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Risk Factors Associated With Health Care Utilization and Costs of Patients Undergoing Lower Extremity Joint Replacement

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Abstract

Background: The Comprehensive Care for Joint Replacement program implemented by the Centers for Medicare and Medicaid Services did not incorporate risk adjustment for lower extremity joint replacement (LEJR). Lack of adjustment places hospitals at financial risk and creates incentives for adverse patient selection.
Objective: To identify patient-level risk factors associated with health care utilization and costs of patients undergoing LEJR.
Methods: A comprehensive search of research databases from January 1, 1990, through January 31, 2016, was conducted. The databases included Ovid MEDLINE In-Process & Other Non-Indexed Citations, Ovid MEDLINE, Ovid EMBASE, Ovid Cochrane Central Register of Controlled Trials, Ovid Cochrane Database of Systematic Reviews, and SCOPUS and is reported according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement. The search identified 2020 studies. Eligible studies focused on primary unilateral and bilateral LEJR. Independent reviewers determined study eligibility and extracted utilization and cost data.
Results: Seventy-nine of 330 studies (24%) were included and were abstracted for analysis. Comorbidities, age, disease severity, and obesity were associated with increased costs. Increased number of comorbidities and age, presence of specific comorbidities, lower socioeconomic status, and female sex had evidence of increased length of stay. We found no significant association between indication for surgery and the likelihood of readmission.
Conclusion: Developing a risk adjustment model for LEJR that incorporates clinical variables may serve to reduce the likelihood of adverse patient selection and enhance appropriate reimbursement aligned with procedural complexity.

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Recent projections suggest that the number of total hip arthroplasties and total knee arthroplasties performed in the United States may more than double from 2005 to 2030.[1] Data from the voluntary Bundled Payments for Care Improvement project introduced by the Centers for Medicare and Medicaid Services (CMS) suggest that bundled payments reduce costs.[2] The CMS implemented the Comprehensive Care for Joint Replacement (CJR) program, which dramatically transformed payment design for lower extremity joint replacement (LEJR). Although variation exists in patient and procedural complexity for LEJR, CMS-paid hospitals set episode prices with limited consideration for patient-level complexity. Due to the absence of a validated risk adjustment model in this context, the CJR program adjusted target pricing for joint replacement due to hip fracture only.[3] The CMS did include protection for providers from monetary loss during the course of a single performance year, including patient exclusions for conditions such as end-stage renal disease, service exclusions for use of clotting factors, and graduated stop-loss (and conversely stop-gain) provisions.[4]

Despite considerations in the CJR program to shield providers from excessive cost, a potential unintended consequence of the bundled payment strategy is preferential marketing to and selection of patients who are less likely to develop medical complications. Conversely, surgeons and health care systems will have incentive to delay or decline surgeries for higher-risk patients or to refer these patients to public or tertiary care centers.[5-7] Risk-adjusted payments have been proposed as a solution to remove disincentives for providing care to higher-risk patients.[8]

The primary aim of this systematic review was to identify patient-level risk factors potentially associated with increased health care utilization and costs for patients undergoing LEJR. Results inform an ongoing empirical analysis focused on examining the implications of including these factors in CJR program target price setting methods.

METHODS

This systematic review was conducted according to guidance from the Cochrane Collaboration and is reported according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement.

Inclusion Criteria

We sought to replicate the bundle of services included in the LEJR bundle.[9] The episode for the LEJR bundle of care begins with the index hospitalization that results in discharge under Medicare Severity Diagnosis Related Group 469 (major joint replacement or reattachment of lower extremity with major complications or comorbidities) or 470 (major joint replacement or reattachment of lower extremity without major complications or comorbidities) and ends 90 days after discharge. As such, we included studies of primary unilateral or bilateral LEJR (hip, knee, or ankle) with health care utilization and cost outcomes reported for the index hospitalization, including 3 days before admission and 90 days after discharge.

