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Perioperative complications of legally blind patients undergoing total knee arthroplasty: A national inpatient sample database study

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A B S T R A C T

Introduction: Vision impairment is a significant health concern that leads to increased morbidity and mortality globally. Significantly, legally blind (LB) patients have higher rates of hospitalization, cost, and orthopedic-related complications. Total knee arthroplasty (TKA) is commonly used to treat advanced knee osteoarthritis. However, there is limited literature reporting the demographic and hospitalization characteristics and operative outcomes of patients with LB who underwent TKA. This study addresses this gap in literature.

Method: We conducted a retrospective study using a Nationwide Inpatient Sample database. We assessed perioperative complications, length of stay (LOS), and healthcare expenditure among legally blind and control cohort patients who underwent TKA. Propensity matching was conducted to identify factors associated with perioperative complications.

Results: Between 2016 and 2020, there were 558,371 patients underwent TKA, with 0.1% of patients documented as legally blind. Of this cohort, the average age was significantly older than the control, 70.01 years versus 66.72 years ($p < 0.001$), respectively. Patients from the LB cohort had a longer length of stay (2.9 ± 1.7 days) than those from the control cohort (2.4 ± 1.3 days) ($p < 0.001$). Significantly, patients in the legally blind group incurred higher expenditures than those in the control group ($68,936 versus $64,808, respectively; $p < 0.001$). (Table 2). Propensity matching yields similar results. Analysis of TKA-associated operative complications suggested that legally blind patients had a higher proportion of blood loss anemia (20.97%, $p < 0.05$), required blood transfusions secondary to surgery (3.1%, $p < 0.05$), and periprosthetic fractures (2.6%, $p < 0.05$) than the control group (15.3%, 1.5%, and 0.42%, respectively).

Conclusion: We report that LB patients are, on average, older and have an extended LOS, higher expenditure, and higher rates of specific TKA-associated operative complications than those without legal blindness. To date, this is the first study of its kind to provide large, population-based data on the demographics, costs, and TKA-operative complications in patients with LB and, as such, provides a purposeful basis for future research.

1. Introduction

Vision impairment is a significant health concern that adversely affects approximately 8% of the U.S. population.[1] While the causes of vision impairment are multifactorial, the health consequences associated with it extend beyond the visual system to include reduced quality of life, increased mortality, and orthopedic-associated sequela (i.e. impaired mobility, falls, and fractures).[2] Legally blind individuals, defined as those with visual acuity of 20/200 or less in the 'better' eye with correction, are at particularly high risk of adverse health outcomes and healthcare utilization.[3]

Total knee arthroplasty (TKA) is a mainstay surgical procedure that aims to reduce pain and improve function in patients with advanced knee osteoarthritis. The procedure is one of the most clinically successful measures and its utilization is expected to increase with considerable growth.[4] Despite its efficacy, TKA is associated with a variety of operative complications, including infections, deep vein thrombosis, and wound healing problems. These complications are especially concerning in patients with visual impairments, such as legally blind individuals, who may be more susceptible to adverse outcomes owing to their underlying conditions.

Despite the well-established TKA-associated operative complications, there is a paucity of literature on these outcomes in a legally blind population. Current literature regarding this topic suggests that visual impairment is a risk factor for operative complications in general.[5] Furthermore, legally blind patients are found to have longer hospital stays and higher rates of readmission than patients without impaired vision.[6] However, further research is necessary to narrow the knowledge

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gap that exists within this niche population, given that the number of legally blind individuals is burgeoning globally.

Currently, the only literature that provides a comparable review of total joint arthroplasty in the legally blind population was conducted in patients undergoing total hip arthroplasty (THA) and reported that legally blind patients had longer lengths of stay (LOS) and higher rates of non-home discharges (NHD).[7] To date, no existing literature provides a comprehensive national overview of TKA-operative complications in the legally blind population. Consequently, this study employed a retrospective analysis of the Nationwide Inpatient Sample (NIS) database to evaluate the patient characteristics, demographics, and prevalence of operative issues among legally blind patients who had TKA. We hypothesized that legally blind patients would experience higher rates of operative complications, longer hospital stays, and higher costs associated with their care than non-legally blind patients.

