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Cost Containment of Total Knee Arthroplasty in the US: DEA Analysis on Regional Cost and Clinical Comparison between 2010 and 2013

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Abstract

The purpose of this research is to evaluate clinical and cost effectiveness of total knee replacement surgery (TKA) for adults hospitalized in the United States between 2010 and 2013. We tried to answer the question that whether lower length of stay and higher utilization of post-op facilities would be helpful to control the overall costs. Using the National Hospital Discharge Survey (NHDS) database and cost data from Blue Cross Blue shield, this study seeks to identify which U.S. region renders the highest quality patient care during a three-year span of 2008-2010. Using length of stay and discharge disposition (2010) as input factors, and regional TKA costs (2013) as output factors, Data Envelopment Analysis (DEA), a non-parametric method, illustrated the efficiency ranking of four regions in the US on TKA expenditures. The result shows the West is the most efficient region on controlling the overall cost by shrinking the length of stay and increasing the utilization of short-term/long-term care facilities.

Keywords

Total Knee Arthroplasty (TKA), Data Envelopment Analysis (DEA), Cost Efficiency, Quality of Care

1. Introduction

U.S. healthcare spending has outpaced that of any other high-income countries, reaching 17.9% of the nation's gross domestic product in 2017. Recent actuary studies released by the Center for Medicare and Medicaid Services suggest that U.S. health spending will reach nearly $6 trillion in spending by 2027, equaling

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19.4% of total US GDP. This growth will increase at an average rate of 5.5% per year over the next decade, a result of healthcare price growth and as an aging population becoming eligible for Medicare. These price increases will account for nearly half of growth healthcare spending while an increase in utilization will account for an additional third of total spending [1]. This staggering rise has driven patients, legislators, hospital administrators, healthcare professionals, researchers, and insurance carriers to closely analyze cost data and quality indicators to develop strategies for cost containment and quality assessment. Moreover, despite this spending, no major differences have been noted in U.S healthcare delivery and outcomes when compared with ten high-income nations, which further elicits close scrutinization of national spending [2].

While administrative costs and pharmacotherapeutics appear to be accelerating these costs, demands for medical care coupled with increasing hospital costs are also major drivers in rising expenditure [3]. Growth in total hospital spending between 2000 and 2027 is projected to average 5.7% increase per year leading to an overall price inflation of 2.7% for personal healthcare prices over this time period [4]. As an aging population creates greater demand for Medicare coverage, growth in Medicare spending is expected to average 7.4% annually compared to 4.8% for private insurance and 5.5% for Medicaid [1].

As the number of Medicare beneficiaries is expected to rise, utilization of surgical and medical interventions such elective total knee replacement surgery (TKA) is being closely scrutinized for projected growth. More specifically, longitudinal studies of Medicare administrative data have examined historical trends in volume and per capita utilization of TKA. For example, one study found that among Medicare beneficiaries, total knee arthroplasty volume increased 162% from 1991 to 2010, being driven by both an increase in the number of Medicare enrollees and per capita arthroplasty utilization [5]. As total knee arthroplasty is now among the most common surgical interventions in the United States, with more than 718,000 total knee replacements performed with an aggregate cost of over $11 billion in 2011, it is closely being examined for cost and outcomes [6]. Demographic statistics collected through the National Center for Health Statistics, a division of the CDC, reveal that in 2008, 2009, and 2010, total knee replacement was the most frequently performed inpatient procedure for adults (age 45 and over). This data collected through the National Hospital Discharge Survey (NHDS) also revealed that women have a higher rate of total knee replacement (65.5 per 10,000 population in 2010) than men (45.3 per 10,000 in 2010) [7]. Furthermore, the number of procedures performed doubled from 2000 to 2010 [8] [9].

As outlined above, the prevalence of TKA is being closely studied with particular focus on effectiveness and quality of the procedure and total hospital costs. Therefore, the purpose for this research is to evaluate cost and patient outcome data for adults hospitalized in the United States after TKA, using the National Hospital Discharge Survey (NHDS), to identify which U.S. region is the most cost effective and has the highest quality of care during a three-year span,

2010-2013. Of the regions examined, metrics on patient outcomes (including mortality, patient hospital days, and discharge disposition) as well as total costs associated with patient stays is explored to evaluate effectiveness and quality of care.

This research includes the following parts: a literature review is conducted in part 2; methodology is introduced in part 3; results are explained in part 4; part 5 illustrates the conclusion, demonstrating the potential implications; and part 6 is discussion, illustrating the shortcomings for the research.

2. Literature Review

Staggering growth in elective knee replacements has gained national attention of patients, legislators, and physician professional organizations. Recent projection studies by the American Academy of Orthopedic Surgeons have estimated total knee replacements to grow at a staggering rate of 189% by 2030 totaling 1.28 million total procedures; by 2060 this procedure is projected to increase 382% reaching 2.6 million total procedures [8]. Increased indications for this surgery are also considered major drivers in utilization. For example, a strong positive association between obesity and knee disease has also been well documented (and other comorbid factors such as sports-related injuries and expanded surgical indications) will increase projected procedural operations [10].

