Inconsistent Surgical Implant Documentation: A Case Study in Total Knee and Hip Arthroplasty

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ABSTRACT: Value-based care initiatives require accurate quantification of resource utilization. This study explores hospital resource documentation performance for total knee and hip arthroplasty (TKA, THA) implants and how this may differ between hospitals. This retrospective study utilized the Premier discharge database, years 2006 to 2020. TKA/THA cases were categorized into 5 tiers based upon the completeness of implant component documentation: Platinum, Gold, Silver, Bronze, Poor. Correlation between TKA and THA documentation performance (per-hospital percentage of Platinum cases) was assessed. Logistic regression analyses measured the association between hospital characteristics (region, teaching status, bed size, urban/rural) and satisfactory documentation. TKA/THA implant documentation performance was compared to documentation for endovascular stent procedures. Individual hospitals tended to have very complete (Platinum) or very incomplete (Poor) documentation for both TKA and THA. TKA and THA documentation performance were correlated (correlation coefficient = .70). Teaching hospitals were less likely to have satisfactory documentation for both TKA ($P = .002$) and THA ($P = .029$). Documentation for endovascular stent procedures was superior compared to TKA/THA. Hospitals' TKA and THA-related implant documentation performance is generally either very proficient or very poor, in contrast with often well-documented endovascular stent procedures. Hospital characteristics, other than teaching status, do not appear to impact TKA/THA documentation completeness.

KEYWORDS: Implant documentation, total knee replacement, total hip replacement, resource attribution, value-based care

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Introduction

Motivation

Health systems continuously aim to improve their analytical insight through the merging of core business information systems.[1] For example, integrating enterprise resource planning applications and the electronic health record enriches patient health data in regard to resource utilization and internal cost information. Accurate internal cost data is necessary in the pursuit to measure, monitor, and minimize the cost of care, while maintaining quality.[2] Specifically, such data is integral to value-based care performance initiatives which have been pioneered in select clinical contexts, especially high-volume procedures that have substantial per-procedure cost variation,[3,4] such as total knee and hip arthroplasty (TKA, THA) surgery.

To support discussions on value, hospital supply chains often provide utilization and hospital internal cost statistics for resources used to treat patients. However, the granularity of this data can be suboptimal as the documentation of acute care episodes is rarely, if ever, performed with the thought of future supply chain analyses in mind. In fact, many American hospitals employ third-party proprietary organizations, such as Premier, to help them assess their complicated and chaotic cost/charge data. In the fractured American healthcare environment, charges for a specific treatment, such as a TKA operation, may differ on the order of degrees depending on the insurance status of the patient. Hospitals maintain an in-house list of token prices for specific treatments, called chargemasters, though these prices are often artificially inflated, used as a means of a negotiation tactic with payers, and are typically only reserved for uninsured or self-pay patients. Scattered negotiations occur between hospitals, insurers, and vendors. Companies like Premier collect data from many hospitals and provide hospitals with general data on costs across American hospitals, thereby providing individual hospitals with the industry information to improve efficiency within their organization.

Overall, this complicated cost and charge ecosystem may negatively impact hospitals' ability to achieve increased standardization of resource utilization,[5,6] a necessary intermediate goal given the industry's trend toward value-based care. Indeed, various reports have noted challenges in the pursuit of value-based care relating to the inability to attribute costs to specific patient cases.[7,8] Errors in cost and charge attribution could occur at many steps, often dependent on hospital-specific processes and flows. In surgical cases involving implants, the first step in accurate cost attribution involves the adequate documentation of implants. As a result, this study aims to explore hospital resource documentation performance for TKA and THA implants and how this may differ between hospitals.

Methods

Study design, data source, and study sample

After obtaining Institutional Review Board approval, this retrospective cohort study leveraged the Premier Healthcare Database. This database is generated by Premier network member hospitals. Hospitals join the network voluntarily (for a fee) and share their proprietary data. In return, hospitals receive information and benchmarks about their own performance, relative to their competitors, on a number of dimensions. The Premier network includes more than 4000 hospitals representing over 121 million inpatient admissions.[9] Premier aggregates and normalizes all chargemaster-level data related to each hospital encounter across all members to create its benchmarks and reports. Premier anonymizes hospitals and standardizes chargemaster terminology.