We excluded studies reporting no patient-level outcomes, including those reporting only hospital- or surgeon-level characteristics, such as hospital/surgeon volume, partial vs total joint replacement, hospital ward staffing or design, surgical approach, and provision of anticoagulation or antianemia medications. We also excluded studies for the following reasons: (1) language other than English, (2) full text not available through our library or interlibrary loan, (3) published as abstracts only, (4) focused solely on a pediatric population, (5) reported revision surgeries and primary surgeries together, and (6) reported only outcome timeframes greater than 90 days after surgery.

Search Strategy and Criteria

A comprehensive search of research databases from January 1, 1990, through January 31, 2016, was conducted. The databases included Ovid MEDLINE In-Process & Other Non-Indexed Citations, Ovid MEDLINE, Ovid EMBASE, Ovid Cochrane Central Register of Controlled Trials, Ovid Cochrane Database of Systematic Reviews, and SCOPUS. The search strategy used controlled vocabulary to search for health care utilization, expenditures, and costs (Supplemental Appendix 1, available online at http://www.mcpiqojournal.org). We used search terms focusing on (1) patients with LEJR (knee, hip, or ankle), (2) resource expenditure including cost or utilization, and (3) the period after surgery, up to 90 days or 13 weeks. All abstracts retrieved by the search were evaluated independently by 2 reviewers according to aforementioned criteria (M.A.K., M.M.J., L.M.P., S.M.). Studies identified for possible inclusion by either reviewer were assessed in full text by 2 reviewers (M.A.K., M.M.J., L.M.P., J.A., B.J.B., M.H.M., A.N.L.). A third reviewer resolved discrepancies in full-text screening (M.A.K., M.M.J., J.A.). Data were abstracted by 1 of 4 abstracters (M.A.K., M.M.J., J.A., A.N.L.). Ten percent of studies were double abstracted and discrepancies corrected (M.M.J.).

The methodological quality of the studies was judged based on items selected to address risk-of-bias domains in observational studies. Quality of evidence was categorized as high, medium, or low based on domains from the GRADE (Grading of Recommendations Assessment, Development and Evaluation) approach,[10] including the methodological limitations of the studies, the statistically significant effect size (relative association measure >2.0 considered a large effect), sample size (<200, 200-999, ≥1000), inconsistency

in the results of studies looking at the same risk factors and outcomes, and directness of the evidence to the question at hand. Risk factors and outcomes were abstracted as they were found in each manuscript and grouped into categories after all data were abstracted. When multiple studies contributed to the same association and were consistent in the direction of association, we considered that to be evidence warranting high certainty (high quality). When results were inconsistent in the direction of association, we considered that to warrant lower certainty in the evidence.

Search Results

Of the 2025 studies identified in the search (2020 from the database search and 5 from the hand search of the reference lists of included studies and reviews), 1656 (82%) were excluded in abstract review (Figure 1). An additional 39 studies (2%) passing abstract review were excluded because we were unable to obtain full text through our library or interlibrary loan. The remaining 330 studies (16%) were reviewed in full text.

A total of 79 studies were included and abstracted for analysis; 54 reported studies were conducted in the United States. Characteristics of the included studies were summarized, including the outcomes and risk factors reported by each study (Supplemental Appendix 2, available online at http://www.mcpiqojournal.org). After the data were abstracted, we reviewed outcomes and risk factors found in the literature and organized them into 6 categories of outcomes and 20 categories of risk factors (Table 1).

After reviewing all the abstracts retrieved by the search, we determined that outcomes reported in the oldest studies were very different from those in more recent studies. For example, Singh et al[11] reported that average length of stay (LOS) was cut in half between 1990 and 2000: from 9.7 days in 1991-1993 to 4.5 days in 2000-2002 for black patients and from 8.3 days to 4.2 days for white patients in the same periods. We, therefore, excluded 21 studies that had passed the abstract review but were published between 1990 and 1999. Thus, the studies included in this systematic review were all published from 2000 through the first 4 weeks of 2016.