With rapid growth of TKA, the economic burden on patients, insurance carriers, and hospitals is being closely studied to examine cost variation throughout the nation. In particular, hospitals are under increasing pressure to better understand costs and patients are shopping to better understand hospital prices and surgical outcomes. Value based and accountable payment methods, introduced by the Centers for Medicare and Medicaid Services in 2013, created payments for a wide range of medical and surgical interventions including TKA. Further shifting financial risk, the Centers for Medicare and Medicaid Services began a program which holds hospitals financially accountable for expenditures related to Medicare from hospital admission to 90 days after discharge. These efforts have created greater accountability on hospitals to better understand costs, pricing, and patient outcomes [11] [12].

As providers are preparing for new payment models such as bundling and reference-based pricing, population-based studies are exploring reimbursements and outcomes. In particular, one study analyzed over 2.92 billion private insurance claims of over 88.7 million individuals from 2007-2011, spanning across the nation and found that some hospitals charged 2.3 more than other hospitals for total knee arthroplasty. This study also found that over a fifth of the total price variation across cases occurs within the same hospital, for the same procedure, suggesting that the bargaining leverage of insurers heavily influences prices [9]. Additionally, as Medicare is the single largest payer of knee arthroplasties, covering nearly two-thirds of all total knee and hip replacements in the U.S, studies on Medicare data have focused on patient outcomes and reveal little variability in quality outcomes [9] [13]. Hass and Kaplan's 2017 study focused exclusively on Medicare data found that between 95% - 97% of hospitals were not statisti-

cally different from one another on risk-adjusted complications and readmissions for TKAs. These results suggest that as hospitals have little variation in quality and there is significant opportunity to reduce costs without adverse outcomes [12].

This cost variation has been well documented in other studies, which has been of particular interest of healthcare insurers. For example, one study conducted by a leading national health insurance agency, Blue Cross Blue Shield, found that some hospitals charge substantially more than others even within the same metropolitan market. In 64 markets across the U.S, cost can vary as much as 380 percent depending on the area with a 2.67x difference within a single geographic market [14]. Furthermore, market structure appears associated with price levels. For example, monopoly hospitals are associated with 12 percent higher prices, shifting financial risk to insurers; in concentrated insurer markets the opposite correlation has been found with hospitals bearing more financial risk [9]. One study determined that the average cost of care for TKA across hospitals varied by a factor of about 2 to 1, indicating that hospitals at the 90th percentile of cost spent nearly twice as much as those the one in the 10th percentile of cost, despite similar patient outcomes [12].

In 2016 the United States spent nearly twice as much as 10 other high-income countries but little difference in quality outcomes have been documented. To counterbalance increasing cost of care related to TKA, increasing attention has been directed at length of stay following TKA. Aggressive postoperative physical therapy and early mobilization can result in reduced length of stay (LOS), especially during the first 24 hours postoperatively, with the initiation of rehabilitation within 24 hours after surgery achieving better balance and normal gait [15] [16]. Therefore, early mobilization postoperatively can result in reduced length of stay by 1.8 days without an increase in negative outcomes [15]. As such, shortened length of stay has been associated with positive patient outcomes and high-quality patient care. Many other factors influence LOS following TKA. In a study evaluating discharge data from the Nationwide Inpatient Sample from 2009-211, nearly 75% of patients had a hospital LOS of 3 days or less and the most significant predictors of LOS ≥ 4 included medical complications and ages ≥ 80 among others [17]. Furthermore, discharge to either home or a skilled nursing facility following a total knee arthroplasty has been correlated with poorer patient outcomes. One study found that discharge to a skilled care facility has been associated with increased odds for respiratory, septic, thromboembolic, and urinary complications suggesting that discharge to home after hospitalization for TKA whenever possible would result in better patient outcomes [18]. Therefore, a shortened length of stay (≤3 days) coupled with a discharge disposition to home has been correlated with the highest positive patient health outcomes. As hospital length of stay and discharge disposition are closely associated with patient outcomes, these quality indicators will be utilized in this study to determine quality of care delivered in all four regions of the United States.

3. Data and Methodology

3.1. Data

To evaluate regional cost and clinical effectiveness of total knee replacement throughout regions of the United States, data from the National Hospital Discharge Survey (NHDS), a division of the Center for Disease Control (CDC), was examined for three years 2008-2010. This database contains characteristics of inpatients discharged from non-federal short-stay hospitals in the United States. The NHDS contains patient discharges from noninstitutional hospitals located in the 50 states and District of Columbia. Short-stay hospitals (hospitals with an average length of stay for all patients of less than 30 days) and those whose specialty is general (medical or surgical) or children's general are included in the survey. The survey excludes federal, military, and Department of Veterans Affairs hospitals; institutional hospital units (e.g., prison hospitals); and hospitals with fewer than six beds.

Each discharge record in the NHDS contains demographic characteristics (including region, age, sex, marital status, among others) as well as discharge status, days of care and one primary and up to fifteen secondary discharge and procedure diagnoses for each discharge during a hospital stay. Discharge records were abstracted for demographic information (age, gender, race, region, and marital status), diagnostic codes, procedural codes, length of stay, sources of payment, and discharge disposition. The diagnosis and procedure codes are derived from the International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM). Discharges who underwent total knee replacements were included if they had the ICD-9-CM code for this procedure (V43.65, 4365, V4365) in the diagnosis or procedure fields. Total knee revisions including partial knee replacements were excluded from this study.

