# Decline in Racial Disparities for United States Hospital Admissions After Anterior Cruciate Ligament Reconstruction From 2007 to 2015

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**Background:** Racial disparities in perioperative complications have been shown to exist for many procedures in orthopaedic surgery. Although anterior cruciate ligament reconstruction (ACLR) is commonly performed as an outpatient procedure, the rate of admission to the hospital postoperatively is not insignificant. Hispanic patients have been shown to have higher odds of admission compared with non-Hispanic patients.

**Hypothesis:** We hypothesized that racial disparities would decrease from 2007 to 2015, resulting in lower rates of hospital admission for Black and Hispanic patients.

**Study Design:** Descriptive epidemiology study.

**Methods:** This study represents a retrospective analysis of the National Surgical Quality Improvement Program (NSQIP) database for patients undergoing ACLR between 2007 and 2015. We performed bivariate analysis as well as binary logistic regression, with postoperative admission as the primary outcome. Previously identified risk factors for admission were used as predictors in addition to a term for the statistical interaction between year of surgery and ethnicity.

**Results:** A total of 7542 patients undergoing ACLR were assessed. The logistic regression model showed that Hispanic patients had higher overall odds of admission (odds ratio [OR], 3.320; $P < .001$) than White patients; Black patients also had higher odds compared with White patients (OR, 1.929; $P = .009$). However, there was a significant interaction between year of surgery and both Black ethnicity (OR, 0.907; $P = .026$) and Hispanic ethnicity (OR, 0.835; $P = .002$), indicating a significant decrease in the admission rates for these minority patients compared with White patients over time. Other risk factors for admission were the use of regional anesthesia (OR, 3.482; $P < .001$), bleeding disorders (OR, 5.064; $P = .002$), a higher body mass index (OR, 1.029; $P < .001$), and longer operative times (OR, 1.012; $P < .001$). More recent surgery was associated with lower odds of admission (OR, 0.826; $P < .001$).

**Conclusion:** Admission rates after ACLR declined from 2007 to 2015. Black and Hispanic patients were more likely to be admitted overall, but they also saw a greater decrease in the odds of admission than White patients. This represents a reduction in disparity between the 2 groups and is a reassuring improvement in racial disparity trends after a common sports procedure.

**Keywords:** knee; ligaments; ACL; disparities

Racial disparities have been identified across the spectrum of health care in America, including but not limited to infant mortality, diabetes incidence, heart failure outcomes, cancer screening and treatment, and various surgical procedures.[‡] Unfortunately, racial disparities have also been shown in the orthopaedic literature, largely among total joint arthroplasty procedures. In particular, it is well documented that disparities exist in both access and outcomes after total hip and knee arthroplasty.[§] Medicare data from 1991 to 2008 as analyzed by Singh et al[33] indicated that racial disparities in access and outcome for both hip and knee arthroplasty failed to improve over that time period, whereas Aseltine et al[2] more recently found an encouraging reduction among Connecticut hospitals in the rates of disparate outcomes between White and Black patients after total hip arthroplasty from 2005 to 2015.

Anterior cruciate ligament reconstruction (ACLR) is a widely performed procedure in the United States, accounting for an estimated cost of US$3 billion annually.[6,20,34] While ACLR is commonly considered an outpatient procedure, recent data have shown a noninsignificant rate of hospital admission after surgery. A 2017 analysis of risk factors for hospital admission after ACLR showed an

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[‡]References 1, 5, 13, 15, 17, 18, 27, 29, 35.
[§]References 3, 9-11, 14, 17, 21, 22, 28, 34, 42.

admission rate of 13.1%, with use of epidural anesthesia, history of bleeding disorders, and Hispanic ethnicity as independent risk factors for hospital admission.[4] The association between Hispanic ethnicity and rates of admission was particularly intriguing, as it highlights a possible racial disparity in sports medicine surgery. Our purpose in this study was to investigate the trends among ethnicities for hospital admission after ACLR from 2007 to 2015 in the United States. Specifically, we hypothesized that racial disparities would decrease over time, resulting in lower rates of hospital admission for Black and Hispanic patients. We also hypothesized that admission rates would decrease over time across all racial groups.