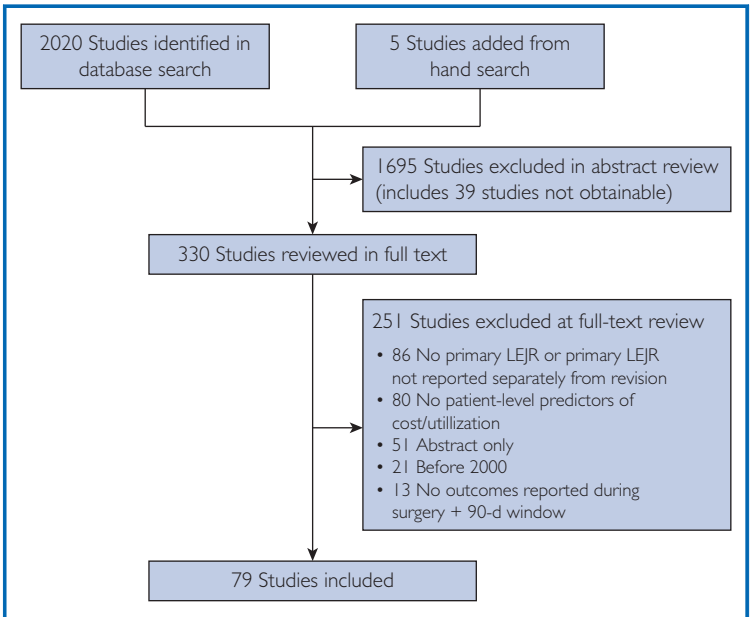

FIGURE 1. Study selection process. LEJR = lower extremity joint replacement.

Data Synthesis

Given that the purpose of the systematic review is to identify risk factors of health care utilization and cost that can be added to risk-adjustment models, point estimates of the effect of each predictor were not developed or pooled owing to the heterogeneity in study design, population, and outcome reporting.

RESULTS

The literature included evidence on 61 pairs of risk factors and outcomes (Figure 2). Of these 61 risk factor and outcome pairs, 9 were supported by high-quality evidence, with all 9 pairs finding a nonzero association between the risk factor and outcome. Moderate-quality evidence supported 42 risk factor and outcome pairs, 34 with a nonzero association; low-quality evidence was found on 10 risk factor and outcome pairs, 7 with a nonzero association.

The evidence base was strongest for the LOS and cost outcomes, which were the most common in the literature and reported by 50 and 26 studies, respectively. Most studies (53 of 79 [67%]) reported outcomes during the index hospitalization only. A further 16 studies (20%) reported outcomes

TABLE 1. Outcome and Risk Factor Categories

Outcome or risk factor	Description
Outcomes	
Acute (index) hospital utilization	Resources used during initial hospital stay; eg, critical care/intensive care unit stay, operating room time, blood transfusions
Cost	Amount billed or paid for health care services; sometimes reported as hospital charges or as standardized charges
LOS	Number of days in initial hospitalization; LOS for postacute care categorized separately
Postacute inpatient care utilization	Nonacute inpatient care (eg, skilled nursing facility, rehabilitation hospital, etc); measured as LOS or as discharge disposition (eg, % discharged to postacute care vs home)
Postdischarge outpatient utilization	Outpatient care received after discharge (eg, physical therapy)
Readmission	Readmission to acute hospital; generally measured as a binary outcome rather than as LOS
Risk factors	
Admission urgency	Generally measured as elective vs emergency
Age	Measured continuously or in age categories
Comorbidities	Measured as index scores (eg, Charlson Comorbidity Index) or as a series of binary indicators. Comorbidities included varied across studies. Obesity is categorized separately.
Day of the week	Day surgery was performed
Disease indication	The reason the patient was having surgery; the most frequent diseases reported were osteoarthritis and rheumatoid arthritis
Distance to hospital	Distance from patient's home to hospital where treated
Functional status	Measures of patient's presurgery functional status (eg, muscle atrophy, wasting, use of walking aids, ADL/IADL scores, knee stiffness, timed get up and go test, stair score, walking aid score)
Height	Patient height
Obesity	Most commonly measured using BMI categories; some studies present a dichotomous version (generally split at 30), others present ≥4 categories
Payer type	Government, private, workers' compensation, or other payer
Perioperative risk factors	Variety of measures that could increase the complexity of decision making and care during or after surgery; most commonly reported ASA score. Other measures: preoperative laboratory values including hemoglobin, hematocrit, sodium, history of anticoagulant use, unilateral vs bilateral surgery, same-day vs staged bilateral surgery, and history of solid organ transplant
Procedure type	Hip vs knee vs ankle
Race/ethnicity	Frequently presented as white, black, Hispanic, other
Region	Region of the United States or other country
Risk score	Multidomain risk scores
Severity of disease	APR-DRG, Severity of illness score, Crowe score, pain score (visual analog scale), clinical characteristics
Sex	Male, female
Social support	Measured as living arrangement (alone vs with other) or marital status
Socioeconomic status/income	Generally measured by income for the zip code or postal code where the patient lives
Urban setting	Rural vs urban