As cost data was not captured in the National Hospital Discharge Survey, total cost data was abstracted from Blue Cross and Blue Shield's Health of America Report 2015, which contains mean cost data of TKA in major cities nationwide. The Health of America report published three years of independent Blue Cross and Blue Shield claims data for typical knee replacement surgeries and includes claims for primary (non-Medicare) BCBS members incurred 46 months ending July 2013, paid through September 2013. The episode costs used in this data are based on total amount of procedure and ancillary costs for a period time pre and post procedure. Published cities in this report were designated a geographical region based on a United States regional map. The total costs for each region were summed to ascertain total regional cost.

3.2. Methodology

We will test the economic efficiency of both days of care and discharge status using a non-parametric methodology. Economic efficiency is a combination of both technical efficiency (output with least input) and allocative efficiency (resources allocation for greatest-valued uses). Our examines whether shrinking

days of care and discharging patients to healthcare facilities are effective ways to achieve cost containment.

The applied methodology and statistical model are the same as Jia and Zhang's 2017's health administration cost research [3]. We apply a non-parametric method that allows the estimation of efficiency frontier and efficiency losses known as Data Envelopment Analysis (DEA). This method is generally applied to decision-making units, by the firms, or non-profit or public organizations that convert inputs into outputs. The DEA methodology, originating from Farrell's (1957) seminal work and popularized by Charnes, Cooper, and Rhodes (1978), assumes the existence of a convex production frontier and accommodates multiple inputs and outputs without the requirement for a common denominator of measurement [19] [20]. DEA is particularly well-suited for analyzing the cost containment of TKA process, as we used multiple inputs to produce one output, based on the observed relationship between the quality of care and total costs. The production frontier in the DEA approach is constructed using linear programming. An empirical piece-wise linear frontier, *i.e.* "best practice frontier", isolates potential efficient units (points on the frontier) from inefficient units (all points enveloped by the frontier).

The measurement of technical efficiency using DEA depends on the assumed types of returns to scale. Returns to scale refers to the changes in output when all inputs change by a certain proportion. Constant returns to scale (CRS) mean proportion changes in input will lead to the same proportionate changes in output; and variable returns to scale mean the same proportion changes in input will lead to disproportionate changes in outputs, including increasing returns to scale (IRS) and decreasing returns to scale (DRS). Charnes, Cooper, and Rhodes (1978) developed DEA as a way to measure technical efficiency under constant returns to scale [20]. However, the CRS model is not able to distinguish between scale efficiency and pure technical efficiency. In 1984, Banker, Charnes and Cooper revised the model to measure technical efficiency under VRS, and capture the scale efficiency of each unit. Scale efficiency is then obtained by dividing each country's CRS technical efficiency score by its VRS technical efficiency score [21].

The overall shape of the frontier depends on the production possibility set, *i.e.* the assumption made for attainable points. The efficient units will be those that have an efficiency score of 1 (or 100%) and the inefficient ones will be those with efficiency scores less than 1 (or 100%). We will only use the output-oriented methods since there is only one output and multiple inputs. Under the assumption of VRS, the efficiency of country j can be obtained by solving the DEA model:

$$\max\left(\sum_{i=1}^{n} u_i y_{ij} + u_0\right)$$

Subject to

$$\sum_{k=1}^{N} v_k x_{kj} = 1$$

$$\left(\sum_{i=1}^{n} u_i y_{ij} + u_0\right) - \sum_{k=1}^{N} v_k x_{kj} \le 0,\ \forall j = 1,2,3,4$$

$$u_i, v_k \ge 0$$

where y_{ij} is the amount of output *i* produced by area *j*, x_{kj} is the amount of input *k* used by area *j*, u_i is the weight given to output *i*; and v_k is the weight given to input *k*.

The first constraint indicates that the weighted sum of inputs for a particular area equals to one. The second constraint shows that all areas are on the frontier or below the frontier. The weights u_i and v_k are unknown and obtained in the solution to the linear programming problem. The term u_0 determines the returns to scale: $u_0 > 0$ means increasing returns to scale (IRS), $u_0 < 0$ means decreasing returns to scale (DRS), and $u_0 = 0$ means constant returns to scale (CRS).

In this DEA method, the output variable is the total cost of TKA procedure for each area, and the input variables are post-op days of care and the percentage of discharges requiring further care. The post-op days of care has been measured by two measurements: total days of care and average days of care for each area.

3.3. Quality Assessment

Length of Stay: Length of stay as associated with patient outcomes and a determinant of surgery success has been well described in previous literature. Patient length of stay < 3 days following TKA is associated with higher positive patient outcomes and decreased hospital expenditure. Therefore, high quality patient care as determined by length of stay was ascertained to be highest when <3; length of stay was also stratified into three distinct other groups of (4 - 8 days, 9 - 29 days, and 30+ days).

Discharge Status: Discharge status is described in the NHDS by six categories (1 = Routine routine/discharged home, 2 = left against medical advice, 3 = discharged/transferred to short-term facility, 4 = discharged/transferred to long-term care institution, 5 = alive, not stated 6 = dead, 9 = not stated or not reported). Discharge status as an indicator of quality outcomes has been described in previous literature as highest when patients are discharged home. Conversely, patients discharged to skilled care facilities (short term or long-term facility) or those who do not follow care protocols (left against medical advice) face the poorest outcomes and potential negative health events. Therefore, 1 (Routine routine/discharged home) and 5 (Alive) were combined as positive patient outcome; 2 (left against medical advice), 3 (discharge/transferred to short term facility) and 4 (discharged/transferred to long-term care institution) were combined as negative patient outcome and 6 (Dead) was isolated to determine quality of care. The category 9 not stated was omitted for the purposes of this study.