2. Methods

2.1. Database description

Nationwide Inpatient Sample (NIS), a large publicly accessible inpatient database, was developed through a federal-state-industry partnership supported by the Agency for Healthcare Research and Quality (AHRQ). It is connected to databases and software tools created for the Healthcare Cost and Utilization Project (HCUP). The large sample dataset of the NIS provides an opportunity to develop regional and national estimates, and allows for the analysis of unique patient cohorts, such as legally blind patients. The information is based on a quality assessment analysis by an independent contractor that compares data points with accepted normative values and examines 20% of the hospitals in the United States. The NIS database contains several variables including patient demographics and medical profiles, hospital course information, and cost of patient care, The International Classification of Diseases (ICDs), Tenth Revision, Clinical Modification/Procedure Coding System was used for the 2016–2019 revision.

2.2. Data acquisition

This study was considered exempt from IRB approval as data were void of specific patient information and publicly accessible. This study compiled all patients with ICD-10 and Clinical Modification/Procedure Coding System (CMP) codes for total knee arthroplasty (TKA). Two specific cohorts. Legally and non-legally blind (control) patients were obtained from patient records collected between 2016 and 2019. The ICD codes are outlined in Appendix A.

Patient demographic factors included age, sex, ethnicity, obesity status, and preexisting comorbidities. Postoperative complications included anemia, hypotension, acute renal failure (ARF), deep vein thrombosis (DVT), and pulmonary embolism (PE). Our analysis included the assessment of periprosthetic infections (PPIs), prosthetic dislocation, periprosthetic fracture, and systemic sequelae, such as myocardial infarction and pneumonia. Finally, the amount of time each patient spent in the hospital (total length of stay) and the cost of care were collected. All preoperative variables and postoperative complications were based on the ICD codes outlined in Appendix A.

2.3. Statistical analysis

All statistical analyses were performed using SPSS version 27.0 (IBM, Armonk, NY, USA). Descriptive statistics were used to compile patient demographic information. Comparisons were made between the corresponding and non-corresponding datasets. A 1:1 propensity score matching process was conducted using preoperative variables. Propensity matching was performed based on age, sex, ethnicity, obesity, and diabetes with and without complications. T-tests were used to analyze the numerical variables. Chi-square analysis was used to analyze binomial variables. Fisher's exact test was used when incidence values were <5. All tests were considered statistically significant if the p value was ≤0.05. The odds ratios and corresponding 95% confidence intervals for surgical outcomes and complications were determined by calculating the ratio of the incidence in the LB group to that in the control.

3. Results

The study sample consisted of N = 558,371 patients who underwent total knee arthroplasty (TKA) between 2016 and 2019 (Table 1). Within this cohort, 391 (0.1%) patients were considered legally blind (LB), and N = 557,980 (99.9%) did not meet the criteria for lawfully blind (control).

3.1. Patient demographics

Of the legally blind cohort, the average age of the patients is 70.01 ± 10.8 years, 66.2% (N = 259) are females ($p < 0.06$), and 80.7% ($p < 0.001$) are of Caucasian ethnicity. A comparative analysis with the control cohort suggested that the LB group was significantly older (66.7 years in control, $p < 0.001$), with a similar proportion of females (61.5%, $p < 0.06$) and Caucasian patients (81.1%, $p < 0.001$). Furthermore, stratification by ethnicity highlights that patients identified as of Native American ethnicity compose the minority in both cohorts, 0.5% (N = 2) and 0.5% (N = 2529) in the LB and control groups, respectively. Additionally, there was no significant difference in the number of patients categorized with obesity between the cohorts (32.2% and 30.9% in the LB and control groups, respectively; p = 0.5). (Table 1).

3.2. Unmatched patient admission profile

The length of stay of patients in the LB cohort (2.9 ± 1.7 days) was significantly longer than that of patients in the control cohort (2.4 ± 1.3 days) ($p < 0.001$). An assessment of the contributing factors, such as tobacco-related disorders, indicated no significant difference between the LB (14.3%) and control (15.8%) groups (p = 0.44). Furthermore, there was no significant difference between the percentage of patients with diabetes mellitus without complications (13.0% and 14.8%, p = 0.4) or diabetes mellitus with complications (0.8% and 0.3%, p = 0.08) in the LB and control groups, respectively. Nevertheless, those in the legally blind group incurred significantly higher costs than those in the control group ($68,936 compared to $64,808, respectively; $p < 0.001$). (Table 2).

