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SYMPOSIUM: VALUE BASED HEALTHCARE

Drivers of Surgery for the Degenerative Hip, Knee, and Spine: A Systematic Review

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Abstract

Background Surgical treatment for degenerative conditions of the hip, knee, and spine has an impact on overall healthcare spending. Surgical rates have increased dramatically and considerable regional variation has been observed. The reasons behind these increasing rates and variation across regions have not been well elucidated.

Questions/purposes We therefore identified demographic (D), social structure (SS), health belief (HB), personal (PR) and community resources (CR), and medical need (MN) factors that drive rates of hip, knee, and spine surgery.

Methods We conducted a systematic review to include all observational, population-based studies that compared surgical rates with potential drivers (D, SS, HB, PR, CR, MN). We searched PubMed combining key words focusing on (1) disease and procedure; (2) study methodology; and (3) explanatory models. Independent investigators selected potentially eligible studies from abstract review and abstracted methodological and outcome data. From an initial search of 256 articles, we found 37 to be potentially eligible (kappa 0.86) but only 28 met all our inclusion criteria.

Results Age, nonminority, insurance coverage, and surgeon enthusiasm all increased surgical rates. Rates of arthroplasty were higher for females with higher education, income, obesity, rurality, willingness to consider surgery, and prevalence of disease, whereas spinal rates increased with male gender, lower income, and the availability of advanced imaging.

Conclusions Regional variation in these procedures exists because they are examples of preference-sensitive care. With strategies that may affect change in factors that are potentially modifiable by behavior or resources, extreme variation in rates may be reduced.

Introduction

Orthopaedic procedures have allowed surgeons to improve the lives of patients with degenerative musculoskeletal conditions by reducing pain and restoring function. THA and TKA are well-recognized examples of successful interventions in degenerative joint diseases [9, 15, 20, 33, 38, 45, 49, 50]. In degenerative disease of the lumbar spine (DDLS), recent studies have shown that surgical decompression and fusion can improve pain and function for specific indications [55, 56].

The success of these surgical interventions coupled with increased demands of a growing aging population has produced a commensurate increase in the use rates [6, 8, 42, 53]. In the past decade, we have seen a rise in the use of these procedures. From 1992 to 2001, rates of THA increased 34% to 2.9 per 1000 Medicare enrollees, TKA increased 40% to 5.7 per 1000 enrollees, and spinal surgery increased 53% in the Medicare population to 4.3 per 1000 enrollees [54]. In addition, as technology has advanced, the individual implant costs have increased and now comprise a considerable amount of healthcare spending. Hospital Medicare payments for joint arthroplasty have increased nearly 22% since 1993

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and the US hip and knee market for implants and devices was estimated at $6.4 billion in 2009 [41]. The US spinal implant market is now $6.8 billion, 30 times larger than it was in 1994 [40]. The annual cost of treating musculoskeletal health conditions from 2002–2004 was $510 billion, equivalent to 4.6% of the US gross domestic product (GDP) with indirect costs totaling nearly $850 billion (7.7% of GDP) [3].

Although use rates and costs have increased in recent years, many reports document use rates across geographic regions suggesting that where you live may determine the likelihood of undergoing surgery [7, 14, 17, 30–32, 35, 37, 44, 53, 54, 61]. For example, there is a reported nearly 20-fold difference in rates of spinal fusion across US counties [54]. The systematic component of variance (SCV) measures the variation in rates adjusting for random variation within regions, which is stable across a range of rates and population sizes. The SCV for TKA, THA, and spinal surgery in 2000–2001 was 55.0, 67.2, and 93.6, respectively, whereas in comparison, the SCV for hip fracture repair during the same period was only 13.8 [54].

This phenomenon, termed small-area variation, is better explained by differences in factors other than disease prevalence or resource availability, mainly physician uncertainty or enthusiasm [10, 51, 54, 57, 58]. Several studies have examined individual factors that influence surgical rates, namely race, income, education, disease, and the use of diagnostic imaging [13, 18, 28, 29, 35, 46]. However, few have considered multiple factors collectively for individual conditions such as surgeon attitude, patient preference, socioeconomic status, and race, making the appreciation of the relative importance of one factor over another problematic [7, 30, 47]. The combination of high costs and considerable variation warrant further examination into reasons behind the disparate nature of their use.

Andersen's Behavioral Model of Health Services Use provides a comprehensive framework for explaining patient behavior in the use of health services whereby behavior is primarily influenced by patients' predisposing characteristics (demographics, social structure, and health beliefs), enabling resources (personal and community), and need (perceived and evaluated) [5].

The purpose of our study was to identify the factors influencing use rates of total joint arthroplasty (TJA), namely THA and TKA, and lumbar spinal surgery (LSS) for DDLS. Specifically, we aimed to determine the influence of demographics (D), social structure (SS), health beliefs (HB), personal resources (PR), community resources (CR), and medical need (MN) on rates of THA, TKA, and DDLS surgery using this conceptual model. We presumed (D) age and gender; (SS) income, education, and race/ethnicity; (PR) insurance status; and (MN) rates of degenerative disease influence rates of surgery, whereas (HB) health beliefs and (CR) community resources play a smaller role.

Search Strategy and Criteria

With the assistance of a medical librarian, we searched PubMed for all English language journals to identify relevant articles up to September 16, 2010, and contacted content experts for additional studies. Conceptually, we combined three main themes (disease and procedure; study methodology; and explanatory models) (see Appendix A). These strategies yielded 283 references (Fig. 1). We included all population-based observational studies (ie, administrative claims data or nationwide surveys) with a primary outcome of use rates of hip or knee arthroplasty or lumbar spinal surgery for degenerative conditions. We excluded 27 studies in languages other than English.