4. Results

4.1. Graphical Analysis

Regional Discharges: The total number of discharges over three years for all

regions is summarized in Figure 1. The South (842 total discharges) and Midwest (803 total discharges) experienced significantly higher procedural operations of TKA when compared to the West (259 total discharges) and Northeast (689 total discharges). Figure 2 displays the total discharges stratified by year and region over the three-year period. In consistence with previous studies, the procedural rate of TKA progressively increased over a three-year period in all regions with particular proliferation in 2010. The Northeast, Midwest, and South share similar frequency and growth of operations over three years. Notably, while the West is observed to have a lower relative frequency of operations when compared to the other regions, this may be due to the limitations of the survey data such as non-sampling or measurement errors because of hospital nonresponse or inaccurately recorded information.

Length of Stay: Figure 3 displays the days of care after surgery for all regions

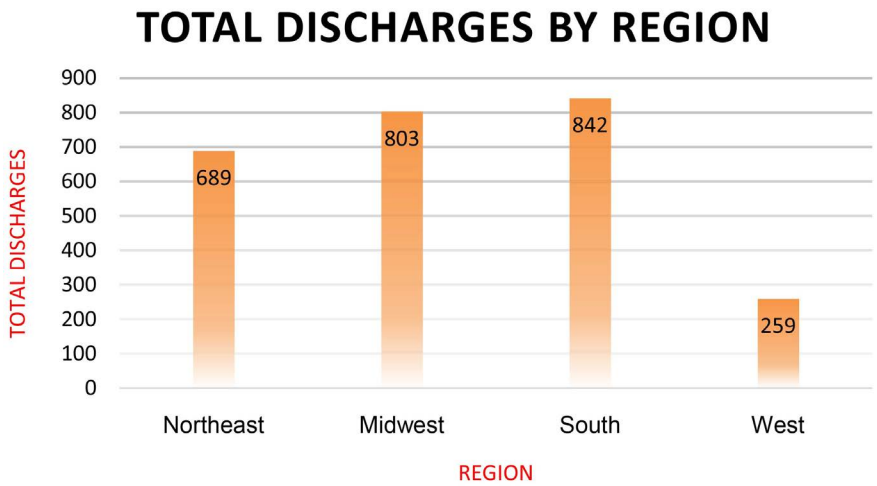


Figure 1. Total patient discharges by region in three-year period (2008-2010). Source: National Hospital Discharge Survey (NHDS).

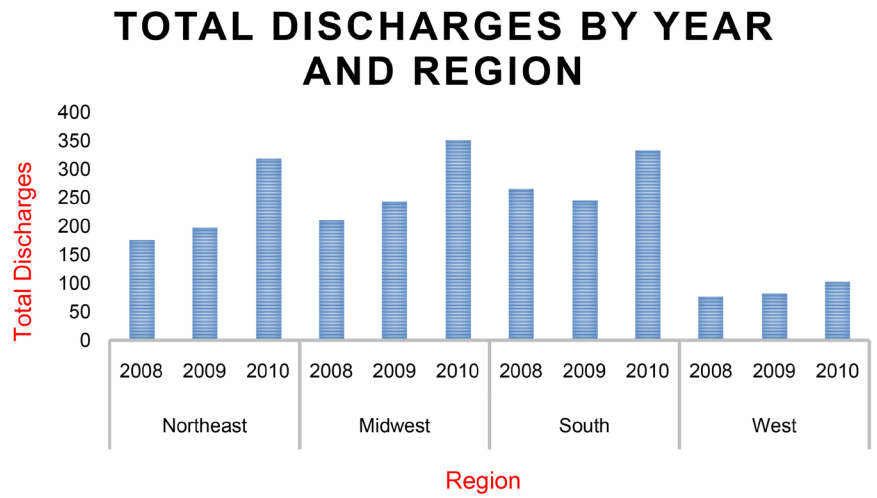


Figure 2. Total number of discharged patients stratified by region and year (2008-2010). Source: National Hospital Discharge Survey (NHDS).