Table 1
Patient demographic characteristics of legally blind patients and the control group patients.

Age (years) ± SD	Legally Blind group (N = 391)	Control group (N = 557,980)	Significance
	70.01 ± 10.8	66.72 ± 9.5	<.001
Sex			
Female	259 (66.2%)	343,161 (61.5%)	.062
Male	132 (33.8%)	214,704 (38.5%)	.062
Race			
Caucasian	305 (80.7%)	434,912 (81.1%)	<.001
African American	40 (10.6%)	44,799 (8.4%)	<.001
Hispanic	22 (5.8%)	33,572 (6.3%)	<.001
Asian	[a] (0.8%)	8248 (1.5%)	<.001
Native American	[a] (0.5%)	2529 (0.5%)	<.001
Other	[a](1.6%)	11,876 (2.2%)	<.001
Obesity	126 (32.2%)	17,235 (30.9%)	.586

[a] - Numbers between 1 and 10 are not reported due to HCUP data use agreement.

3.3. Matched patient admission profile

The matched analysis sample consisted of 391 LB and 378 control patients. Within this cohort, the LB group was older than the control group, 70.01 years versus 69.8 years, respectively ($p < 0.001$). Moreover, the proportion of females, 66.2% and 66.1%, and patients with obesity, 32.2% and 32.5%, is similar between the two cohorts: 66.2% and 66.1%, in the LB and the control, respectively. ($p > 0.05$).

Although not statistically significant, the length of stay for patients in the LB cohort (2.9 ± 1.7 days) was slightly longer than that of the control cohort (2.5 ± 1.9 days) ($p > 0.05$). An evaluation of contributing factors, such as those with tobacco-related disorders, revealed a significant difference between the LB (14.3%, N = 56) and control (14.2%, N = 54) groups ($p < 0.05$). Nonetheless, there was no significant difference between the proportion of patients with diabetes mellitus without complications (13.04% and 13.2%, $p > 0.05$) and diabetes mellitus with complications (0.76% and 0.79%, $p > 0.05$) between the LB and control groups. In contrast to the unmatched analysis, the matched cohorts revealed no significant difference in total expenditure, $68,936 and $68,688, between the LB and control cohorts, respectively ($p > 0.05$). (Table 3).

3.4. Perioperative complications

The operative complications associated with TKA in the LB and control groups are presented in Tables 4 and 5. Unmatched data suggest that legally blind patients have a higher proportion of blood loss anemia (20.97%, $p < 0.05$), requiring blood transfusions secondary to surgery (3.1%, $p < 0.05$), and periprosthetic fractures (2.6%, $p < 0.05$) than the control group (15.3%, 1.5%, and 0.42%, respectively). (Table 4). Matched propensity analysis suggested that a significantly higher proportion of legally blind patients required blood transfusions (3.1%, $p < 0.05$) and experienced periprosthetic fractures (2.6%, $p < 0.05$) than the control group. However, no significant differences in the mortality rates were observed (Table 5).

4. Discussion

In this study, we conducted a retrospective analysis to report the national patient profile of TKA-associated operative complications in patients with legal blindness. We found that patients with severe vision impairment tended to be older, disproportionally 'Caucasian,' and tended to have prolonged hospital stays, higher incurred expenses, and higher rates of procedure-associated perioperative complications.

Chronic co-morbidities are associated with reduced quality of life (QOL), especially in older populations.[8] With the aging of the U.S. population, vision impairment is a burgeoning health challenge of the modern age. Numerous studies have highlighted the correlation between advancing age and developing vision impairment, reduced QOL, and higher mortality rates.[9–11] Our analysis suggests that legally blind patients, at an average age of 70 years in our study, were older than the control cohort. Our findings further support the current accepted literature, which proposes that the average age for the onset of severe vision impairment is 50 years and older.