Two investigators (CDR, PDK) independently selected potentially eligible studies from a review of the abstracts. Any disagreements were resolved by a third investigator (SSB). We measured the overall agreement using Cohen's kappa statistic [34].

Potentially eligible articles were retrieved in full and blinded to author and institution. Two investigators (NNB, RG) then applied our inclusion and exclusion criteria to all potentially eligible articles. Disagreements were resolved by a third investigator (SSB). Data on study methodology and results were abstracted using a standardized form for all included studies and we excluded those that did not have multivariate or bivariate statistical explanatory models of use (Appendix B).

Our initial search produced 256 articles and we identified one additional article from content experts. Of those, we found 38 abstracts to be potentially eligible (kappa 0.86). We excluded six studies not including a predictor model explaining differential rates and three with an arbitrarily selected cohort. After blinded review, 29 met our inclusion criteria. Two studies were similar analyses based on the same cohort [30, 31] where one measured outcomes as arthroplasty rates [30] and the other on ratios of provision relative to need, which was excluded. Twenty-eight studies were included in our analysis with various characteristics [2, 7, 8, 11, 13, 14, 17–19, 22, 25–27, 29–32, 35–37, 39, 44, 46, 47, 52–54, 60, 61] (Table 1). Twenty-six of the articles arose from English-speaking countries (US, Canada, England, and Australia) [7, 8, 11, 13, 14, 17–19, 22, 25–27, 30–32, 35, 36, 39, 44, 46, 47, 52–54, 60, 61] and 22 were from fee-for-service healthcare systems [2, 7, 8, 13, 14, 18, 19, 22, 25–27, 32, 35, 39, 44, 45, 47, 52–54, 60, 61]. Sixteen of the articles explained the use of surgery using a multivariate model (two to 13 variables) [7, 13, 17–19, 22, 25, 27, 30–32, 36, 37, 44, 47, 53, 61], whereas 12 articles looked at univariate analyses to explain variation in surgical rates. Twenty articles were derived from population-based claims data, in which three used additional survey data in

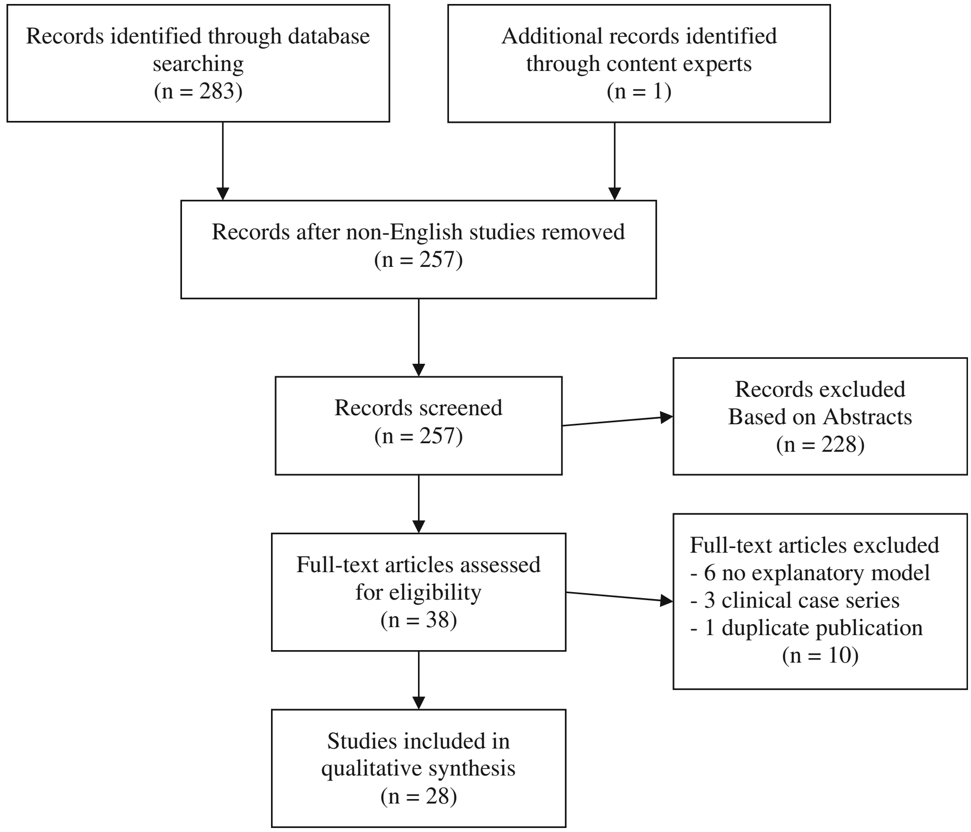

Fig. 1 This flow diagram illustrates the number of articles selected from search and the number remaining after sequential exclusion criteria applied.

their explanatory model [2, 7, 8, 11, 13, 14, 17, 22, 26, 29–32, 35–37, 44, 53, 54, 60, 61]. Eight articles were derived from survey data primarily.

Results

Arthroplasty rates were associated with demographic (D) predictors, age and gender (Table 2). Age followed an inverted U-shaped distribution (peak age 60s–70s). Higher rates were found for female gender.