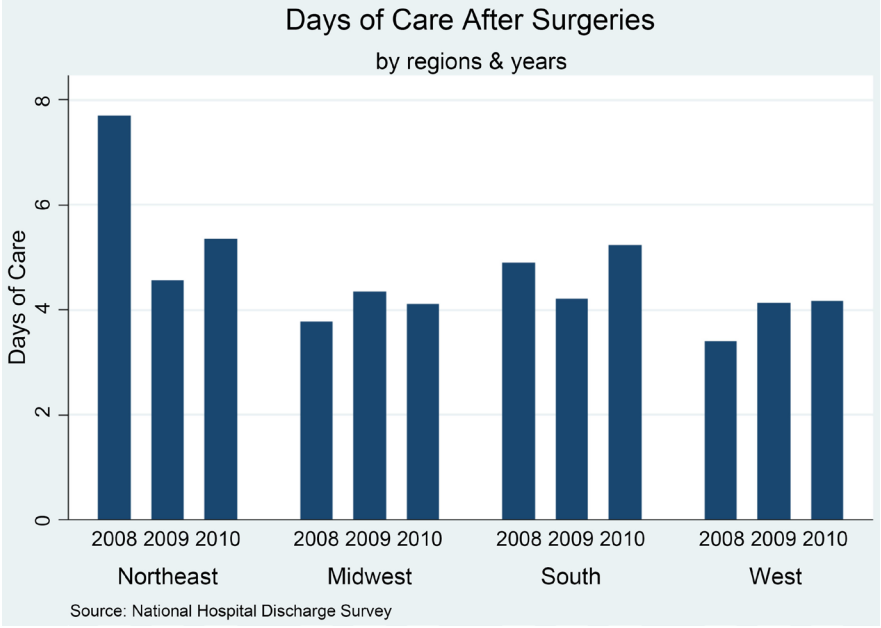


Figure 3. Mean length of stay for all three regions for three years (2008-2010).

over three years. As shown the average length of stay for all regions varies between four to six days with a considerably shortened length of stay in the West (as noted above this may be due to limitations in survey data). In 2008, the Northeast had longer days of care reaching nearly eight total days. Conversely, in 2008, the Midwest and West experienced significantly shorter lengths of stay averaging less than four days the shortest length of stay for all regions over three years.

Discharge Status: **Figure 4** and **Figure 5** display all patient discharges for all regions over three years, classified by discharge status. These results demonstrate the vast majority of patients are discharged to home or without adverse outcomes-classified as "positive patient outcomes". Notwithstanding this trend, a relatively high number of patients were discharged to another next level of care requiring further medical intervention-classified as "negative patient outcomes". Of note, four deaths were noted post-operatively in 2008 and 2010. Two of these patient deaths occurred in 2008 (one in the Midwest and one in the West), while two additional deaths occurred in the Northeast in 2010. **Figure 5** further confirms the increasing trend of TKA from 2008 through 2010.

Length of stay and total cost: **Figures 6(A)-(D)** demonstrate the total number of discharges per region stratified by year grouped by length of hospital stay. These figures also display total regional cost. These results indicate that majority of patients in all four regions will discharge in less than four days with most patients discharging in less than eight days. The West has substantially higher costs but when compared to other regions, however, it has the lowest length of stay. The lowest cost region, the Northeast, discharges the majority of patients under four days; notably, while the Northeast remains the lowest cost region, it has the poorest patient outcomes, particularly in 2010 with an additional two patient deaths in the same year (as noted in **Figure 4**).

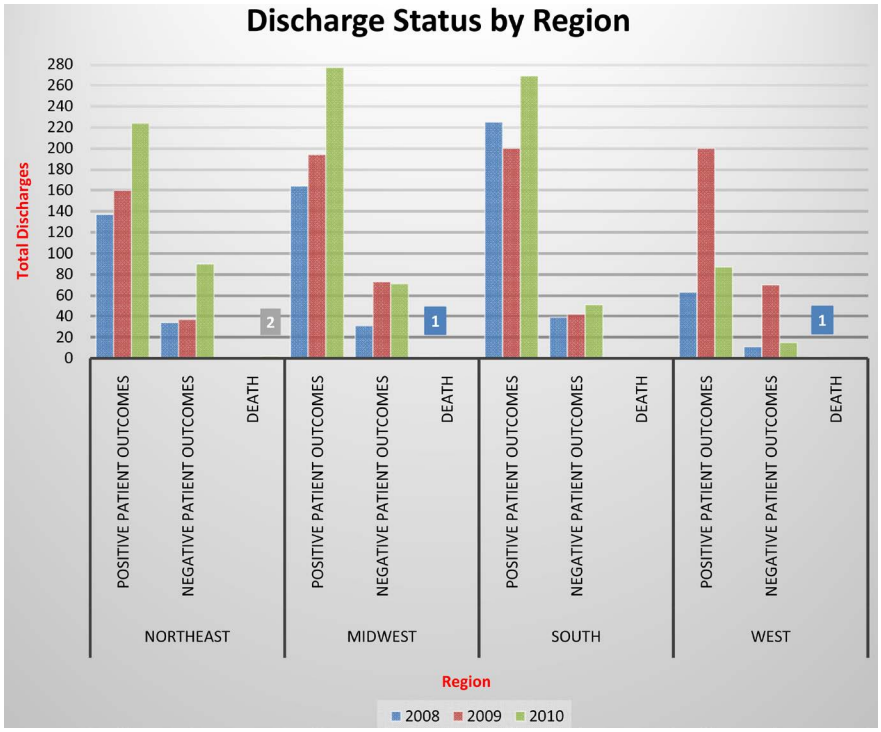


Figure 4. Discharge status of patients every year categorized by patient outcomes and region (2008-2010). Source: National Hospital Discharge Survey (NHDS).