## METHODS

### Data Source

We analyzed data from the National Surgical Quality Improvement Program (NSQIP) database from 2007 to 2015. This data set is collected by the American College of Surgeons (ACS) from patient charts; contains information about patient demographics, Current Procedural Terminology (CPT) codes, and 30-day patient outcomes; and represents a high-quality, prospectively collected surgical database encompassing approximately 750 medical centers.[7] Medical centers are excluded from the ACS NSQIP database if their interobserver disagreement rate between clinical reviewers is greater than 5% or if their 30-day follow-up rate is less than 80%. Finally, this database provides a highly accurate source of postoperative admission and has been validated in the ACLR population.[4] All cases with CPT code 29888 (arthroscopically aided anterior cruciate ligament reconstruction) were selected. Excluded were 5 cases with missing values for anesthesia type, 12 missing the American Society of Anesthesiologists (ASA) classification, 5 missing body mass index (BMI), and 1 case missing sex. Additionally, there were 4461 cases with unknown or missing race that were excluded.

### Measures

The primary outcome for this study was the change over time in postoperative admission to the hospital. This was identified by at least 1 overnight stay in the hospital after surgery. Patient characteristics included in our analysis were patient race, age, BMI, and presence of bleeding disorders. Other factors included in the analysis were the use of regional anesthesia, total operation time, and year of surgery. These surgical and patient factors have been

TABLE 1
Bivariate Chi-square Analysis of Demographic Variables[a]

| | n | Discharged, % | Admitted, % | P Value |
|---|---|---|---|---|
| Age, y | | | | <.001 |
| 16-19 | 698 | 84.0 | 16.0 | |
| 20-29 | 2766 | 86.2 | 13.8 | |
| 30-39 | 2015 | 87.7 | 12.3 | |
| 40-49 | 1428 | 89.0 | 11.0 | |
| 50-59 | 529 | 91.1 | 8.9 | |
| ≥60 | 106 | 83.0 | 17.0 | |
| Total | 7542 | 87.2 | 12.8 | |
| Sex | | | | .004 |
| Female | 2887 | 88.6 | 11.4 | |
| Male | 4655 | 86.3 | 13.7 | |
| Total | 7542 | 87.2 | 12.8 | |
| Race | | | | <.001 |
| Asian | 548 | 87.8 | 12.2 | |
| Black | 904 | 84.6 | 15.4 | |
| Hispanic | 230 | 74.3 | 25.7 | |
| White | 5860 | 90.5 | 9.5 | |
| Total | 7542 | 87.2 | 12.8 | |
| BMI, kg/m$^2$ | | | | <.001 |
| <18.5 | 31 | 87.1 | 12.9 | |
| 18.5-24.9 | 2373 | 89.2 | 10.8 | |
| 25.0-29.9 | 2879 | 87.4 | 12.6 | |
| ≥30.0 | 2259 | 84.9 | 15.1 | |
| Total | 7542 | 87.2 | 12.8 | |

[a]BMI, body mass index.

previously identified as independent predictors of admission after ACLR using the NSQIP data set.[4]

### Statistical Analysis

An initial bivariate analysis comparing admission rates for different demographic groups was performed using chi-square testing. Binary logistic regression comparing patients who were admitted postoperatively with those discharged on the same day was then performed. Patient age, BMI, and year were included as continuous variables. For race, White patients were used as the reference category. A race × year interaction term was included in the regression to estimate the statistical interaction between race and year of surgery in the odds of admission. P values less than .05 were considered statistically significant (SPSS Statistics V 25.0; IBM).

### RESULTS

After exclusion, there were 7542 cases included in our analysis. The overall admission rate was 12.8% (Table 1). The

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TABLE 2
Binary Logistic Regression Predicting the Odds
of Hospital Admission After ACLR[a]

|  | OR (95% CI) | *P* Value |
| --- | --- | --- |
| Intercept | 0.043 (0.029-0.064) | <.001 |
| Regional anesthesia | 3.482 (2.666-4.548) | <.001 |
| Bleeding disorder | 5.064 (1.823-14.069) | .002 |
| BMI | 1.029 (1.018-1.040) | <.001 |
| Year | 0.826 (0.799-0.855) | <.001 |
| Total operation time | 1.012 (1.010-1.013) | <.001 |
| Asian | 0.786 (0.574-1.077) | .134 |
| Hispanic | 3.320 (2.013-5.478) | <.001 |
| Black | 1.929 (1.178-3.160) | .009 |
| White | Reference | — |
| Black × year | 0.907 (0.833-0.988) | .026 |
| Hispanic × year | 0.835 (0.743-0.938) | .002 |