Postsecondary education, higher income, obesity, nonminority race/ethnicity, and rural residence (SS) were associated with higher rates of TJA, THA, and TKA (Table 3).

HB was considered in a single study of TJA [27]. The willingness of patients to consider surgery was positively associated (hazard ratio [HR], 3.2; 95% confidence interval [CI], 2.46–4.16], $p < 0.001$) with rates of TJA.

Insurance (PR) was assessed in three studies on TJA [18, 19, 39]. One study [19] found that Medicare coverage only (without supplemental insurance) was associated with lower rates of TJA (odds ratio [OR], 0.45; 95% CI, [0.22–0.90]). A second study [39] found patients without prior insurance had higher rates of TJA (OR, 0.45; 95% CI, [0.22–0.90], $p < 0.006$) once under Medicare coverage compared with those continuously insured. Another study [18] found having no insurance coverage was not associated with rates of TJA (HR, 0.86; 95% CI, 0.32–1.81]). One Australian study [26] found rates of surgery in the private compared with public system were higher (rate ratio, 1.1 for THA, 1.2 for TKA); however, no statistical inference was provided. One other study on TKA [25] found uninsured patients had lower rates of surgery (OR, 0.61; 95% CI, 0.40–0.92]) compared with those holding private insurance.

CR was assessed with multiple predictors relating to the surgeon, other physicians, the hospital system, and imaging resources (Table 4). Increased surgeon supply was associated with higher rates of THA but not TKA. The propensity of surgeons to recommend surgery ("enthusiasm") was associated with higher TKA rates. Higher supply of nonsurgeons, more female physicians, and more specialized nonsurgical physicians were all associated with lower rates of arthroplasty.

A history of degenerative osteoarthritis (OA) and the presence of physical limitations (MN) were both associated with higher TJA rates (Table 5). Higher rates of THA were seen with higher prevalence of OA, whereas physical limitations were related to higher TKA rates.

Rates of LSS from one study [7] were associated with male gender and older age (Table 2). Age followed an inverted U-shaped distribution (highest age 60s–70s).

Table 1. Study characteristics

Author (publication year)	Setting	Health system	Years	Primary source	Procedures	Multivariate model (number of factors)*	Standardization method
Agabiti (2007)	Italy	FFS	1997–2000	Claims	THA	N (3)	Age-gender-city
Bederman (2011)	Ontario, Canada	FFS	2002–2006	Claims	LSS	Y (12)	Age-gender
Bederman (2009)	Ontario, Canada	FFS	1995–2001	Claims	LSS	N (2)	None
Cookson (2007)	England	NHS	1991, 2001	Claims	THA	N (1)	Age-gender-ward
Coyte (1997)	Ontario, Canada	FFS	1984–1990	Claims	TKA	Y (3)	Age-gender-year
Coyte (1996)	Ontario, Canada	FFS	1984–1990	Claims	TKA	N (3)	Age-gender
Dixon (2006)	England	NHS	2000	Claims	THA, TKA	Y (6)	Age
Dunlop (2008)	USA	FFS	1998–2004	Surveys	THA, TKA	Y (9)	Age-race
Dunlop (2003)	USA	FFS	1993, 1995	Surveys	TJA	Y (5)	None
Friedman (1995)	USA	FFS	1980–1987	Claims	THA	Y (7)	None
Hanchate (2008)	USA	FFS	1994–2004	Surveys	TKA	Y (9)	None
Harris (2009)	NSW, Australia	FFS	1997–2006	Claims	THA, TKA, LSS	N (1)	None
Hawker (2006)	Ontario, Canada	FFS	1996–1998	Surveys	THA, TKA	Y (12)	None
Jarvholm (2008)	Sweden	NHS	1987–1999	Claims	THA, TKA	N (1)	Age-BMI
Judge (2009)	England	NHS	2002	Claims	THA, TKA	Y (11)	Age-gender-ward
Katz (1996)	USA	FFS	1985–1990	Claims	TKA	Y (3)	Age
Lurie (2003)	USA	FFS	1996–1997	Claims	LSS	N (1)	None
Majeed (2002)	England	NHS	1997–1998	Claims	THA	Y (2)	Age-gender
Makela (2010)	Finland	Public	1998–2005	Claims	THA	Y (7)	Age-gender
McWilliams (2009)	USA	FFS	1996–2005	Surveys	TJA	N (1)	None
Peterson (1992)	USA	FFS	1988	Claims	THA, TKA	Y (2)	Age
Skinner (2006)	USA	FFS	2000	Surveys	TKA	N (3)	Age-gender-race
Steel (2008)	USA	FFS	2000–2004	Surveys	THA, TKA	Y (10)	None
Wang (2009)	Victoria, Australia	FFS	2001–2005	Surveys	THA, TKA	N (5)	None
Weinstein (2004)	USA	FFS	2000–2001	Claims	THA, TKA, LSS	Y (3)	Age-gender-race
Weinstein (2006)	USA	FFS	1992–2003	Claims	LSS	N (2)	Age-gender-race
Wilson (1994)	USA	FFS	1980–1988	Claims	TKA	N (2)	Age
Wright (1999)	Ontario, Canada	FFS	1984–1990	Claims	TKA	Y (4)	Age-gender

FFS = fee-for-service; NHS = National Health System; TJA = total joint arthroplasty; LSS = lumbar spinal surgery; N = no; Y = yes; BMI = body mass index.

* Number of factors included in analysis.

Lower income and more prevalent knowledge of official languages (SS) were associated with higher rates of LSS (Table 3).