All TKA and THA procedures performed from January 2006 to June 2020 were included. Cases were identified based on Diagnosis-Related Group (DRG) codes, 469 and 470, "Major Joint Replacement with or without a major complication." Cases were further differentiated into TKA and THA cases using International Classification of Diseases, 9th (ICD-9) and 10th (ICD-10) revision codes (TKA: ICD-9 81.54, ICD-10 0SRC0xx, ICD-10 0SRD0xx; THA: ICD-9 81.51, ICD-10 0SRB0xx, ICD-10 0SR90xx). Encounter identifiers, hospital identifiers and characteristics, and standardized chargemaster descriptions were obtained.

Study variables

The primary outcome of interest was a hospital's performance on chargemaster documentation of implants used in TKA/THA surgery, as outlined below. Other study variables included hospital characteristics, namely geographic region, teaching status, bed size, urban/rural designation, and cost structure (procedural vs ratio of cost to charges).

Defining hospital implant documentation performance

Standard charge descriptions for TKA and THA were inspected and classified as a core component, a total system, an unspecified component, or an ancillary resource. The classification system employed is based on the premise that a TKA or THA procedure requires a set of core implants to complete the procedure. The TKA uses 4 core components: articulating surface/insert, femoral component, patellar component, and tibial baseplate. Similarly, THA utilizes 4 core components: femoral stem, a femoral head, an acetabular liner, and an acetabular cup. Arthroplasty procedures cannot be performed without these components. However, some hospitals document the 4 components together with one charge as a "total system." As such, it is expected that hospitals will either charge the 4 components or just the "total system." In some cases, standard chargemaster descriptions observed in the database were found to be vague or incomplete, for example, "Ortho Implant," "Ortho Hip Implant," or "Ortho Knee Implant." These charges were classified as unspecified components. Ancillary resources (eg, "Implant Ortho Connector") were excluded from analysis. Table 1 details the classification schema and corresponding examples of standard chargemaster descriptions.

Table 1. Example standard charge descriptions.

TOTAL KNEE ARTHROPLASTY	
Four-component	
Articulating surface/ Insert	Implant knee articulating surface
Femoral component	Implant knee femoral
Patella component	Implant knee patella
Tibial baseplate	Implant knee tibial component
Total system	Implant knee total
Unspecified component	Implant knee unspecified piece
Total hip arthroplasty	
Four-component	
Acetabular cup	Implant hip acetabular cup
Acetabular liner	Implant hip acetabular liner
Femoral head	Implant hip femoral head
Femoral stem	Implant hip femoral stem
Total system	Implant hip total
Unspecified component	Implant hip unspecified piece

For each TKA or THA procedure, a grading system was applied to describe the level of documentation completeness. Each case was labeled as follows: (1) *Platinum* if either a total system or all 4 core component charges were identified, (2) *Gold* if 3 of the 4 core components and at least one unspecified implant charge were identified, (3) *Silver* if 2 of the 4 core components and 2 or more unspecified implant charges were identified, (4) *Bronze* if 1 of the 4 core components and 3 or more unspecified implants were identified, along with any cases that had 4 or more unspecified implant charges and that did not

meet the criteria of any higher standard, and (5) *Poor* for all other cases not meeting criteria for any of the other standards. This grading system was created by the authors to assist in conceptualizing the spectrum of documentation performance.

Analysis

For both TKA and THA, documentation performance was compared across all hospitals. Documentation performance was assessed for each hospital via the Platinum percentage, that is, the fraction of all procedures performed at each unique hospital that were classified as Platinum, the highest standard of documentation. Because the expectation is for hospitals to document each used implant item perfectly, the Platinum percentage alone was chosen to reflect documentation performance.

Overall Platinum percentages, for both TKA and THA, were calculated for each hospital across all years, and the frequencies of Platinum percentages were plotted. To explore how documentation trends may have changed over time, TKA and THA Platinum percentages were calculated for each hospital by year and were similarly plotted. The correlation between a hospital's documentation performance for TKA and THA was assessed by applying a Pearson correlation analysis. Logistic regression analyses were conducted to evaluate the association between satisfactory hospital documentation performance by hospital characteristics, such as urban/rural location, geographic region, teaching status, cost structure, and size as defined by number of beds. Satisfactory documentation performance was considered to be a Platinum percentage >50%; this cutoff was chosen as a result of the bipolar clustering of hospital Platinum percentage at extremely high or low percentages. Odds ratios (OR) and 95% confidence intervals are reported.