ADL/IADL = activity of daily living/instrumental activity of daily living; APR-DRG = All Patient Refined Diagnosis Related Group; ASA = American Society of Anesthesiologists; BMI = body mass index; LOS = length of stay.

for the hospitalization and some period after, with 11 of those studies (69%) reporting outcomes for the 90-day period included in the CJR program.

We briefly report herein the risk factor and outcome pairs supported by high quality of evidence. Complete results are available in Figure 2 and Supplemental Appendixes 2 and 3 (available online at http://www.mcpiqojournal.org). Samples of effects reported in studies of high methodologic quality are reported in Table 2.

Cost Outcomes

Eight studies observed that medical comorbidities were associated with increased costs.[12-19] Age,[13,14,20-22] disease severity,[20,23-26] and obesity were associated with increased cost. Most of the effect of body weight seems to be driven by morbid or severe obesity (body

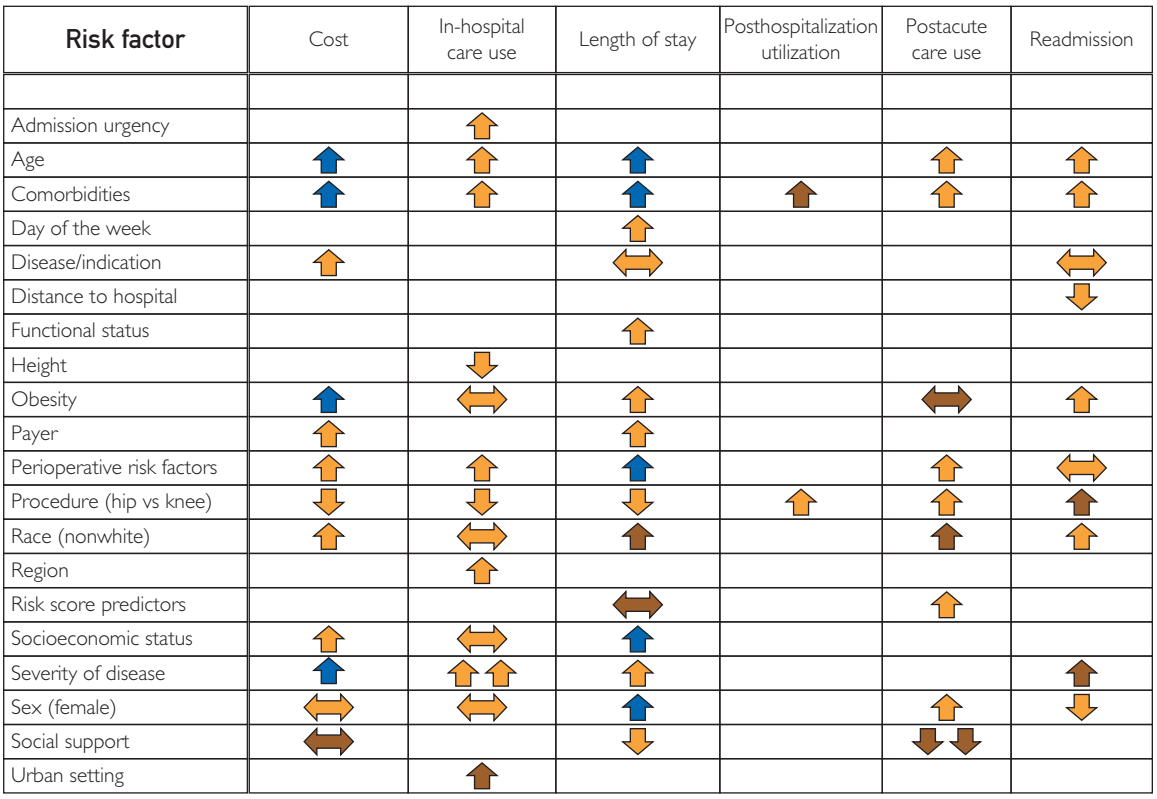

FIGURE 2. Risk factors and outcomes.The association was considered large (2 arrows) when a relative association measure was greater than 2.0, otherwise the effect was considered smaller (single arrow). A sideways arrow indicates evidence of no effect. Brown, orange, and blue colors denote low-, moderate-, and high-quality evidence, respectively.

mass index [BMI; calculated as the weight in kilograms divided by the height in meters squared] >35 or 40) compared with normal weight (BMI of 18-25) and overweight (BMI of 25-29).[16,20,21,27-32]

LOS Outcomes

The bulk of the evidence suggests a moderate increase in LOS associated with either increased numbers of medical comorbidities or the presence of specific comorbidities, for example, diabetes, metabolic syndrome, coronary artery disease, and chronic heart failure.[12,15,17-19,33-41]

The perioperative risk factor category incorporated a broad variety of measures indicating increased complexity of medical decision making or care of the patient during or after surgery. The most frequently reported measure was the American Society of Anesthesiologists physical classification system score,[42] reported in 12 of the 22 studies.[34,41,43-52] The strongest evidence supported increased LOS associated with perioperative risk factors.[21,34,41,43-46,48,51,53-58]

