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Trends in Periprosthetic Hip Infection and Associated Costs: A Population-Based Study Assessing the Impact of Hospital Factors Using National Data

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ABSTRACT

Background: Periprosthetic joint infection (PJI) is an important cost driver in hip arthroplasty revisions, thus necessitating careful trend monitoring. Recent national trend data are lacking; we therefore assessed national PJI burden, trends in prevalence, and hospitalization costs.

Methods: We extracted data on hip arthroplasty revisions from the National Inpatient Sample (2003-2013; n = 465,209). Trends in PJI prevalence and hospitalization costs were (1) assessed for the full cohort and (2) stratified by hospital teaching status, hospital bed size (≤299, 300-499, and ≥500 beds), and hospital region (Northeast, Midwest, South, and West). The Cochran-Armitage trend test (PJI prevalence) and linear regression (hospitalization costs) determined significance of trends. Trends were adjusted for patient's age, gender, insurance type, race, Deyo-Charlson comorbidities, obesity, length of stay, and hospital characteristics.

Results: Overall, PJI prevalence was 15.0% (n = 70,011); adjusted prevalence increased from 13.1% in 2003 to 16.4% in 2013 ($P < .0001$), while adjusted median PJI hospitalization costs increased from $28,240 in 2003 to $31,529 in 2013 ($P < .0001$). Rural hospitals had the lowest PJI burden (12.5%; n = 4,525), while urban and teaching hospitals had the highest PJI burden (16.4%; n = 40,297). The stratified analyses, particularly in large hospitals (>500 beds), showed that PJI prevalence increased from 13.0% (2003) to 17.4% (2013; a 33.8% increase; $P < .0001$). Similarly, PJI revision hospitalization costs increased from a median of $27,490 (2003) to $31,312 (2013; a 14% increase; $P < .0001$).

Conclusion: The burden of PJI in hip arthroplasty revision is increasing and—while additional research is needed—there appears to be a particular shift of revision burden to larger hospitals with increasing costs.

Periprosthetic joint infection (PJI) is a potentially devastating and feared complication of joint arthroplasty, associated with significant morbidity and economic burden [1,2]. This condition presents not only a diagnostic challenge but also a management dilemma with substantial gaps in evidence and varying rates of successful treatment mentioned in the literature [3,4]. Moreover, with a growing and aging population, the PJI burden is expected to increase along with the projected increases in demand for primary hip and knee arthroplasties [5]. It is therefore crucial to monitor national trends in PJI rates and associated costs.

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Using 1990-2004 national data, Kurtz et al [6] found that among patients who underwent revision hip arthroplasty, PJI prevalence increased from 3.3% in 1990 to 8.0% in 2004. Conversely, a recently published study using 2000-2013 New York State data suggests that this trend may be plateauing [7]. This, however, may not be nationally representative.

In addition to equivocal data on trends in PJI rates, the majority of population-based studies on the economic burden of PJI do not focus on trends or cost differences between hospital types [2,8]. Therefore, using data from the 2003-2013 National Inpatient Sample, we aimed at providing an updated analysis of the national PJI burden in patients undergoing hip arthroplasty revisions. We sought to assess (1) trends in prevalence and inpatient costs for PJI and (2) whether these trends were affected by hospital characteristics.

Methods

Data Source, Study Design, and Study Sample

In this retrospective cohort study, we extracted data from the National Inpatient Sample which is created for the Healthcare Cost and Utilization Project by the Agency for Healthcare Research and Quality. It is the largest national all-payer inpatient database in the United States and contains data on more than 7 million annual inpatient stays [9]. The database is a sample of 20% of the nation's discharges from community hospitals and provides weights for each case to calculate nationally representative numbers. It contains information on hospital characteristics and patient demographic and clinical information using the International Classification of Disease-9th Revision (ICD-9) codes. Our study cohort was defined (similar to previous studies [7]) as any patient who underwent a revision for a hip arthroplasty procedure (ICD-9 codes 00.70, 00.71, 00.72, 00.73, 80.05, 81.53) from 2003 to 2013. PJI prevalence was defined as the percentage of revision cases with an ICD-9 diagnosis code (996.66) indicative of PJI. We excluded patients with missing information on costs (n = 6539), length of hospitalization (n = 2), and unknown mortality status (n = 71).

