Joint replacement and hip fracture readmission rates: impact of discharge destination. *PM R.* 2010;2:806-810.
- Collado M. Patient health causes substantial portion of geographic variation in Medicare costs. *Find Brief.* 2013;16:1-4.
- Martin JR, Jennings JM, Dennis DA. Morbid obesity and total knee arthroplasty: a growing problem. *J Am Acad Orthop Surg.* 2017;25:188-194.
- Rodriguez HP, von Glahn T, Rogers WH, Safran DG. Organizational and market influences on physician performance on patient experience measures. *Health Serv Res.* 2009;44:880-901.
- Goodwin JS, Lin YL, Singh S, Kuo YF. Variation in length of stay and outcomes among hospitalized patients attributable to hospitals and hospitalists. *J Gen Intern Med.* 2013;28:370-376.
- Lampert R, Wang Y, Curtis JP. Variation among hospitals in selection of higher-cost, "higher-tech," implantable cardioverter-defibrillators: data from the National Cardiovascular Data Registry (NCDR) implantable Cardioverter/Defibrillator (ICD) Registry. *Am Heart J.* 2013;165:1015-1023. e2.
- Losina E, Walensky RP, Kessler CL, et al. Cost-effectiveness of total knee arthroplasty in the United States: patient risk and hospital volume. *Arch Intern Med.* 2009;169:1113-1121; discussion 1121-1112.
- Rabe-Hesketh S, Skrondal A. *Multilevel and Longitudinal Modeling Using Stata; Volume 1: Continuous Responses.* 3rd ed. Stata Press; 2012.
- Raudenbush SW. *Hierarchical Linear Models: Applications and Data Analysis Methods.* SAGE Publications; 2002.
- Born KB, Coulter A, Han A, et al. Engaging patients and the public in Choosing wisely. *BMJ Qual Saf.* 2017;26:687-691.
- Zikmund-Fisher BJ, Kullgren JT, Fagerlin A, Klamerus ML, Bernstein SJ, Kerr EA. Perceived barriers to implementing individual choosing Wisely® recommendations in two national surveys of primary care providers. *J Gen Intern Med.* 2017;32:210-217.
- Reinhardt UE. The Economist's model of Physician Behavior. *JAMA.* 1999;281:462-465.