Lower socioeconomic status,[14,39,41,59] female sex,[21,34-36,38-41,43,45,46,48,53,60-63] and increased age[21,22,35-41,43-46,48,51,53,54,59,63-65] were also risk factors for longer LOS.

Readmission Outcomes

Quality of evidence for the association between disease/indication for surgery and readmission was high but suggested no effect.[66]

DISCUSSION

In this systematic review, 20 risk factor categories were identified that are associated with health care utilization and cost for patients undergoing LEJR. These patient-level risk factors could be used in the development of

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TABLE 2. Magnitude of Association or Impact of Risk Factors in Studies of High Methodologic Quality

Risk factor	Outcome	Example study	Quantitative estimates
Age	Cost	Cram et al,[14] 2015	1.06% (95% CI, 1.03%-1.08%) increase in Medicare payments for entire episode of care associated with 1-y increase in age
	LOS	Bou Monsef and Boettner,[53] 2014	Mean ± SD LOS: <60 y: 3.2±1.2 d 60-69 y: 3.3±1.2 d 70-79 y: 3.5±1.2 d ≥80 y: 3.8±1.6 d *P* value from Kruskal-Wallis test<.0001
Comorbidities	Cost	Cram et al,[14] 2015	5.10% (95% CI, 5.03%-5.17%) increase in Medicare payments for entire episode of care associated with 1 additional comorbidity
	LOS	Stundner et al,[19] 2013	Odds ratio for prolonged LOS: Depression: 1.28 (95% CI, 1.22-1.35) Anxiety: 1.20 (95% CI, 1.15-1.25) Depression and anxiety: 1.79 (95% CI, 1.33-2.40)
Obesity	Cost	D'Apuzzo, et al[28] 2015	Mean total cost (range) Nonobese: $14,715 ($31-$305,526) Morbidly obese: $15,174 ($24-$121,202) *P*<.001
Perioperative risk factors	LOS	Bou Monsef and Boettner,[53] 2014	Mean ± SD LOS by anticoagulant drug use: Aspirin: 3.3±1.1 d Coumadin: 3.6±1.1 d Aspirin + coumadin: 3.6±1.4d
Socioeconomic status	LOS	Styron et al,[39] 2011	Increased LOS by income; *P* value for no difference from reference category: ≥$45,000 (reference) <$25,000: 4% higher; *P*=.008 $25,000 to $34,999: 1% higher; *P*=.012 $35,000-$44,999: 1% higher; *P*=.013
Severity of disease	Cost	Adrados et al,[25] 2015	Costs for hip replacement by severity of illness: Minor: $19,072 (95% CI, $18,863-$19,281) Moderate: $20,542 (95% CI, $20,329-$20,744) Major: $27,159 (95% CI, $6646-$27,672) Extreme: $43,626 (95% CI, $42,153-$45,099)
Sex (female)	LOS	Bou Monsef and Boettner,[53] 2014	Mean ± SD LOS by sex: Male: 3.3±1.3 d Female: 3.5±1.2 d *P*>.0001 from Wilcoxon rank sum test