HB was evaluated in a single study of LSS [7]. Those authors found no association between surgical rates and the propensity of patients to consider surgery (incidence rate ratio, 1.04; 95% CI, 0.95–1.13], $p < 0.4$).

One study [26] found LSS rates in the private system (PR) were four times higher than that in the public; however, no statistical inference was provided.

The propensity of surgeons to recommend surgery ("enthusiasm") but not the surgeon supply (CR) was associated with higher LSS rates (Table 4). Orthopaedic surgeons compared with neurosurgeons and higher over lower volume surgeons were more likely to perform fusions over decompressions. Availability of MRI scanners and higher rates of CT/MRI imaging were also associated with higher LSS rates.

Prevalence of back pain (MN) was not associated with higher rates of LSS (Table 5).

Discussion

Increasing surgical rates and high variation in hip, knee, and spine surgery have been implicated in the escalating costs of health care. Driving factors behind these rates have not been well understood. We aimed to identify the main factors (D, SS, HB, PR, CR, and MN) that drive rates of TJA and LSS.

We recognize limitations to the literature and our study. First, studies that consider the factors influencing surgical rates must come from observational population-based

Table 2. Demographic predictors of surgical rates

Predictor	Procedure	Reference	Categories	Effect size	95% Confidence interval	p	Comment
Age	TJA	18	65+ to 51–64	HR, 2.34	(1.23–4.29)		
	TJA	19	70–79 to 80+	OR, 1.69	(1.12–2.56)		
	TJA	27	63–68 to 62–	HR, 1.47	(1.03–2.10)	0.001	Inverted U-shaped
	TJA	47	65–74 to 60–64	OR, 1.06	(0.64–1.76)	0.81	Inverted U-shaped
	THA	2	65–74 to 75+	RR, 2.2–2.7	N/R	N/R	Income quintiles
	THA	17	65–84	r, 0.72		0.045	Inverted U-shaped
	THA	30	70–74 to 50–54	RR, 6.92	(6.55–7.31)	0.001	Inverted U-shaped
	THA	52	per year	HR, 1.07	(1.06–1.09)	0.001	
	TKA	13	75–79 to 54–	OR, 106.2		< 0.001	Inverted U-shaped
	TKA	17	65–84	r, 0.48		0.23	Inverted U-shaped
	TKA	25	47–64 to 65+	OR, 0.72	(0.52–1.01)		
	TKA	30	75–79 to 50–54	RR, 14.95	(13.99–15.98)	0.001	Inverted U-shaped
	TKA	32	75–79 to 65–69	OR, 1.41			
	TKA	52	per year	HR, 1.08	(1.07–1.10)	0.001	
	TKA	61	%pop > 75y	β, 115.6		< 0.001	Linear regression parameter
	LSS	7	70–74 to 80+	IRR, 2.17	(1.95–2.42)	< 0.001	Inverted U-shaped
Gender	TJA	18	F to M	HR, 1.16	(0.88–1.41)		
	TJA	27	F to M	HR, 1.09	(0.81–1.45)	0.57	
	TJA	47	F to M	OR, 0.97	(0.61–1.54)	0.91	
	THA	2	F to M	RR, 1.5–1.6		N/R	Income quintiles
	THA	30	F to M	RR, 1.30	(1.28–1.33)		
	THA	52	F to M	HR, 1.06	(0.88–1.28)	0.55	
	TKA	13	F to M	OR, 1.331		< 0.001	
	TKA	25	F to M	OR, 1.26	(1.08–1.48)		
	TKA	30	F to M	RR, 1.10	(1.08–1.12)		
	TKA	32	F to M	OR, 1.95			
	TKA	46	F to M	OR, 1.32	(1.30–1.33)	<0.001	
	TKA	52	F to M	HR, 1.08	(0.90–1.29)	0.42	
	TKA	60	F to M	RR, 1.37			For whites
	TKA	60	F to M	RR, 3.03			For blacks
	LSS	7	F to M	IRR, 0.84	(0.79–0.89)	< 0.001	

TJA = total joint arthroplasty; HR, hazard ratio; OR, odds ratio; RR, rate ratio; r = correlation coefficient; β = regression parameter; IRR = incidence rate ratio; N/R = not reported.

cohorts. Our systematic review was limited to observational studies in which patients were included on population-based criteria like registries, administrative claims data, or national surveys rather than observational clinical trials in which patients are enrolled if they seek care. Second, like all systematic reviews, the quality of the review is limited by the quality of the individual studies and the search. Third, while we used a comprehensive search strategy, we searched only PubMed. A different strategy with other databases may have yielded a different search. Fourth, administrative population-based studies are disadvantaged by their data, usually designed for reimbursement and not for research purposes. However, they are strengthened by their large patient numbers and remain the most practical source for studying relationships that cannot occur at a direct patient level (eg, surgeon/hospital supply). Additionally, these ecologic relationships (in which data are aggregated over groups rather than used at an individual level) studied here do not link an individual patient's chance of getting surgery with some individual factor; rather, they suggest a relationship at a population or regional level. Finally, data obtained from nationwide surveys may not be representative of the population as a whole. However, the relationships from survey data can be analyzed at the level of the individual patient. Experimental health services research such as randomizing hospitals could, in theory, better evaluate these relationships. However, it would be impossible to conduct for many factors (eg, surgeon enthusiasm, surgeon volume).