The prevalence of health disparities affecting various ethnic and racial groups is well-documented. Varma et al. reported that non-Hispanic whites represent the most significant number of people affected by vision impairment and will continue to represent the most significant proportion until 2050, based on a modeled demographic survey.[3] While other regional analyses reflect various causes of vision impairment with higher predilection in specific ethnicities.[3] In our study, those designated as Caucasian ethnicity comprised most patients in both legally blind (80.7%) and control groups (81.1%). While numerous factors contribute to vision impairment, its sequelae, and adverse health outcomes, our findings present an avenue for future research to assess ethnically associated inequities in vision impairment and health outcomes.

However, few studies have assessed the impact of vision impairment in the context of orthopedic injuries and hospitalization data. Current research reports that elderly patients with severe deficits in visual acuity are prone to higher rates of fractures, falls, mobility issues, and secondary injuries.[2] These vision-associated sequelae have led to reports of longer length of stay (LOS) and higher expenses incurred for management.[1,2,6] Morse et al. reported that patients with vision loss had an average LOS of 6.48 days compared to patients without vision loss, 5.26 days; additionally, LB patients had a higher total cost of care ($64,711 versus $61,060 in control).[12] These findings are further supported by the historical analysis of Javitt et al. and Frick et al.[13,14] However, most of these studies are either niche-population analyses, analyses conducted on single or tertiary care centers with limited population size, or performed a retrospective analysis within a fixed period. A comparable nationwide study by Harris et al. reports that hospitalized patients with severe impairment and blindness (SVI/B) had a significantly longer LOS than those without SVI/B.[15] However, this study did not reflect a significant difference in total hospital expenses between SVI/B and non-SVI/B patients. Our study, utilizing a nationwide database and in congruence with the current literature, reports a longer LOS in legally blind patients (2.86 days vs. 2.35 days) and higher medical expenses in this population.

Operative complications are associated with almost all medical and surgical procedures. Common complications of total knee arthroplasty (TKA) in the general population include bleeding, wound complications, thromboembolic disease, infections, and periprosthetic fractures.[16] However, to the best of our knowledge—after extensive review—no

Table 2
Unmatched analysis-patient admission characteristics of legally blind patients and the control group patients.

Variables	Legally Blind group (N = 391)<	Control group (N = 557,980)	Significance
Length of Stay (days) ± SD	2.86 ± 1.73	2.35 ± 1.93	<.001
Total charges (USD)	68936.99 ± 47035.46	64808.01 ± 45833.71	<.001
Tobacco-related disorders	56 (14.3%)	88,313 (15.8%)	.444
DM Without Complication[a]	51 (13.0%)	82,413 (14.8%)	.391
DM With Complications[a]	3 (0.8%)	1401 (0.3%)	.077

[a] DM: Diabetes Mellitus.

Table 3
Matched Analysis Patient characteristics of legally blind patients and the controlled group.

Variables	Legally Blind group (N = 391)	Control group (N = 378)	Significance
Age (years) ± SD	70.01 ± 10.81	69.83 ± 10.44	<.001
Sex			
Female	259 (66.2%)	250 (66.1%)	1.000
Male	132 (33.8%)	128 (33.9%)	1.000
Length of Stay (days) ± SD	2.86 ± 1.73	2.47 ± 1.86	0.978
Total charges (USD)	68936.99 ± 47035.46	68688.87 ± 44103.85	0.384
Tobacco-related disorders	56 (14.3%)	54 (14.2%)	.0384
DM Without Complication[a]	51 (13.04%)	50 (13.22%)	1.000
DM With Complications[a]	[b](0.76%)	[b] (0.79%)	1.000
Obesity	126 (32.2%)	123 (32.5%)	.939

[a] DM: Diabetes Mellitus.
[b] - Numbers between 1 and 10 are not reported due to HCUP data use agreement.

Table 4
Unmatched Analysis- Postoperative complications differences between legally blind patients and control group.