Endovascular stent comparison

Because the standards of documentation used for TKA and THA were generated de novo in this study, documentation performance was assessed for endovascular stenting procedures to establish a reference benchmark for implant documentation. Endovascular stent documentation was selected as a comparison procedure as it requires less complex core component documentation (just the stent), is a non-orthopedic procedure, and is ascertainable in the Premier database. Cases labeled with DRG 247: "Percutaneous Cardiovascular Procedures with Drug-eluting Stent without Major Complication or Comorbidity" were included in analysis. A case was considered to have complete (Platinum) documentation if it had at least one charge described as a stent. The Platinum percentage for each hospital was calculated and plotted.

All analyses were conducted using SAS version 9.4 (SAS Institute, Cary, NC).

Results

Overall, 1 821 279 TKA cases and 1 057 266 THA cases were included representing 992 unique hospitals. The majority of cases were labeled as either Platinum or Poor (Table 2). The distribution of individual hospital Platinum percentage was not normally distributed, with a disproportionate number of hospitals yielding a percentage of 0% to 10% and 91% to 100% (Figure 1a and b). This bimodal pattern was exaggerated upon analysis of hospital performance by year with at least 48% of hospitals demonstrating a 0% to 10% or 91% to 100% Platinum percentage in every year for both TKA and THA. Interestingly, the bimodal distribution marginally decreased across the period of analysis for both TKA and THA.

Hospital-specific platinum percentages for TKA were positively correlated with hospital-specific platinum percentages for THA (Pearson correlation coefficient = .70, $P < .0001$).

The logistic regression analyses (Table 3), assessing hospital characteristics with satisfactory documentation for TKA and THA, show that there were no meaningful between-hospital differences by hospital bed size or urban/rural designation. Hospitals located in the West were more likely to have satisfactory documentation for TKA relative to all other regions except the South for THA. Teaching (compared to non-teaching) hospitals were less likely to have satisfactory documentation for both TKA and THA.

Table 2. Overall case distribution by documentation levels.

	TKA (N = 1 821 279)	THA (N = 1 057 266)
Platinum	847 782 (46.6%)	513 011 (48.5%)
Gold	103 505 (5.7%)	77 207 (7.3%)
Silver	24 014 (1.3%)	17 281 (1.6%)
Bronze	79 119 (4.3%)	39 092 (3.7%)
Poor	766 859 (42.1%)	410 675 (38.8%)

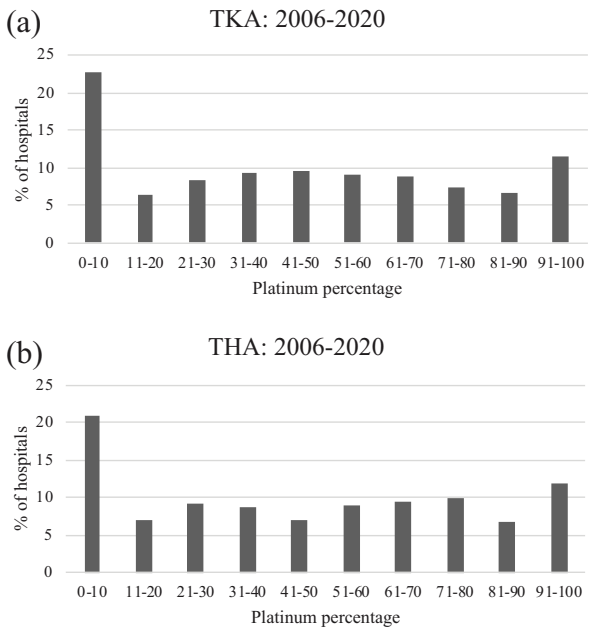

Figure 1. Distribution of % platinum cases by hospital. (a) TKA and (b) THA.

Table 3. Logistic regression results of hospital characteristics and satisfactory TKA and THA documentation (>50% Platinum).