Table 3. Social support predictors of surgical rates

Predictor	Procedure	Reference	Categories	Effect size	95% Confidence Interval	p	Comment
Education	TJA	18	< 12 years compared with 12 years or more	HR, 0.79	(0.55–1.02)		
	TJA	27	Postsecondary	HR, 1.54	(1.08–2.20)	0.02	
	TJA	47		OR, 1.54	(1.00–2.38)	0.048	
	THA	22		OR, 1.55		0.01	
	THA	52	Postsecondary	HR, 1.37	(1.33–1.66)	0.001	
	TKA	25	Postsecondary	OR, 1.37	(1.10–1.72)		
	TKA	52	Postsecondary	HR, 0.98	(0.81–1.18)	0.81	
	LSS	7	Postsecondary	IRR, 0.85	(0.46–1.57)	0.6	
Employment	TJA	27		HR, 1.09	(0.56–2.12)	0.81	
	TJA	47		OR, 1.29	(0.74–2.25)	0.374	
	THA	17		r, 0.49		0.215	
	THA	29	Floor layers to white collar	RR, 1.58	(0.93–2.68)		
	TKA	17	Manual labor	r, 0.21		0.622	
	TKA	25		OR, 1.17	(0.95–1.44)		
	TKA	29	Floor layers to white collar	RR, 4.72	(1.8–12.3)		
Income	TJA/LSS	53		lower		N/R	Correlation analysis
	TJA	18	Quartiles	HR, 0.58	(0.40–0.77)		Lower income to higher income
	TJA	27	40 k+ to 20 k−	HR, 0.61	(0.34–1.10)	0.021	
	TJA	47	Tertiles	OR, 1.24	(0.76–2.04)	0.927	
	THA	2	Quintiles	RR, 1.15	(1.05–1.23)	0.002	
	THA	22		OR, 0.78	NS		
	TKA	25	$20,000+ to $5000−	OR, 1.54	(1.19–1.96)		
	TKA	46	Median (zip)	OR, 1.19	(1.17–1.22)		
	LSS	7	Per $10,000	IRR, 0.89	(0.83–0.96)	0.002	
Social Needs	THA	11	Dichotomous	RR, 0.79	(0.76–0.81)	N/R	Composite score (unemployment, overcrowding, noncar/ home ownership)
	THA	17	Quartiles	r, −0.45		0.26	Quartiles of deprivation
	THA	30	Quintiles	RR, 0.94	(0.90–0.99)	0.036	Composite score (income, employment, health, education, skills/training, housing/services, crime, environment)
	THA	36	Acute needs index	r, −0.17		0.17	Composite measure of need
	THA	36	GMS cash limited index	r, −0.12		0.33	Composite measure of need
	TKA	17	Quartiles	r, −0.07		0.866	Quartiles of deprivation
	TKA	30	Quintiles	RR, 1.05	(1.00–1.10)	0.006	Composite score (income, employment, health, education, skills/training, housing/services, crime, environment)
Obesity	TJA	18		HR, 1.67	(1.35–1.97)		
	TJA	27		HR, 1.48	(1.03–2.12)	0.004	
	TJA	47		OR, 1.32	(0.88–2.00)	0.184	
	THA	52		HR, 1.05	(1.03–1.07)	0.001	

Table 3. continued

Predictor	Procedure	Reference	Categories	Effect size	95% Confidence Interval	p	Comment
	TKA	25		OR, 2.61	(2.15–3.17)		
	TKA	52		HR, 1.13	(1.12–1.15)	0.001	
Race/ethnicity	TJA	18	Black	HR, 0.4	(0.19–0.58)		
	TJA	18	Hispanic	HR, 0.87	(0.16–2.10)		
	TJA	19	Non-white	OR, 0.63	(0.40–1.00)	0.05	
	TJA	27	Non-white	HR, 0.96	(0.50–1.88)	0.9	
	TJA	47	Black	OR, 0.34	(0.17–0.66)	0.002	
	THA	17	Ethnicity	r, −0.38		0.354	
	THA	30	Black	RR, 0.98	(0.91–1.05)		
	THA	52	Italy/Greece versus UK/Australia	HR, 0.35	(0.26–0.47)	0.001	Country of birth
	TKA	17	Ethnicity	r, −0.17		0.695	
	TKA	25	Nonwhite	OR, 0.73	(0.59–0.89)	0.002	
	TKA	32	Black	OR, 0.4		N/R	For men
	TKA	32	Black	OR, 0.86		N/R	For women
	TKA	46	Non-white	OR, 0.62	(0.60–0.63)	< 0.001	
	TKA	52	Italy/Greece versus UK/Australia	HR, 0.31	(0.24–0.40)	0.001	Country of birth
	TKA	60	Black	RR, 0.31	(0.17–0.28)		For men
	TKA	60	Black	RR, 0.69	(0.66–0.72)		For women
	LSS	7	Nonofficial language	IRR, 0.89	(0.83–0.95)	< 0.001	
Rural	TJA/LSS	53		Higher		N/R	Correlation
	TJA	27		HR, 1.01	(0.79–1.30)	0.91	
	THA	17		r, 0.64		0.085	
	THA	30		RR, 1.05	(1.01–1.10)	0.008	
	THA	44		r, 0.50		< 0.001	
	TKA	17		r, 0.76		0.028	
	TKA	30		RR, 0.99	(0.95–1.03)	0.66	
	TKA	44		r, 0.46		0.001	
Social support	TJA	27	Lives alone	HR, 0.56	(0.28–1.12)	0.079	
	TJA	47	Married	OR, 1.43	(0.87–2.34)	0.155	
	TJA	47	Grandchild care	OR, 1.15	(0.73–1.80)	0.557	

TJA = total joint arthroplasty; HR = hazard ratio; OR = odds ratio; RR = rate ratio; IRR = incidence rate ratio; r = correlation coefficient; N/R = not reported; NS = not significant.