Post Operative Variables	Legally Blind Group (N = 391)	Control group (N = 557,980)	Odds Ratio (Legally blind/Control Group)	Odds Ratio 95% Confidence interval	Significance
Acute Renal Failure	13 (3.32%)	11,072 (1.98%)	1.699	(0.977, 2.954)	.067
Myocardial Infarction	0	109 (.019%)	.999	(0.999, 0.999)	1.000
Blood Loss Anemia	82 (20.97%)	85,475 (15.31%)	1.467	(1.150, 1.872)	.003
Pneumonia	0	1088 (.19%)	.999	(0.999, 0.999)	1.000
Pulmonary Embolism	[b] (.256%)	1237 (.221%)	1.154	(0.162, 8.220)	.580
Deep Vein Thrombosis	[b](.511%)	1260 (.226%)	2.272	(0.566, 9.126)	.222
Periprosthetic Fracture	[b] (2.56%)	2353 (.422%)	6.198	(3.304, 11.627)	<.001
Periprosthetic dislocation	[b] (1.53%)	4256 (.762%)	2.028	(0.905, 4.544)	.082
Periprosthetic mechanical complication	[b] (1.27%)	4499 (.806%)	1.594	(0.659, 3.852)	.253
Periprosthetic Infections	[b] (1.27%)	5797 (1.03%)	1.234	(0.510, 2.982)	.611
Superficial SSI[a]	0	26 (.004%)	.999	(0.999, 0.999)	1.000
Deep SSI[a]	0	8 (.0014%)	.999	(0.999, 0.999)	1.000
Wound dehiscence	[b](.512%)	528 (.094%)	5.428	(1.349, 21.839)	.054
Blood Transfusion	12 (3.069%)	8242 (1.477%)	2.112	(1.188, 3.753)	.018

[a] SSI: surgical site infection.
[b] - Numbers between 1 and 10 are not reported due to HCUP data use agreement.

Table 5
Matched Analysis- Postoperative complications differences between legally blind patients and control group.

Operative Variables	Legally Blind Group (N = 391)	Control group (N = 378)	Odds Ratio (Legally blind/Control Group)	Odds Ratio 95% Confidence interval	Significance
Died During Hospitalization	0	0	a	a	a
Acute Renal Failure	13 (3.325%)	[b] (2.64%)	1.266	(0.548, 2.922)	.674
Myocardial Infarction	0	0	a	a	a
Blood Loss Anemia	82 (20.97%)	59 (15.6%)	1.435	(.992, 2.076)	.062
Pneumonia	0	[b] (.5%)	.490	(0.456, 0.527)	.241
Pulmonary Embolism	[b] (.255%)	[b] (.26%)	.967	(0.060, 15.511)	1.000
Deep Vein Thrombosis	[b] (.511%)	[b] (.26%)	1.938	(0.175, 21.465)	1.000
Periprosthetic Fracture	[b] (2.557%)	[b] (.52%)	4.934	(1.074, 22.671)	.037
Periprosthetic dislocation	[b] (1.53%)	[b] (.52%)	1.947	(0.484, 7.846)	.506
Periprosthetic mechanical complication	[b] (1.278%)	[b] (.26%)	4.883	(0.568, 41.996)	.217
Periprosthetic Infections	[b] (1.277%)	[b] (.52%)	2.435	(0.470, 12.629)	.451
Superficial SSI*	0	0	a	a	a
Deep SSI*	0	0	a	a	a
Wound dehiscence	[b] (.511%)	0	.507	(0.473, 0.544)	.499
Blood Transfusion	12 (3.069%)	[b] (.79%)	3.958	(1.108, 14.138)	.034

[a] Since incidence was 0 in one group, odds ratio and significance values could not be computed.
[b] Numbers between 1 and 10 are not reported due to HCUP data use agreement.

literature has assessed the rates of TKA operative complications in legally blind patients. In our study, LB patients had a higher risk of blood loss anemia, requiring blood transfusions, and periprosthetic fractures than non-LB patients. Similar LB-patient population studies have reported a higher risk of acute renal failure, pneumonia, and need for blood transfusion secondary to total hip arthroplasty.[7]

Nutritional status refers to the condition of an individual in relation to the intake, absorption, and utilization of consumed nutrients. The causes of poor nutritional status have been categorized as decreased intake, altered utilization, or increased requirements.[17] Several studies have highlighted the relationship between visual impairment and its impact on nutritional status through a decline in functional status.[18] Payette et al. and Sharkey et al. reported an independent association between vision impairment and lower energy and protein intakes.[19,20] Steinman et al. suggests that legally blind, older individuals are more likely to be clinically underweight.[21] To address the issue of poor nutritional status in visually impaired individuals, it is essential to implement proper preoperative nutritional screening and optimization strategies. One potential screening tool is to assess serum ferritin levels, which can provide information about iron deficiency and anemia.[22] Identifying and addressing nutritional deficiencies before surgery can help reduce the risk of postoperative anemia and the need for blood transfusions.[23]