[a]BMI, total operation time, and year were continuous variables. The reference year was 2007. ACLR, anterior cruciate ligament reconstruction; BMI, body mass index; OR, odds ratio.

mean age of all patients was 32.7 years (range, 16-89 years), and 61.7% of the patients were male. White patients comprised 77.7% of the sample, and 30.0% of patients had a BMI of $\geq 30$ kg/m$^2$. Analysis of hospital admission versus patient demographics showed that there were significant differences in admission rates between demographic groups. Patients in the $\geq 60$-year age group had a 17.0% admission rate compared with 8.9% for the 50- to 59-year age group ($P < .001$). Slightly more male patients were admitted than female patients, with admission rates of 13.7% and 11.4%, respectively ($P = .004$). Hispanic patients had the highest overall admission rate of 25.7% compared with 9.5% of White patients ($P < .001$). For patients with a BMI of $\geq 30$ kg/m$^2$, the admission rate was 15.1% compared with 10.8% for patients with a BMI of 18.5 to 24.9 kg/m$^2$ ($P < .001$).

The model predicting the odds of admission after ACLR showed several significant factors (Table 2). The use of regional anesthesia was associated with greater odds of admission (odds ratio [OR], 3.482; $P < .001$). Longer operative times also increased the likelihood of admission (OR, 1.012 per minute; $P < .001$). Patients with a bleeding disorder were significantly more likely to be admitted (OR, 5.064; $P = .002$), as were patients with a greater BMI (OR, 1.029; $P < .001$). Year of surgery was also a significant factor, with later years associated with lower odds of admission (OR, 0.826; $P < .001$). Hispanic patients were 3.320 times more likely to be admitted than White patients ($P < .001$), and Black patients were 1.929 times more likely to be admitted than White patients ($P = .009$). The significant Hispanic × year ($P = .002$) and Black × year ($P = .026$) interaction terms indicated that the admission rates of Hispanic and Black patients decreased relative to that of White patients between 2007 and 2015. As the $P$ value for Asian race was not significant ($P = .134$), an interaction term was not included.

Figure 1 uses the binary logistic regression model in Table 2 to show the estimated odds of admission for White,

Black, and Hispanic patients over the length of the study. Values other than race and year were fixed at their reference level; the reference patient did not have regional anesthesia or a bleeding disorder, had a BMI of 28.3 kg/m$^2$, and had surgery lasting 104.8 minutes. At the beginning of the study, the estimated admission rate of Hispanic patients was double that of White patients (51.8% vs 24.5%, respectively), and the estimated admission rate of Black patients was approximately 57% higher (38.4% vs 24.5%, respectively). By 2015, the Hispanic estimated admission rate was 5.2%, the Black estimated admission rate was 5.9%, and the White estimated admission rate was 6.6%. As the model in Table 2 showed no significant effects for Asian patients, the estimated odds of admission were not significantly different from those of White patients.

To determine whether patient comorbidity level decreased over time, thus explaining some of the decreasing admission rates, we performed an additional analysis of ASA classification (Appendix Tables A1 and A2). A 2-way analysis of variance of race and year predicting the ASA classification showed that although the mean ASA class varied by year ($P = .029$), it did not vary significantly by race ($P = .245$) or by the race × year interaction term ($P = .550$).

## DISCUSSION

The most important finding of this study was a decrease in the disparity between Hispanic, Black, and White patients in postoperative admission rates. After controlling for all other significant factors known to influence admission after ACLR, Black and Hispanic patients experienced higher odds of postoperative admission at the beginning of our study. However, by the end of our study, the estimated odds of admission between all patient groups were comparable. An additional analysis demonstrated that this reduction in disparity was not caused by changing levels of comorbidity over the period of the study, which is a possible confounding factor.