This study design remains the best source of information from which to draw conclusions.

From this study, we found age was related to rates of TJA and LSS and followed an inverted U-shaped distribution. Like most degenerative diseases, prevalence increases with age, but higher comorbidity limits the surgical options for older patients. Females had higher rates of TJA, whereas males had higher rates of LSS. Females have a higher prevalence of arthritis as well as back pain [4, 48]. Despite more back pain in females, males accounted for 56% of healthcare visits [4].

Arthroplasty rates were higher for patients with higher education and income, nonminority race/ethnicity, obesity, and rural residence (SS). For LSS, lower income and nonminority were both associated with higher surgical rates. Disparities are now being reported with increasing frequency in musculoskeletal health and other disciplines of health care [24, 43]. Although there may certainly be altered disease prevalence based on environmental factors and cultural acceptance of limitations associated with the impairments from degenerative musculoskeletal conditions among ethnic minorities, culturally competent care and

Table 4. Community resource predictors of surgical rates

Predictor	Procedure	Reference	Categories	Effect size	95% Confidence interval	p	Comment
Surgeon supply	TJA/LSS	53		higher		N/R	Correlation
	THA	22		OR, 1.52		0.01	
	THA	30	Quintiles	RR, 1.06	(1.00–1.12)	0.07	
	THA	44		r, 0.06		0.7	
	TKA	14		r, −0.16		0.26	
	TKA	30	Quintiles	RR, 1.05	(0.99–1.11)	0.023	
	TKA	44		r, 0.09		0.1	
	LSS	7		IRR, 0.98	(0.96–1.01)	0.2	
	LSS	54		R-sq, 0.02			
Surgeon Volume	LSS	8	High volume	OR, 2.9	(2.5–3.2)	< 0.001	Fusions to decompressions
Surgeon specialty	LSS	8	Orthopaedists	OR, 12.46	(10.6–14.6)	< 0.001	Fusions to decompressions
	LSS	54	Orthopaedists	R-sq, 0.03			
Surgeon attitudes	TKA	61	Enthusiasm	β, 6.7		< 0.001	Propensity of surgeons to operate
	TKA	61	Outcome perception	β, 0.14		0.08	Perception of treatment outcomes
	LSS	7	Enthusiasm	IRR, 1.26	(1.05–1.51)	0.013	Propensity of surgeons to recommend surgery
MD supply	THA	22	MD supply	OR, 0.68		N/R	
	THA	30	Anes supply	RR, 0.9	(0.86–0.95)	0.001	Highest to lowest quintile
	THA	30	MD supply	RR, 0.79	(0.73–0.85)	0.001	Highest to lowest quintile
	THA	37	Anes supply	none			
	TKA	14	PMR supply	r, −0.42		0.002	
	TKA	14	Rheum supply	r, −0.25		0.08	
	TKA	14	PCP supply	r, −0.10		0.47	
	TKA	30	Anes supply	RR, 0.92	(0.87–0.96)	0.001	Highest to lowest quintile
	TKA	30	MD supply	RR, 0.91	(0.86–0.97)	0.001	Highest to lowest quintile
	LSS	7	PCP supply	IRR, 1.08	(0.99–1.18)	0.08	
MD factors	THA	36	PCP Trainers (%)	r, −0.24		0.05	
	THA	36	Child Health GPs (%)	r, −0.36		0.003	
	TKA	61	Female (%)	β, −6.5		0.02	Linear regression parameter estimate
	TKA	61	NA-trained (%)	β, −4.1		0.002	Linear regression parameter estimate
	LSS	7	Enthusiasm	IRR, 1.14	(0.96–1.34)	0.13	Propensity of referring MDs to refer for surgery
Hospital factors	THA	17	Hospital supply	r, −0.66		0.073	Number of centers offering TJA
	THA	22	Hospital volume	OR, 2.54		0.01	
	THA	30	Bed occupancy	RR, 0.98	(0.93–1.03)	0.12	Highest to lowest quintile
	THA	30	Hosp Volume	RR, 1.11	(1.05–1.18)	0.005	Highest to lowest quintile
	TKA	17	Hospital supply	r, −0.80		0.017	Number of centers offering TJA
	TKA	30	Bed occupancy	RR, 1.06	(1.00–1.12)	0.33	Highest to lowest quintile
	TKA	30	Hosp Volume	RR, 1.09	(1.03–1.16)	0.001	Highest to lowest quintile

