The Journal of Arthroplasty 30 (2015) 1883–1886

Contents lists available at ScienceDirect

The Journal of Arthroplasty

journal homepage: www.arthroplastyjournal.org

# The Combined Influence of Sociodemographic, Preoperative Comorbid and Intraoperative Factors on Longer Length of Stay After Elective Primary Total Knee Arthroplasty

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ARTICLE INFO

*Article history:*
Received 29 January 2015
Accepted 17 May 2015

*Keywords:*
length of stay
SES
socioeconomic status
primary TKA
value in healthcare
value-based care

ABSTRACT

This study assessed the collective association of sociodemographic, preoperative comorbid and intraoperative factors with longer length of stay (LOS) following elective primary total knee arthroplasty. Sociodemographic characteristics examined on 2638 adult cases included age, race/ethnicity, gender and socioeconomic status (SES). Intraoperative factors included operating time and anesthesia type. The collective associations of lower SES, female gender, advanced age, non-Caucasian race/ethnicity and certain comorbidities do present a synergistically elevated risk for longer LOS. In a value-driven healthcare environment, these findings further warrant the need for policymakers and payers to consider sociodemographic status when allocating resources to hospitals serving such patients.



Value in healthcare simply defined is quality relative to cost; though measuring it is quite complex. Ideally, the concept of value does encompass patient centeredness, outcomes, safety, and access to equitable high-quality, efficient healthcare at a relatively low cost. Readmission and hospital length of stay (LOS) following a procedure are important quality indicators and markers of resource utilization respectively [1]. In the United States (US), following the initiation of the Patient Protection and Affordable Care Act (PPACA) of 2009, payers such as the Centers for Medicare & Medicaid Services (CMS) began instituting reimbursement penalties for 30-day readmissions associated with certain conditions. This suggests that providers of healthcare (includes hospitals) have a strong financial incentive to decrease rates of readmissions and consequently other drivers of resource utilization. Total knee arthroplasty (TKA), which is the most effective treatment for end-stage osteoarthritis of the knee, is one of such procedures that has received a lot of attention in reimbursement changes.

As the volume of TKA procedures increases alongside rising healthcare costs, efforts must be made to contain costs without compromising quality. This suggests that identifying factors that may present an increased financial burden to the healthcare delivery system is essential. Some of these factors are multifaceted as they are intertwined with social, psychological, political and economic issues. With the growing interest to disentangle race/ethnicity and socioeconomic status (SES) in healthcare access and utility [2], few studies [1,3–17] have examined the association of preoperative patient-related SES and clinical factors with postoperative outcomes following hip or knee arthroplasty. However, the collective impact of sociodemographic (i.e. involving a combination of social and demographic characteristics) and clinical (preoperative comorbidities and intraoperative) factors after TKA are underexplored. While unscheduled readmissions are very important outcomes, this study primarily assessed the collective association of sociodemographic, preoperative comorbid and intraoperative factors with longer length of stay after elective primary TKA.

## Patients and Methods

### *Data Source and Study Population*

From 2011 to 2014, sociodemographic (age, patient-reported race/ethnicity, gender, income estimation from patient zip code [proxy for SES]), preoperative comorbidities (includes American Society of Anesthesiologists [ASA] score, body mass index [BMI]), primary indication for surgery, intraoperative factors (operating time [defined as number of minutes from incision to wound closure] and anesthesia type) and postoperative hospital LOS (calculated as the difference in days between the dates of surgery and discharge) data for 2638 elective primary TKA (International Classification of Disease Ninth Edition [ICD-9-CM] procedure code 81.54) cases were retrospectively retrieved from a

No author associated with this paper has disclosed any potential or pertinent conflicts which may be perceived to have impending conflict with this work. For full disclosure statements refer to http://dx.doi.org/10.1016/j.arth.2015.05.032.

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http://dx.doi.org/10.1016/j.arth.2015.05.032
0883-5403/

metropolitan high-volume single specialty hospital's electronic health record (EHR) and administrative database. An LOS greater than 3 days was considered 'longer' based on the median LOS at the primary institution.

Race/ethnicity was categorized as Caucasian (non-Hispanic) or minority (non-Caucasian – i.e. all patients of Hispanic origin, mixed races, African American/Black, Asian Pacific or Native American/Indian origin). Preoperative comorbidities were categorized into diseases affecting major body systems and/or conditions using ICD-9 CM codes reported at the time of index surgery: infectious diseases (001-139), neoplasia (140-239), endocrine (240-279), blood disease/blood forming organs (280-289), central nervous system (320-389), circulatory (390-459), respiratory (460-519), digestive (520-579) and genitourinary (580-629).

SES being a complex construct that involves both material and social factors was measured using median household per capita income by residential zip code (at time of index surgery) as generated and reported by the US National Census Bureau's American Community Survey (ACS) [18] from 2006 to 2010. The national dataset was divided into quartiles with the lowest income quartile defined as low SES. Patients in this study cohort who had zip codes that fell within that income category or quartile were classified as low SES. This approach of SES measure was chosen because it is known to reflect aggregate characteristics of a populace over individual characteristics, and provide insight into certain social attributes which often govern healthcare access, utility and delivery. It has also been successfully utilized in several studies in other disciplines [17,19–28].