Admission to the hospital after ACLR has been shown to be very expensive. Saltzman et al[30] performed a systematic review in 2016 and found that the costs for outpatient ACLR ranged from $677 to $4160, whereas ACLR with overnight hospitalization ranged from US$7692 to US$12,040. This additional cost was levied disproportionately on minority patients throughout most years of our study. The reduction in this disparity, which ultimately led to Black and Hispanic patients having slightly lower estimated odds of admission than White patients, represents a major cost savings to the health care system as well as a step toward greater racial equity in orthopaedics. Aseltine et al[2] recently elucidated a similar trend, demonstrating a reduction in the readmission disparity between Black and White patients after total joint arthroplasty. This study represents the second example of a reduction in racial disparities in orthopaedics.

Although the NSQIP database does not capture specific factors leading to a reduction in disparity, there were a number of policy initiatives occurring at the time of this study that may have played a role. At a minimum, these
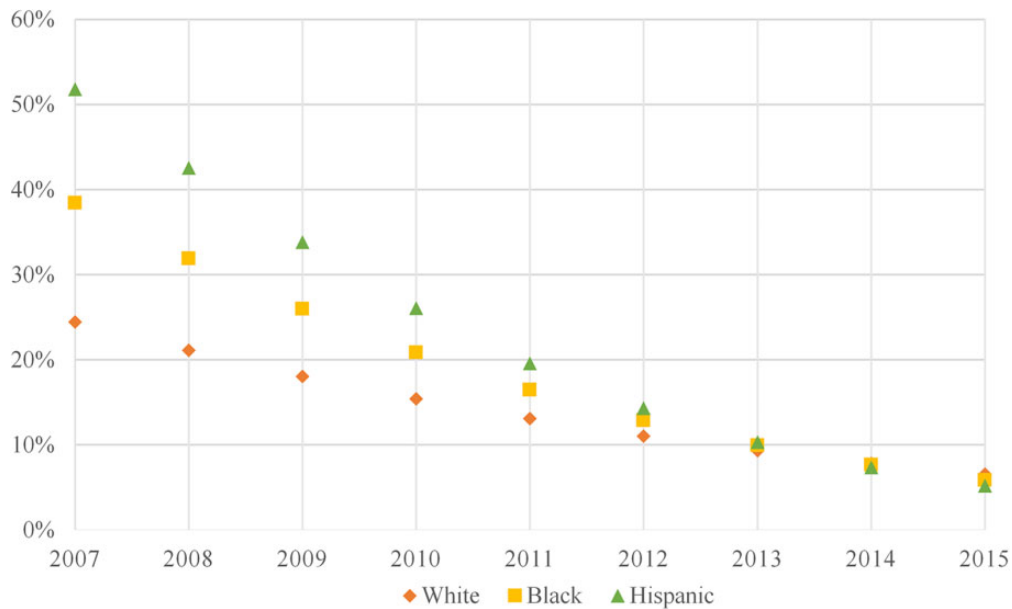
**Figure 1.** Estimated odds of postoperative admission after anterior cruciate ligament reconstruction by race/ethnicity and year of surgery. Data were derived from the binary logistic regression in Table 2. The estimated odds of admission for Asian patients were not significantly different from those of White patients.

initiatives have placed a renewed interest in cost containment and standardization of the high quality of care. For instance, the Centers for Medicare and Medicaid Services (CMS) initiated programs such as the Hospital Consumer Assessment of Healthcare Providers and Systems as well as Hospital Compare, which allow patients to easily view in-depth quality ratings as well as an overall star rating for hospitals based on factors such as unnecessary admission.[39,40] The CMS also started the Surgical Care Improvement Project in 2005.[36] Programs specific to orthopaedics have also been implemented. Section 3021 of the Affordable Care Act created the CMS Innovation Center to test models of improved care.[37] This Innovation Center has created orthopaedic-specific quality improvement programs, such as the Comprehensive Care for Joint Replacement model.[38] This model ties payments to quality and cost measures. Although there is no direct cause-effect relationship, it is plausible that a general climate of focus on quality improvement played a role in the reduction of racial disparities found in this study. Specifically within ACLR, surgeons may have become more focused on reducing preventable postoperative admission to the hospital.