Table 4. continued

Predictor	Procedure	Reference	Categories	Effect size	95% Confidence interval	p	Comment
Hospital type	THA	22	Government Hosp	OR, 0.90		N/R	
	THA	22	Insurance	OR, 2.46		0.01	Private Insurance charges (%)
	THA	22	Teaching	OR, 0.85		N/R	
	THA	30	Teaching	RR, 0.97	(0.93–1.01)		
	TKA	30	Teaching	RR, 0.9	(0.86–0.95)		
	TKA	61	Teaching beds (%)	β, 1.2		0.04	Linear regression parameter estimate
OR supply	THA	30	Day-case OR supply	RR, 0.93	(0.88–0.99)	0.12	Highest to lowest quintile
	THA	30	OR supply	RR, 1.11	(1.03–1.20)	0.005	Highest to lowest quintile
	TKA	30	Day-case OR supply	RR, 1.11	(1.04–1.18)	0.011	Highest to lowest quintile
	TKA	30	OR supply	RR, 0.96	(0.91–1.01)	0.018	Highest to lowest quintile
Medical costs	THA	22	MD Fees	OR, 0.10		0.05	
	THA	37	Care expenses	increase		0.001	Need-adjusted expenses of specialized care
Imaging	LSS	7	MRI Scanners	IRR, 1.3	(1.09–1.57)	0.004	
	LSS	35	CT/MRI rates	R^2, 0.22	r, 0.47	0.001	

TJA = total joint arthroplasty; LSS = lumbar spine surgery; HR = hazard ratio; OR = odds ratio; RR = rate ratio; r = correlation coefficient; β = regression parameter; IRR = incidence rate ratio; N/R = not reported; MDs = referring physicians, ORs = operating rooms; Anes = anesthesiologists; PMR = physical medicine and rehabilitation; Rheum = rheumatologists; PCP = primary care physicians; NA-trained = North-American-trained.

Table 5. Medical need predictors of surgical rates

Predictor	Procedure	Reference	Categories	Effect size	95% Confidence interval	p	Comment
Degenerative OA	TJA	18	Previous OA	HR, 6.03	(4.29–9.26)		
	TJA	19	History of OA	OR, 9.0	(5.41–15.0)		
	TJA	19	Previous TJA	OR, 12.6	(9.07–17.5)		
	TJA	27	OA	HR, 1.6	(1.25–2.05)	0.001	
	TJA	47	OA	OR, 2.18	(0.52–9.15)	0.29	
	THA	37	THA (OA)/THA(other)	Increase		0.001	
	TKA	13	Previous OA	OR, 0.93		0.35	
	LSS	7	Back pain	IRR, 0.81	(0.55–1.17)	0.26	
Disability	TJA	18	OA-related limitation	HR, 2.36	(2.02–2.79)		
	TJA	19	ADL limitations	OR, 3.32	(2.26–4.86)		
	TJA	19	physical limitations	OR, 2.02	(1.40–2.92)		
	TJA	27	SF-36 score 67+ to 25−	HR, 1.44	(0.99–2.10)	0.004	
	TJA	27	WOMAC score 54 + to 27−	HR, 2.17	(1.49–3.16)	0.001	
	TJA	47	Diff walking	OR, 1.37	(0.91–2.07)	0.13	
	THA	37	Permanent disability	Decrease		0.001	
	TKA	25	Physical limitations	OR, 3.05	(2.51–3.69)		Stooping or crouching

TJA = total joint arthroplasty; LSS = lumbar spine surgery; OA = osteoarthritis; ADL = activities of daily living; HR = hazard ratio; OR = odds ratio; IRR = incidence rate ratio.

increasing the diversity among providers may be strategies to reduce this potential access disparity.

Patient willingness to consider surgery (HB) was associated with higher rates of TKA but not LSS. Surgery for degenerative conditions of the hip, knee, and spine is an example of preference-sensitive care [59]. Wennberg described three categories of care, namely, effective, preference-sensitive, and supply-sensitive. Effective care includes treatments that are supported by strong evidence (ie, beta-blockers for myocardial infarction). Supply-sensitive care is delivered according to the resources available (ie, nonpalliative treatments at end-of-life care) [21]. Preference-sensitive includes the choice of different treatments, each with different risks and benefits. Because THA, TKA, and LSS are indicated to diminish pain and improve quality of life at the discretion of the patient, these procedures fall into this category. In other words, similar disease severity (from the surgeon's perspective) may be interpreted differently by patients based on their values, beliefs, and assessment of risk and benefit. Therefore, there exists no "true rate" and regional variation is to be expected to some extent. The main driver of this type of care lies with the patient and informed decision-making is the solution. Shared decision-making can play a large role in better informing patients about their condition and expectations after treatment; however, their direct relationship to surgical rates is less clear [1, 16].

Private/supplemental insurance (PR) was associated with higher surgical rates. In fee-for-service health systems, insurance coverage for discretionary procedures plays a critical role. With a renewed interest in universal coverage in the United States, it is yet unclear how this will affect overall surgical rates.

Surgeon supply was associated with increased TJA rates (CR). For TJA and LSS, surgeon "enthusiasm" was related to increased surgical rates. The influence of provider enthusiasm was first hypothesized by Chassin [10]. Conventional wisdom, at that time, suggested inappropriateness and clinical uncertainty were the main influences on regional variation. Chassin showed that geographic differences in use of health services may be caused by differences in the "enthusiasm" of physicians for particular services. Higher supply and specialization of nonsurgeons was associated with lower arthroplasty rates but not LSS. LSS was increased with higher rates and availability of advanced imaging. MRI use illustrates the problem of Granger causality, which exists when two associated factors are driven by a third process [23]. For example, economic growth or expansion may result in both an increase in medical resources and use simultaneously that may erroneously suggest that an increase in resources causes an increase in use [12]. Thus, the relationships between diagnostic and surgical use may be misleading.

Prevalence of OA or physical limitations (MN) was associated with higher rates of arthroplasty; however, back pain was not related to rates of LSS. The selection of a patient with a degenerative spinal disorder who would benefit from surgery is less straightforward than a patient with hip or knee OA. This diagnostic challenge may account for the lack of association with disease prevalence.