Study Variables

The main variables of interest were hospital characteristics: hospital teaching status and location (rural, urban teaching, and nonteaching), hospital bed size (≤299, 300-499, ≥500), and hospital region (Northeast, Midwest, South, and West). As laid out in the Healthcare Cost and Utilization Project, online documentation total hospital charges were converted to costs using available cost-to-charge ratios based on hospital accounting reports from the Centers for Medicare and Medicaid Services [10]. For each hospital, a hospital-specific cost-to-charge ratio is used. In addition, costs were adjusted for inflation reported in January 2013 dollars. Patient variables taken into account were age, gender, race/ethnicity (white, black, Hispanic, Asian/Pacific Islander, Native American, other), insurance type (Medicare, Medicaid, commercial, self-pay, no charge [individuals who were not charged for their medical visit at the date of data collection], other), Deyo-Charlson comorbidities [11], obesity (as this is not part of Deyo-Charlson), and length of stay (in days).

Analysis

First, we assessed unadjusted PJI prevalence and unadjusted median per-hospitalization cost by study variables. Given our large sample size, univariable differences between groups easily reach statistical significance. Therefore, we used standardized differences instead of *P* values to assess differences between groups. A standardized difference of 0.1 (or 10%) has been suggested to indicate a meaningful difference between groups [12,13]. In addition to unadjusted numbers, adjusted trends are important to consider as other explanatory factors such as an increasingly comorbid surgical population may also be responsible for increases in PJI prevalence. To provide adjusted estimates for trends, we applied a multivariable generalized linear model with PJI and cost of hospitalization as the dependent variable. As cost of hospitalization is skewed, we applied the gamma distribution with a log link function in the SAS PROC GLIMMIX procedure [14]. Models were adjusted for all hospital and patient variables mentioned above and provided expected per-patient PJI odds and hospitalization cost. These expected (or adjusted) estimates were aggregated by year and used to graph adjusted trends. Trends were assessed for PJI prevalence and PJI hospitalization costs from 2003 to 2013 for the full cohort and

Table 1
Unadjusted PJI Prevalence Among Hip Arthroplasty Revisions by Hospital Characteristics and Patient Demographics.

Study Variables	PJI			
	Yes, N	No, N	%	Standardized Difference
Full cohort	70,011	395,198	15.0	—
Hospital characteristics				
Hospital teaching status and location				0.1164
Rural	4525	31,595	12.5	
Urban, teaching	40,297	206,152	16.4	
Urban, nonteaching	24,709	155,463	13.7	
Unknown	481	1987	19.5	
Hospital bed size				0.0582
Small (≤299)	9012	57,766	13.5	
Medium (300-499)	15,632	89,479	14.9	
Large (≥500)	44,886	245,966	15.4	
Unknown	481	1987	19.5	
Hospital region				0.0164
Northeast	11,582	64,811	15.2	
Midwest	18,859	105,550	15.2	
South	25,460	142,571	15.2	
West	14,110	82,266	14.6	
Patient demographics				
Gender				0.1464
Male	33,995	163,663	17.2	
Female	35,998	231,143	13.5	
Unknown	18	392	4.4	
Race/ethnicity				0.0706
White	47,334	274,142	14.7	
Black	4621	21,640	17.6	
Hispanic	2559	11,281	18.5	
Asian/Pacific Islander	356	2481	12.5	
Native American	289	1310	18.1	
Other	1120	6148	15.4	
Missing	13,733	78,195	14.9	
Insurance type				0.1367
Medicare	44,167	251,750	14.9	
Medicaid	4752	15,385	23.6	
Commercial	18,282	112,569	14.0	
Self-pay	700	3025	18.8	
No charge	97	448	17.8	
Other	1936	11,472	14.4	
Missing	78	549	12.4	
Deyo-Charlson index (categorized)				0.2530
0	30,894	216,473	12.5	
1	20,058	106,759	15.8	
2	10,031	42,403	19.1	
2+	9028	29,562	23.4	
Obesity	7952	31,371	20.2	0.1160
Age (median [IQR])	66 (55-76)	68 (57-78)	—	0.0613
Length of stay (median [IQR])	6 (4-10)	3 (2-5)	—	0.2731

PJI, periprosthetic joint infection; IQR, interquartile range.