An important aspect of our study is the overall reduction in admission after ACLR. Lyman et al[20] found that from 1997 to 2006, the percentage of ACLR cases performed in an ambulatory surgical center rose from 57.3% to 95.1%. These numbers closely match the results of a study by Mall et al[23] that found that 95% of ACLR cases were performed in an ambulatory surgery center in 2006. Importantly, a recent systematic review and meta-analysis by Ferrari et al[12] found that postoperative complications and patient pain levels are similar between outpatient and inpatient cases. Although our database did not have information on

patient pain levels postoperatively, Liu et al[19] found that pain was the most common reason that patients sought acute care after ACLR. We found that patients who received regional anesthesia alone had 3.482 times greater odds of admission than patients receiving general anesthesia. Patients receiving regional anesthesia in the afternoon may not regain lower extremity function within the standard operating hours of an ambulatory surgery center, thus necessitating an overnight hospital stay. This may be a major factor in why regional anesthesia increased the odds of admission rather than a lack of pain control, as several randomized trials have shown regional anesthesia to be effective in controlling pain levels postoperativey.[16,26]

Identifying racial disparities is an important step in moving toward a more equitable health care system. This study found the existence of a racial disparity in admission rates after a common sports medicine procedure as well as a reduction in that disparity over time. This provides evidence of an increasingly equitable delivery of orthopaedic care in the United States. However, future studies are required to elucidate the underlying initiatives and programs that have led to this disparity reduction so that they may ultimately be reproduced in other settings.

### Limitations

There are several limitations to this study. The largest limitation is the 4461 cases that were missing data on patient race. It is possible that the exclusion of these cases added a bias to our study. However, given that the ACS interrater reliability audits have been shown to be robust in ensuring data accuracy, we are confident that there is a high degree of accuracy in the cases included in our sample and that the

exclusion of cases with missing data is the most appropriate methodology.[32] The NSQIP database also has a 30-day postoperative data collection period that limits our ability to analyze long-term results. In addition, it does not list the reason for admission to the hospital. Although there are many institutions included in this database, privately owned surgery centers are not included. Our results thus may not reflect how ACLR is performed in all settings. We also did not have data on orthopaedic-specific surgical characteristics, such as the type of graft used, functional outcome scores, or physical therapy regimens performed postoperatively. To comply with Health Insurance Portability and Accountability Act requirements, the most granular information available for the date of surgery is the year in which it was performed. There may be intrayear trends that we are therefore missing. Although we controlled for patient-specific comorbidities and demographics, we did not have information on surgeon characteristics. Surgeon training or case volume may play a role in the odds of postoperative admission. Despite these limitations, the NSQIP database allowed us to examine trends in hospital admission after ACLR from 2007 to 2015. The NSQIP database has been shown to be a useful and high-quality database when studying the surgical complications of common orthopaedic procedures.[8,24,25,31,41]

## CONCLUSION

Admission rates after ACLR declined from 2007 to 2015. Black and Hispanic patients were more likely to be admitted, but they saw a greater decrease in the odds of admission than White patients. This represents a reduction in disparity between the 2 groups and is a reassuring improvement in racial disparity trends after a common sports medicine procedure in the United States.

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# APPENDIX

### APPENDIX TABLE A1
Mean American Society of Anesthesiologists Class by Race and Year

| Year | Non-Hispanic | Hispanic |
|------|--------------|----------|
| 2007 | 1.44 | 1.35 |
| 2008 | 1.51 | 1.21 |
| 2009 | 1.57 | 1.43 |
| 2010 | 1.55 | 1.71 |
| 2011 | 1.54 | 1.30 |
| 2012 | 1.59 | 1.71 |
| 2013 | 1.55 | 1.55 |
| 2014 | 1.56 | 1.55 |
| 2015 | 1.56 | 1.50 |
| Total | 1.56 | 1.46 |

### APPENDIX TABLE A2
2-Way Analysis of Variance of the Results in Appendix Table A1[a]

| Variable | Type III Sum of Squares | *P* Value |
|----------|-------------------------|-----------|
| Intercept | 1172.100 | $<.001$ |
| Hispanic | 0.474 | .245 |
| Year | 6.017 | .029 |
| Hispanic $\times$ year | 2.414 | .550 |

[a]American Society of Anesthesiologists class did not vary by race or by the race $\times$ year interaction term.