This systematic review identified a variety of factors that influence differential use of surgery for degenerative conditions of the hip, knee, and spine beyond. Potentially modifiable factors, from a policy perspective, include surgeon enthusiasm, patient health beliefs, resource allocation, and insurance coverage.

Regional variation in these procedures exists because they are highly sensitive to surgeon enthusiasm and preferences of patients informed by their social structure and medical need [58]. With strategies that may affect change in factors that are potentially modifiable by behavior or resources, extreme variation in rates may be reduced.

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Appendix 1. Search strategy

Performed September 16, 2010

(Physician's Practice Patterns/utilization [mh] OR Health Services Research [mh] OR Health Services Accessibility [mh] OR Health Services Needs and Demand [mh] OR Hospitalization [mh] OR Residence Characteristics [mh] OR Socioeconomic Factors [mh] OR Databases, Factual [mh] OR Population Surveillance [mh] OR Small-Area Analysis [mh] OR Health Status Disparities [mh] OR Population Surveillance[mh] OR registries [mh] OR Medicare [mh] OR Medicaid [mh]) OR "population-based" OR "population based" OR register OR "procedure volume" OR "surgical rate*" OR "population based" OR "population-based" OR "Medicare" OR "administrative database" OR "claims database" OR "area variation" OR "geographic variation" OR "regional variation" OR "small area analysis" OR "procedure volume" OR "frequency of use"

[742359 references]

AND

Arthroplasty, Replacement[mh] OR Hip Prosthesis[mh] OR Spinal fusion[mh] OR Lumbar Vertebrae/surgery[mh] OR Spinal diseases/surgery[mh] OR joint prosthesis[mh]) OR "hip replacement" OR "knee replacement" OR "spine surgery" OR (("low back" OR "spine" OR "hip" OR "knee") and "degenerative" and ("surgery" or "surgical")) OR "spinal fusion" OR "arthroplasty" OR "pedicle screw" OR "pedicle screws"

[86761 references]

AND

("determinants" OR "influence" OR "driven" OR "drivers" OR "explanation" OR "explained" OR "correlated")

[1232560 references]

COMBINE 1 and 2 and 3

[283 references]

LIMIT: English

[256 references]

Appendix 2

Data Abstraction Form

Study reference Number:

1. Inclusion criteria

Study design

a) Observational population-based or comprehensive cohort study (insurance claims, registry, etc.) [ie, not an arbitrarily selected cohort of patients]

YES NO -- EXCLUDE

SURVEY DATA CLAIMS DATABASE

b) Primary outcome is utilization of THA, TKA, or lumbar decompression or fusion for degenerative disease

YES NO -- EXCLUDE

c) Utilization rates are compared across:

□ 1. Sociogeographic strata

□ 2. Prespecified cohort groups

□ 3. Procedures
(ie, lumbar fusions to decompressions)

Methodological inclusion criteria

a) Explanatory statistical analysis:
Explanatory factors include any of the following (Major Components):

- Demographics (age, gender)
- Social structure (occupation, income, education level)
- Health beliefs (patient preferences)
- Personal resources (insurance coverage, waiting times)
- Community resources (medical facilities, availability of personnel, preferences of physicians)
- Medical need (prevalence of disease)

□ 1. Multivariate
(comparison across many variables)

□ 2. Bivariate
(comparison across one explanatory variable)

□ 3. Univariate -- EXCLUDE
(no comparison with other variables)

b) Geographic location of procedure:

- □ 1. Tied to patient residence
- □ 2. Tied to hospital location
- □ 3. N/A

c) Attribution of explanatory variables to events

- □ 1. Direct linkage
- □ 2. Ecologic

d) Multilevel or hierarchical modelling for multivariate analysis

YES NO

2. <u>Types of Interventions</u>

THA TKA DECOMPRESSION FUSION

Others: ________________________

3. <u>Participants</u>

<u>Patient characteristics</u>

a) Age ____

b) Gender ____

c) Ethnicity ____

d) Insurance ____

e) Employment ____

<u>Number of patients included in the study</u>

a) Number of procedures

a. THA __________

b. TKA __________

c. PLD __________

d. PLF __________

b) Number of observations (sociogeographic strata) _____________

c) Number of Providers ________________________

d) Number of Hospitals ________________________

e) Number of Hospital Referral Regions ________________________

f) Number of Regions (counties, etc) ________________________

5. Setting

Reimbursement system Name:__________________________________
(ie, Medicare, NHS, etc)

a. Private Insurance YES NO

b. Publicly funded insurance

1. Fee-for-service YES NO

2. Capitation YES NO

Years Included ________________________

Country ________________________

9. Results

Utilization Rates

a) Overall rate (per capita)

a. THA ________________________

b. TKA ________________________

c. PLD ________________________

d. PLF ________________________

b) Other measures of regional variation

a. Extremal Quotient (EQ)

THA_____________TKA_____________ PLD_____________ PLF___________

b. Coefficient of Variation (CV)

THA_____________TKA_____________ PLD_____________ PLF___________

c. Systematic Component of Variance (SCV)

THA_____________TKA_____________ PLD_____________ PLF___________

Explanatory Analysis

Factors Included in Model that Increase Surgical Rates

Major Component (D/SS/HB/PR/CR/MN)	**Specific Factor** (subcategories)	**Significant Direction** (+/-/NS)	**Effect Size** (RR/OR/IRR)	**p**

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