In addition to nutritional screening, occupational therapy (OT) can play a crucial role in preparing individuals with visual impairment for surgery. OT professionals can focus on fall prevention strategies to reduce the risk of postoperative periprosthetic fractures.[24] By addressing environmental hazards, providing education, and recommending assistive devices, OT consultations can help enhance the safety and independence of visually impaired individuals during their recovery period.

It should be acknowledged that a myriad of factors, besides vision impairment alone, can contribute to operative complications, including co-existing comorbidities, patient medical history, age, genetic predisposition, drug/alcohol exposure, and intraoperative complications. Assessment of these factors within our patient population would yield novel correlations and significance; however, this is beyond the scope of this study.

4.1. Limitations

The NIS is the most extensive publicly available inpatient healthcare database (specificity >92%); however, it can still be susceptible to errors in data addition, a lapse of discrimination between comorbidities, and hospital-acquired complications.[25] However, these errors would not drastically alter our study results if they existed.

Additionally, the limitations of the nationwide database include errors in coding both diagnoses and procedures, inability to account for multiple admissions for similar injuries, and limited information

regarding pre-existing comorbidities that can affect costs. Therefore, the accuracy of the study depended on the diagnostic and procedural codes used for the patient health billings. While rates of variation in ICD-10 clinical codes are described by Horsky et al. it should not significantly skew the total cost of hospitalization.[26]

5. Conclusion

To the best of our knowledge, this novel nationwide database study examined hospital admission characteristics and perioperative complications associated with TKA in patients with legal blindness. We observed that legally blind patients who underwent TKA were, on average, older, hospitalized for a longer length of stay, incur higher healthcare expenses, and have a higher risk of specific perioperative complications. To date, this is the first study of its kind to provide concrete, extensive population-based data on the demographics, cost, and complications of TKA in legally blind patients, and as such, provides a purposeful basis for future research.

Declaration of competing interest

None.

Appendix AICD Codes

Obese Codes	Legally Blind Code	Comorbidities codes	Medical Complications codes	Surgical Complications codes
E660	H54.8	Diabetes without complications	Acute renal Failure	Periprosthetic fracture
E6601		E119	N170, N171, N172, N178, N179	T84010A, T84011A, T84012A, T84013A, T84018A, T84019A, M9665, M96661, M96662, M96669, M96671, M96672, M96679, M9669, M9701XA, M9702XA,
E6609		Diabetes with complications	Myocardial Infarction	M9711XA, M9712XA
E661		E1169	I2101, I2102, I2111, I2113, I12114, I12119, I2121, I12129, I21A1	Periprosthetic dislocation
E662		Tobacco related disorder	Blood loss anemia	T84020A, T84021A, T84022A, T84023A, T84028A, T84029A
E668		Z87891	D62	Periprosthetic mechanical complications
E669			Pneumonia	T84090A, T84091A, T84092A, T84093A, T84098A, T84099A
Z6830			J189, J159, J22	Periprosthetic Infection
Z6831			Blood transfusion	T8450XA, T8451XA, T8452XA, T8453XA, T8454XA, T8459XA
Z6832			30233N1	Superficial SSI
Z6833			Pulmonary embolism	T8141XA
Z6834			I2602, I2609, I2692, I2699	Deep SSI
Z6835			DVT	T8142XA
Z6836			I82401, I82402, I82403, I82409, I82411, I82412, I82413, I82419, I82421, I82422, I82423, I82429, I82431, I82432, I82433, I82439, I82441, I82442, I82443, I82449, I82491, I82492, I82493, I82499, I824Y1, I824Y2, I824Y3, I824Y9, I824Z1, I824Z2, I824Z3, I824Z4	Wound Dehiscence
Z6837				T8130XA, T8131XA, T8132XA
Z6838				
Z6839				

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