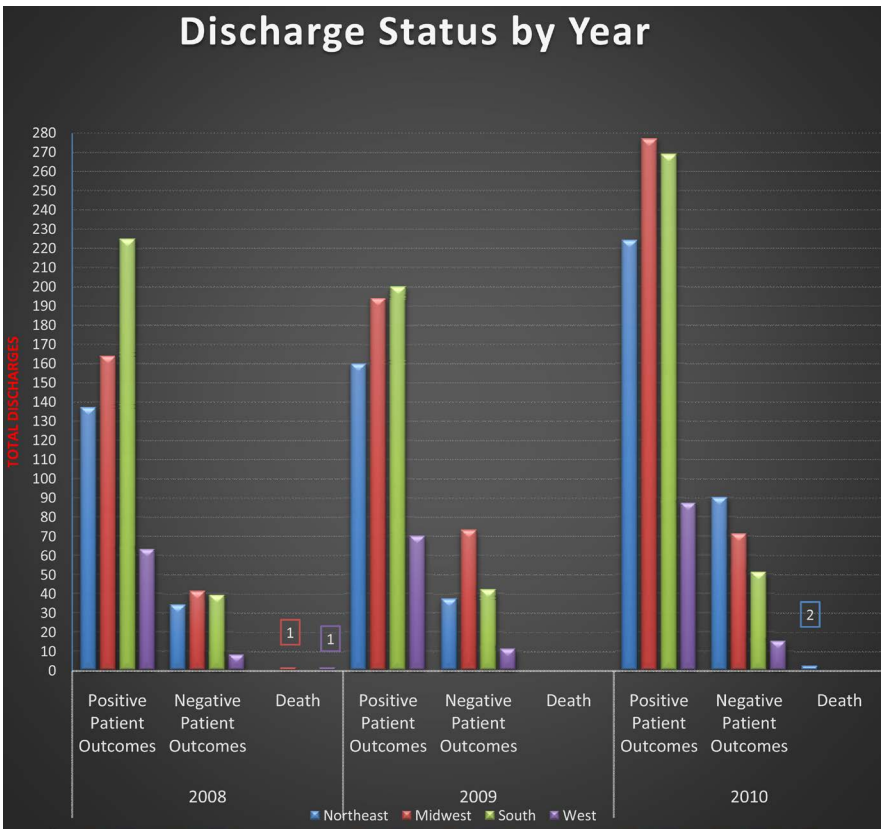
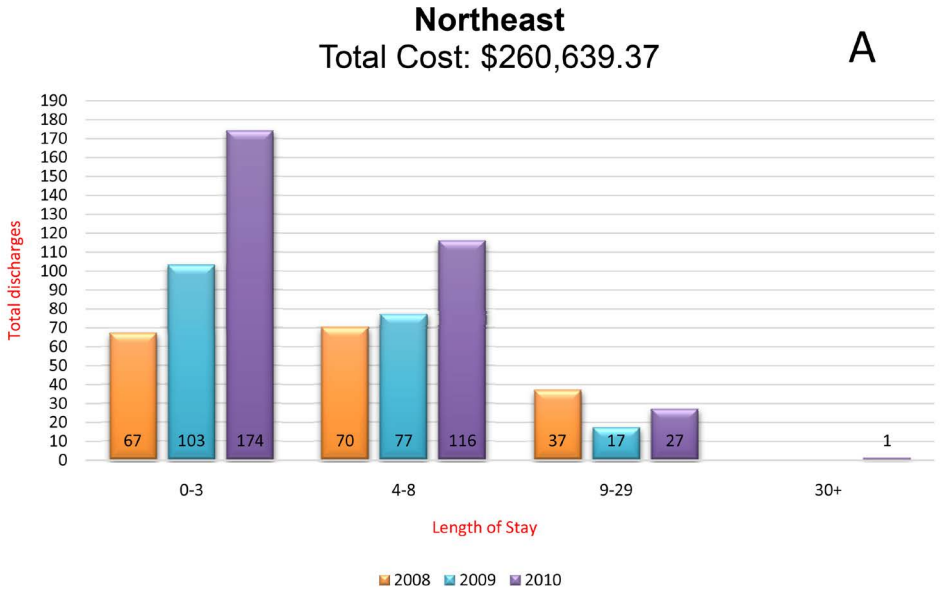
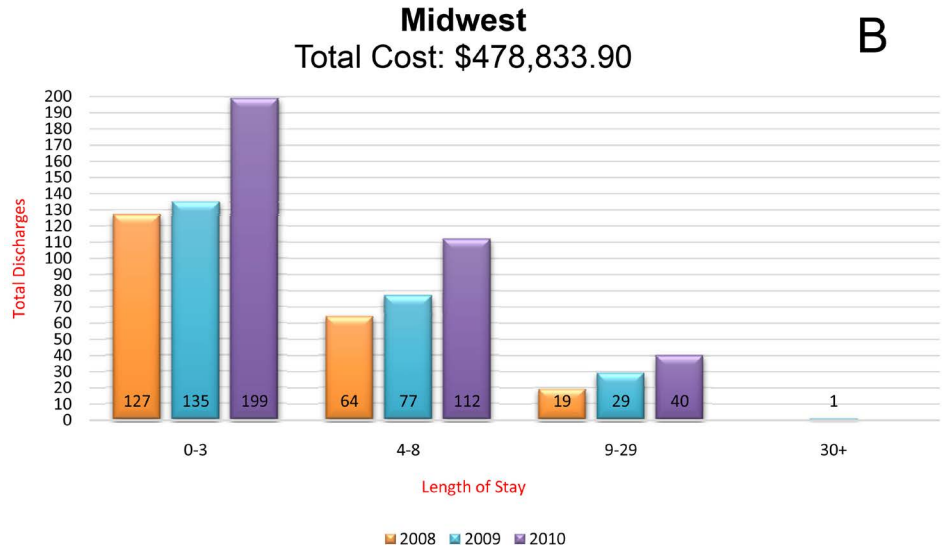
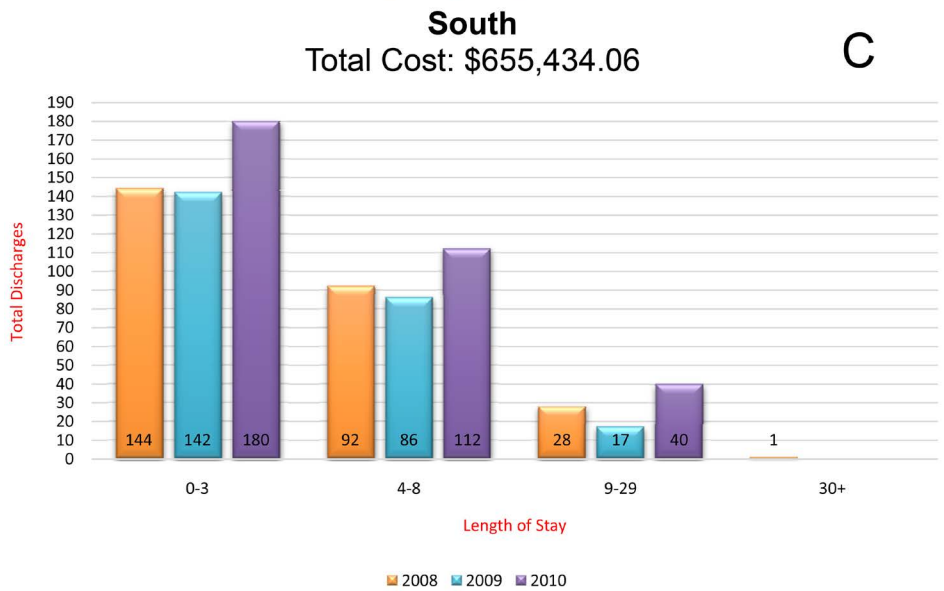