			TKA			THA		
		# Hospitals	OR	95% CI	*P*-value	OR	95% CI	*P*-value
Urban/Rural	Urban	750	Ref	-	-	Ref	-	-
	Rural	242	1.00	0.75-1.35	.987	1.12	0.84-1.51	.431
Hospital Region	West	176	Ref	-	-	Ref	-	-
	Northeast	149	0.48	0.31-0.75	.001	0.51	0.32-0.79	.003
	Midwest	250	0.42	0.28-0.62	<.001	0.45	0.30-0.67	<.001
	South	417	0.63	0.44-0.90	.012	0.75	0.52-1.09	.633
Teaching Status	Non-teaching	674	Ref	-	-	Ref	-	-
	Teaching	318	0.65	0.49-0.86	.002	0.74	0.57-0.97	.029
Cost Structure	Procedural	602	Ref	-	-	Ref	-	-
	RCC	390	0.71	0.55-0.92	.010	0.60	0.46-0.77	<.001
Bed Size	0-99	214	Ref	-	-	Ref	-	-
	100-199	227	0.92	0.63-1.35	.671	0.67	0.46-0.98	.040
	200-299	188	1.11	0.75-1.65	.605	0.78	0.52-1.15	.212
	300-399	139	1.06	0.69-1.63	.807	1.03	0.67-1.57	.910
	400-499	88	0.85	0.52-1.42	.541	1.09	0.66-1.80	.726
	500+	136	0.99	0.64-1.53	.968	0.78	0.50-1.20	.250

Abbreviations: RCC, ratio of cost to charges.

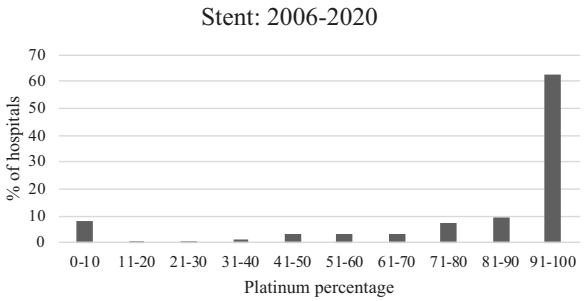

Figure 2. Distribution of Platinum percentage for stents, by hospital from 2006 to 2020.

To provide a simplified classification benchmark for comparison, endovascular stent documentation in the Premier database was explored. Here, most hospitals demonstrated a high level of documentation completeness for these procedures, with over 70% of hospitals documenting a stent in at least 81% of its cases (Figure 2).

Discussion

This study aimed to assess resource documentation for both TKA and THA, as well as hospital-specific factors associated with documentation performance. Despite accurate resource documentation being important for hospital record keeping and value-based care initiatives, significant issues were identified in regard to the attribution of implant resources required to perform TKA and THA.

Overall, a bipolar distribution in documentation performance was observed for both TKA and THA procedures, with individual hospitals demonstrating either very complete or very incomplete resource attribution. This was reflected by individual hospitals' Platinum percentages which tended to be either very high or very low. The same patterns persisted throughout the study period and are in stark contrast with often well-documented endovascular stent procedures. The bimodal distribution of TKA and THA documentation was observed to become less prominent across the period of study, with a noticeable change around the years of 2014 to 2016. This may be attributed to the advent of bundled payments and other value-based initiatives, generally improved documentation systems and practices, and a broader emphasis on interoperability.

Though the total hospital costs of TKA and THA procedures include components such as labor and overhead, arthroplasty implants can cost $4000-$9000 and represent over 40% of the total internal cost to the hospital.[10] It is for this reason that the present study solely explored the documentation of surgical implants. The relative impact of hospital internal cost on its margins and how prices are set have direct effects on

value,[11] particularly as it pertains to insurance reimbursement and, consequently, patient premiums.

Endovascular procedures involve just one core component, the stent. Thus, satisfactory documentation is theoretically easier to achieve, particularly as the criteria for Platinum designation in TKA and THA required the successful documentation of either 4 unique components or a total system. While it is possible that the difference in documentation performance between TKA/THA and endovascular stents could be a natural product of the more rigorous criteria applied to arthroplasties (ie, 4 core components vs 1 stent), the bipolar distribution of TKA and THA implant documentation indicates that minor adjustments to these criteria would not alone be sufficient in overturning the many incompletely documented cases. The comparison between these procedures is limited by many differences, including those related to specialty and procedure setting (catheter laboratory vs surgical operating room). However, the observed differences in documentation performance are stark and reinforce the narrative that documentation and charge attribution is less accurate in TKA and THA procedures.

Several analyses were performed to better investigate individual hospital documentation performance. Individual hospital TKA documentation performance was correlated with that of THA, suggesting that hospital-specific factors may contribute to documentation completeness. Of the hospital characteristics assessed, only non-teaching status of hospitals demonstrated an association with satisfactory documentation for both TKA and THA. This result was unexpected as it was hypothesized that teaching hospitals with greater resources would be better equipped to practice and maintain resource documentation.