### *Statistical Analysis*

Univariate and stepwise multivariate logistic regression analyses to adjust for the effect of multiple variables on the outcomes were conducted. The ability to predict patients' likelihood of longer LOS using patient-related (sociodemographic and preoperative comorbidities) and surgery-related (intraoperative) risk factors were explored. Covariates included in the model were age, gender, SES, BMI, ASA score, operating time, race/ethnicity, anesthesia type, and presence or absence of certain comorbidities. Operating time was analyzed as a continuous variable, while age (<65 vs. ≥65 years), BMI (<40 vs. ≥40 kg/m$^2$), ASA score (<2 vs. ≥2) and anesthesia type (general vs. regional vs. combined) were analyzed as categorical variables. In order to avoid overfitting that could potentially bias the results, only statistically significant univariate variables ($P \leq 0.05$) were included in the final models. The Hosmer–Lemeshow test was used to examine the goodness-of-fit of the models [29].

Adjusted odds ratios (OR) and corresponding 95% confidence intervals (CI) were computed. Categorical variables are summarized as counts with corresponding percentages, while continuous variables are summarized as means with minimum and maximum values, or median and interquartile range depending on distribution of data. Statistical significance was set at $P \leq 0.05$. The statistical analysis was performed using IBM SPSS version 21.0 [30].

## Results

### *Descriptive statistics*

The age range for the cohort was 22–92 years (mean: 64.9; median: 65[IQR, 58–72] years). There were 2338 (88.6%) females, 474 (18%) and 1252 (47.5%) patients of low SES and minority race/ethnicity respectively in the entire cohort. Osteoarthritis (75%) was the most frequent indication for undergoing TKA and 711 (27%) patients had an ASA score >2 (Table 1). Regional anesthesia was administered to 2219 (84%) patients, while 290 (11%) received general anesthesia (Table 2). Eight hundred fifty four (32.4%) patients had LOS greater than 3 days. Though not the primary focus of the study, there were 43 (1.6%) incidents of unscheduled 30-day readmissions. The most prevalent causes of readmissions were pneumonia/influenza (0.5%) and injuries to the gastrointestinal tract (0.3%).

**Table 1**
Patient-Related Factors: Sociodemographic and Clinical Characteristics.

| Variables | Entire Sample, N = 2638 |
|---|---|
| Age (years) | |
| <65 | 1273 (48.3) |
| ≥65 | 1365 (51.7) |
| Gender | |
| Male | 300 (11.4) |
| Female | 2338 (88.6) |
| Race/ethnicity | |
| Caucasian | 1343 (50.9) |
| Minority (non-Caucasian) | 1252 (47.5) |
| Low SES (as measured by zip code) | 474 (18.0) |
| Body mass index (kg/m$^2$) | |
| <40 | 2245 (85.1) |
| ≥40 | 393 (14.9) |
| ASA classification | |
| ≤2 | 1901 (72.1) |
| >2 | 711 (27.0) |
| Missing/unknown | 26 (1.0) |
| Comorbidities by disease category/body system | |
| Blood and blood forming diseases | 647 (24.5) |
| Circulatory | 1125 (42.6) |
| Digestive | 394 (14.9) |
| Endocrine | 1098 (41.6) |
| Genitourinary | 97 (3.7) |
| Infectious diseases | 40 (1.5) |
| Mental disorders | 255 (9.7) |
| Neoplasia | 16 (0.6) |
| Nervous system | 811 (30.7) |
| Respiratory | 317 (12.0) |

ASA = American Society of Anesthesiologists; SES = socioeconomic status. Data are expressed as frequencies with percentages in parenthesis.

### *Risk Factors From Multivariate Analysis*

When analyzed as independent variables, advanced age (≥65 years)(OR 1.25; 95% CI: 1.04–1.50; $P = 0.02$), operating time (OR 1.04; 95% CI: 1.02–1.05; $P < 0.001$), ASA score >2 (OR 1.65; 95% CI: 1.36–2.00; $P < 0.001$), certain infectious diseases (OR 2.38; 95% CI: 1.15–4.92; $P = 0.02$), blood/blood forming diseases (OR 2.08; 95% CI: 1.69–2.54; $P < 0.001$), circulatory disorders (OR 1.29; 95% CI 1.07–1.55 $P = 0.01$), respiratory disorders (OR 1.66; 95% CI: 1.28–2.15; $P < 0.001$) and genitourinary disorders (OR 2.63; 95% CI: 1.67–4.15; $P < 0.001$) were significantly associated with longer LOS. White race/ethnicity (OR 0.80; 95% CI: 0.67–0.96; $P = 0.02$) was protective against longer LOS (Table 3).

When sociodemographic variables were combined, 'low SES + minority race/ethnicity + advanced age' (OR 1.60; 95% CI: 1.12–2.28; $P < 0.001$) and 'low SES + minority race/ethnicity + female gender' (OR 1.32; 95% CI: 1.03–1.71; $P = 0.03$) along with certain comorbid conditions were significantly associated with longer LOS (Table 3).

**Table 2**
Surgery-Related Factors and Outcome Variables (N = 2638).

| Variables | Frequency (%) |
|---|---|
| Anesthesia type | |
| General | 290 (11.0) |
| Regional | 2219 (84.1) |
| Combined regional + general/MAC/unknown | 129 (4.9) |
| Operating time (minutes) | 78 (58-101) |
| Longer LOS (>3 days) | 854 (32.4) |
| 30-day readmissions | 43 (1.6) |

LOS = length of stay; MAC = monitor anesthesia care. Data are presented as median with interquartile range or frequency with percentage.