Figure 5. Regional discharge statuses of patients stratified by patient outcome and years (2008-2010). Source: National Hospital Discharge Survey (NHDS).


Northeast
Total Cost: $260,639.37
A
Total discharges
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
67
103
174
70
77
116
37
17
27
1
0-3
4-8
9-29
30+
Length of Stay
2008
2009
2010


Midwest
Total Cost: $478,833.90
B
Total Discharges
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
127
135
199
64
77
112
19
29
40
1
0-3
4-8
9-29
30+
Length of Stay
2008
2009
2010


South
Total Cost: $655,434.06
C
Total Discharges
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
144
142
180
92
86
112
28
17
40
1
0-3
4-8
9-29
30+
Length of Stay
2008
2009
2010

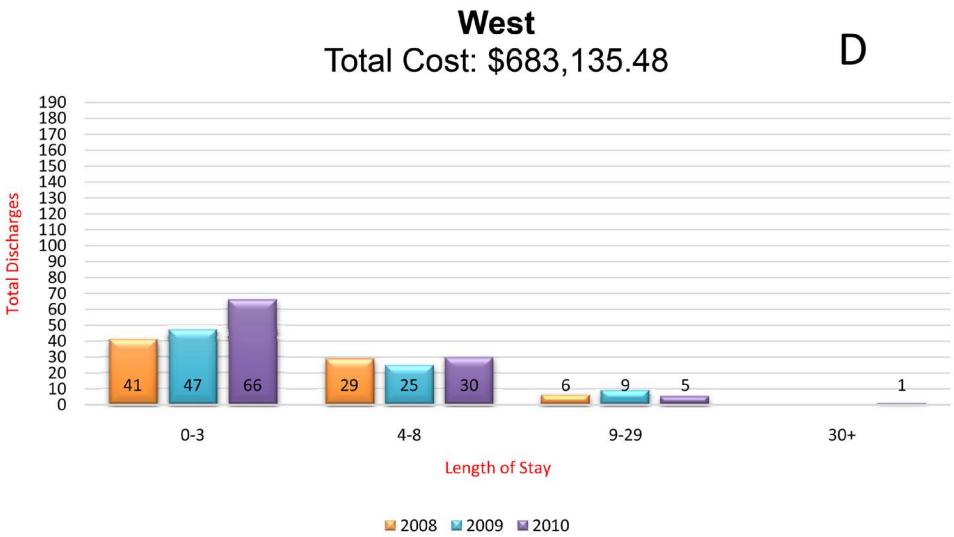


Figure 6. (A-D) Total cost and total number of discharges per region stratified by year (2008-2010) and grouped by length of stay (0 - 3 days, 4 - 8 days, 9 - 29 days, 30+ days). Source: National Hospital Discharge Survey (NHDS).

4.2. Data Envelopment Analysis

The DEA model in this research is multiple-input and one-output model, with quality of care as the input and potential cost as the output. The quality of care includes length of care and discharge status. The length of care is measured as average length of stay. And the discharge status is measured as the percentage of "negative patient outcomes". We use two indicators as the cost of TKA, *i.e.* the total cost of the major hospitals in the specific area and the average cost per person in the specific area. We only used the output-oriented DEA analysis due to the small variations among inputs in these four areas. The DEA results are illustrated in Table 1 & Table 2.