Bed size was one such characteristic that did not yield an association—an interesting result given that bed size was assumed to be correlated with arthroplasty volume. Hospitals located in the West were more likely to have satisfactory documentations versus all other regions for TKA and all but the South for THA. It is possible that hospital documentation performance is influenced more by internal processes than overarching characteristics. This represents an important avenue for future research especially given the existence of numerous studies on accuracy of administrative non-cost data,[12-14] but few with a focus on mechanisms behind inaccuracies.

Implications

Low rates of resource charge attribution may have significant downstream effects. These include (1) challenges in identifying implants and linking them to patients, (2) barrier to accurate hospital value-based care initiatives, and (3) faulty interpretations of peer-to-peer hospital cost performance assessments.

Excellent implant documentation has significant implications for orthopedic surgeons. In the case of peri- and postoperative complications, detailed records as to specific implants used are critical materials in potential malpractice and other legal suits. Additionally, from a quality perspective, responsible surgeons should be vigilant to differences between surgical devices and materials used in their case history. How can the utilization of one implant manufacturer over another be justified when the operating surgeon cannot discern which patients received which implant? Lastly, should there ever be arthroplasty failure or complications requiring surgical re-intervention, future surgeons should be able to know the exact size and model of previous implants used so that the complication can be efficiently resolved.

The ability to trace device implantation is essential in maintaining quality control as well as ensuring compliance with "promoting interoperability," specifically, the ability to capture structured information that is available electronically. While charge data is a downstream element within the clinical documentation chain, one must be careful to conclude that a lack of a charge indicates a lack of documentation. However, it is plausible that the same surgical supply documentation sparseness may exist in upstream resource management systems. The potential gap in quality control is concerning from the perspectives of patients and health systems, alike. One such example can be seen in THA, as significant variation in hip implant systems confers differential risks for complications and need for revision surgeries.[15]

Hospitals leverage databases, such as Premier Healthcare, to benchmark their experiences to peer hospitals. It is plausible that a hospital with a high Platinum percentage would be seen as a less efficient hospital as a result of comprehensively accounted charges. Conversely, a hospital with a low Platinum percentage may be seen as a more efficient hospital as not all procedure-associated charges are accounted. Inaccuracies in documentation can yield substantial lost revenue for hospitals.[16] Furthermore, any action taken by a hospital using false-positive or false-negative information from these benchmarking analyses will surely lead to an inefficient allocation of limited hospital resources designed to curb hospital expenses. A hospital's ability to benchmark costs per case is essential for controlling healthcare expenditures, and it is imperative these data represent the reality of resource utilization.

A targeted solution to this problem is limited. As suggested by these results, the issue may be systemic and will likely require increased transparency and standardization between hospitals and their charge masters. Understanding the processes that lead to under-documentation of hospital resources may provide the initial clarity needed to address the root cause of this problem. Additionally, future work should explore how hospital reimbursement structures (eg, preferred provider organizations, health maintenance organizations) impact resource documentation.

Limitations

This study is burdened by various limitations including the assumption that chargemaster data represents a one-to-one

translation from resource documentation systems to billing systems. Chargemaster data is a downstream element within the clinical documentation system. Consequently, deficiencies in charge data could be germane to the final billing system, or it could originate at any upstream stage, beginning with intraoperative resource documentation. Charge documentation may also be "lost in translation" as Premier standardizes the charge descriptions submitted to them by disparate hospitals. In other words, it is possible that hospitals are accurately documenting internal TKA and THA charges, but the transformations that Premier applies to the submitted data are resulting in unclassified/undefined charge descriptions. Lastly, the data that hospitals send to Premier may be deliberately obfuscated in an attempt to gain the benefit of access to Premier data without having to provide their own true prices.

Conclusions

Individual hospital documentation of TKA and THA cases was found to be either very proficient or very poor at implant documentation, in contrast with often well-documented endovascular stent procedures. No clear hospital characteristics, other than teaching status, were found to impact documentation completeness of TKA and THA. Improvements in the resource documentation process, specifically as it relates to resource attribution and charge capture, are needed, particularly for the accurate functioning and analysis of value-based care initiatives.

Author Contributions

LDC, GWH, MS, SGM, JP, and EW conceived the project idea, designed the methodology, and guided the interpretation. AHI prepared the data for analysis. LDC and AHI analyzed the data and created the figures and tables. LDC and GWH were the primary manuscript writers. All authors were involved in the editing and final preparation and review of the manuscript.

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