LOS = length of stay.

a risk-adjustment or risk-stratification method used by the CMS and other payers. Building on claims-based risk-adjustment approaches currently used by the CMS, including the Hierarchical Condition Category diagnostic classification method, inclusion of risk factors identified via systematic approaches such as this may facilitate the development of more robust risk-adjustment approaches to guide appropriate payment policies. By incorporating risk adjustment as part of LEJR payments, it could decrease the risk of adverse selection while promulgating the development and uptake of alternative payment models.

Strengths of this study include a rigorous method for the search strategy and inclusion of studies. This study has several limitations. First, the search included only studies focused on the total joint replacement population and, therefore, missed risk factors from the broader literature on surgery-associated utilization and cost not specific to LEJR. For example, we identified no studies meeting the inclusion criteria evaluating the effect of a patient's

previous health care costs, which have been shown to be associated with future health care costs.[67-70] Second, risk factors and outcomes were abstracted as they were found in the literature and then were grouped into thematic categories. Other researchers might have created different groupings that could change the evidence quality ratings. Third, although the inclusion criteria were based broadly on the CJR program bundle definition, studies meeting the inclusion criteria do not precisely replicate the population and time horizon captured in the CJR program bundled payment. For example, a study examining costs only within a 30-day window would meet the inclusion criteria for the present study, whereas the CJR program bundle definition uses a 90-day window. Finally, the abstracted data were too heterogeneous to pool for meta-analysis. These limitations do not affect the success of the primary aim of this study: to apply a scientifically rigorous method to identify candidate risk factors to include in models testing risk-adjustment methods for bundled payments.

This study responds to an immediate need for information in a rapidly shifting payment policy environment. Under the CJR program, hospitals selected for participation are subject to price setting that excludes sophisticated risk adjustment methods. The CMS has acknowledged that the absence of a model developed for or specified to the CJR program bundled payment context was a factor in excluding risk adjustment from price setting.[3] A study by Ellimoottil et al[8] determined that with the application of claims-based risk adjustment (CMS Hierarchical Condition Category), hospitals with the least medically complex patient populations could experience a reduction in annual payments by as much as $146,360. Conversely, hospitals with the most medically complex patient populations could experience reconciliation payment increases by as much as $114,184. This study suggests that risk adjustment is needed to ensure that hospitals will not be penalized for providing care to medically complex patients.[8]

A large body of evidence examines the association between patient-level risk factors and increased utilization and cost in LEJR. We identified key risk factors from high-quality studies that should be further evaluated in target pricing for bundled payments. This study serves as the basis for ongoing work to develop and test more comprehensive risk-adjustment models for LEJR.

SUPPLEMENTAL ONLINE MATERIAL

Supplemental material can be found online at http://www.mcpiqojournal.org. Supplemental material attached to journal articles has not been edited, and the authors take responsibility for the accuracy of all data.

Abbreviations and Acronyms: **ADL/IADL** = activity of daily living/instrumental activity of daily living; **APR-DRG** = All Patient Refined Diagnosis Related Group; **ASA** = American Society of Anesthesiologists; **BMI** = body mass index; **CJR** = Comprehensive Care for Joint Replacement; **CMS** = Centers for Medicare and Medicaid Services; **LEJR** = lower extremity joint replacement; **LOS** = length of stay

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