From the DEA analysis results, the West always ranked the first no matter how we measured the outputs. When we measure output using a negative number for total cost, the Northeast performs the poorest. The Northeast is only 38% efficient compared with West, which means within same output amount, the Northeast is only able to apply 38% of resources. When we measure output using average cost, the South performs the worst. The South is 91% efficient when compared with West, which means, the South only applied 91% of resources to achieve the same output amount.

5. Conclusions

In accordance with previous epidemiological studies, this study confirms the growth in utilization of TKA over the three-year period of 2008-2010 in all regions of the United States, with notable upsurge in 2010. In particular, the West region is observed to have a lower total frequency of this operation while the South and Midwest performed a greater frequency. While the average length of stay in the West and Midwest is significantly shorter when compared to other

Table 1. DEA results for total cost as output (2010-2013).

	Average Days of Care			Post Discharge			Combined Two Inputs		
	Rank	VRS_TE	CRS_TE	Rank	VRS_TE	CRS_TE	Rank	VRS_TE	CRS_TE
Northeast	4	0.3815	0.3405	4	0.3815	0.1985	4	0.3815	0.3405
Midwest	3	0.7009	0.6458	3	0.7009	0.5109	3	0.7009	0.6458
South	2	0.9594	0.8144	2	0.9594	0.8853	2	0.9594	0.8853
West	1	1	1	1	1	1	1	1	1

Table 2. DEA results for average cost as output (2010-2013).

	Average Days of Care			Post Discharge			Combined Two Inputs		
	Rank	VRS_TE	CRS_TE	Rank	VRS_TE	CRS_TE	Rank	VRS_TE	CRS_TE
Northeast	2	0.9510	0.8418	2	0.9510	0.5942	2	0.9510	0.8418
Midwest	3	0.9318	0.9003	3	0.9318	0.6749	3	0.9318	0.9003
South	4	0.9111	0.8426	4	0.9111	0.8248	4	0.9111	0.8426
West	1	1	1	1	1	1	1	1	1

regions, the majority of patients in all four regions are discharged in less than four days. The West is noted to have the highest total regional costs ($683,135.48) and the Northeast is observed to have the lowest total regional cost ($260,639.37) but the Northeast is associated with the poorest patient outcomes, particularly with two patient deaths noted in 2010. The results demonstrate the Western region's competency and proficiency in patient outcomes related to TKA but these results are delivered at a higher total cost.

The DEA results provided an input-output explanation about the possible ways to decrease cost through improving quality of care, such as shrinking days of care or improving discharge disposition. Based on the results of the DEA analysis, the West is the most efficient area on cost containment through improving discharging status and regulating days of care, which is consistent with the statistical analysis mentioned above. Although the Northeast spent the lowest on total cost, the longer inpatient stays and higher rate of negative discharge outcomes demonstrate the inefficiency of cost containment. Comparing the quality of care between 4 areas, the South was the least efficient on containing the average cost.

In summary, this study demonstrates that for the elective orthopedic surgical intervention of TKA, the West achieved superior outcomes at a higher total regional cost throughout the three-year span of 2008-2010. The most likely explanation of these results is that greater investment in expertise of the attending surgical medical staff, nursing care, and technologically advanced surgical equipment increases positive patient outcomes and decreases patient length of stay. These findings can serve as means for healthcare providers, patients, and insurers to better understand patient outcome data and cost when determining which region to select for this procedure and research high-quality of care insti-

tutions. These results also indicate that while total and average TKA cost may be contained through improving quality of care, such as dropping the length of stay and decrease the needs of further care after discharge, helping to further inform care decisions. Moreover, low cost areas, such as the Northeast, may indicate poorer patient outcomes but it is conceivable that these hospital systems serve patients with higher severity of illnesses and population wide insurance coverage may be lower.

6. Discussion

There are several important limitations of this study that require mention. The primary shortcoming of this study is the absence of cost data associated with all discharges identified in the NHDS. As noted previously, data for this study was extrapolated from paid claims from one insurer, Blue Cross Blue Shield, over 46 months ending in July 2013. As cost data can have great variability, relevant cost data pertaining to federal insurance claims such as Medicare and Medicaid and other commercial insurers would strengthen the results of this study. Furthermore, while national data sets such as the NHDS provide valuable data to support research on populations and healthcare systems, these data sets have several shortcomings. Primarily, as these data sets rely on accurate documentation and submission of patient-related data, there is considerable potential for underreporting and misclassification of data. Also, NHDS data collection ceased in 2010, limiting analysis of subsequent years; this could have provided valuable results for this study if concurrently studied with future utilization projections. Another important limitation of this study is the quality outcome measurement data which was limited to length of stay and discharge disposition as these are the only clinical indicators available in this data set. Preferably, clinical indicators such as functional status and mobility, complications including infection rates, hospital readmission rates, and other risk factors should be examined to determine quality of care. Additionally, information regarding patient status prior to admission and indication for surgery, which would influence course of treatment and outcomes, would be analyzed.

Ideally, future research would focus on the collection of more accurate national cost data and better describe the utilization and quality outcomes of patients undergoing this procedure. Furthermore, studies have ranked hospital-specific orthopedic programs, but larger regional studies may reveal detailed regional practices which determine why the West has surpassed other regions of the United States. Moreover, quality assessment data aggregated with cost data would assist in the development and improvement of healthcare system delivery to assist in cost containment strategies, particularly for this surgery.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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