Identifying Racial Disparities in Utilization and Clinical Outcomes of Ambulatory Hip Arthroscopy

Analysis of Temporal Trends and Causal Inference via Machine Learning

Yining Lu,*† MD, Kareme D. Alder,* MD, Erick M. Marigi,* MD, John P. Mickley,*† MD, Malik Dancy,* MD, Mario Hevesi,* MD, PhD, Bruce A. Levy,‡ MD, Aaron J. Krych,* MD, and Kelechi R. Okoroha,*§ MD
Investigation performed at the Department of Orthopaedic Surgery, Mayo Clinic, Rochester, Minnesota, USA

Background: Arthroscopic diagnosis and treatment of femoroacetabular pathology has experienced significant growth in the last 30 years; nevertheless, reduced utilization of orthopaedic procedures has been observed among the underrepresented population.

Purpose/Hypothesis: The purpose of this study was to examine racial differences in case incidence rates, outcomes, and complications in patients undergoing hip arthroscopy. It was hypothesized that racial and ethnic minority patients would undergo hip arthroscopy at a decreased rate compared with their White counterparts but that there would be no differences in clinical outcomes.

Study Design: Cross-sectional study.

Methods: The State Ambulatory Surgery and Services Database and the State Emergency Department Database of New York were queried for patients undergoing hip arthroscopy between 2011 and 2017. Patients were stratified into White and racial and ethnic minority races, and intergroup comparisons were performed for utilization over time, total charges billed per encounter, 90-day emergency department (ED) visits, and revision hip arthroscopy. Temporal trends in the utilization of hip arthroscopy were identified, and racial differences in secondary outcomes were analyzed with a semiparametric method known as targeted maximum likelihood estimation (TMLE) backed by a library of machine learning algorithms.

Results: A total of 9745 patients underwent hip arthroscopy during the study period, with 1081 patients of minority race (11.1%). White patients underwent hip arthroscopy at 5.68 (95% CI, 4.98-6.48) times the incidence rate of racial and ethnic minority patients; these incidence rates grew annually at a ratio of 1.11 in White patients compared with 1.03 in racial and ethnic minority patients ($P < .001$). Based on the TMLE, racial and ethnic minority patients were significantly more likely to incur higher costs ($P < .001$) and visit the ED within 90 days ($P = .049$) but had negligible differences in reoperation rates at a 2-year follow-up ($P = .53$). Subgroup analysis identified that higher likelihood for 90-day ED admissions among racial and ethnic minority patients compared with White patients was associated with Medicare insurance ($P = .002$), median income in the lowest quartile ($P = .012$), and residence in low-income neighborhoods ($P = .006$).

Conclusion: Irrespective of insurance status, racial and ethnic minority patients undergo hip arthroscopy at a lower incidence and incur higher costs per surgical encounter.

Keywords: diversity; femoroacetabular impingement; hip; hip arthroscopy; hip/pelvis/thigh; machine learning

Racial disparities in procedural utilization have been observed across numerous medical specialties,[22,28] and similar observations have been made within orthopaedic

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surgery, with a focus of the literature on total joint replacement and trauma.[4,37,42,54] However, an analysis of racial differences among patients who underwent hip arthroscopy has not yet been undertaken. Hip arthroscopy presents a minimally invasive surgical solution for multiple intra- and extra-articular hip pathologies.[14,25,27,30,45] Because of promising outcomes and application versatility, hip arthroscopy has grown significantly in the past several decades.[29,31,39,55] Between 2007 and 2011, Sing et al[39] found a 335% increase in hip arthroscopy procedures completed in patients <30 years old and a 200% increase for patients >60 years old.

While there is sparse literature on interracial differences in the prevalence and incidence of femoroacetabular impingement (FAI), the existing literature points to small differences between White and Chinese as well as White and African-American patients,[12,50] although studies[12,33] have highlighted a slight increase in the incidence of mixed cam-pincer FAI among African-American women compared with their White counterparts. Nevertheless, as hip arthroscopy continues to experience significant growth, it is imperative for surgeons to identify and mitigate possible disparities in access and outcomes for underrepresented populations. Within orthopaedics, subspecialties such as trauma and arthroplasty have examined the influence of health disparities.[2,18,54] For example, White and more affluent patients were observed to have increased rates of clavicle fixation,[36] operative fixations of proximal humerus fractures,[20] and calcaneus open reduction and internal fixations[53] compared with racial and ethnic minority and less affluent patients. However, there are significant methodological challenges in designing randomized controlled trials to study this question. In the absence of level 1 evidence, alternative methods such as propensity matching can control confounding variables and mitigate bias. More recently, double robust estimators utilizing machine learning libraries—namely, targeted maximum likelihood estimation (TMLE)—have demonstrated superior performance compared with traditional propensity scoring methods.[47] While previous applications of machine learning in orthopaedic surgery have focused exclusively on prediction, the TMLE provides an opportunity to apply nonparametric, data-adaptive models to causal inference.

Therefore, this study aimed to examine racial differences in procedural rates, outcomes, and complications in patients undergoing hip arthroscopy using a combination of traditional statistics and machine learning techniques. We hypothesized that racial and ethnic minority patients would undergo hip arthroscopy at a decreased rate compared with their White counterparts but that there would be no differences in clinical outcomes.

METHODS

Data Source

After our study received institutional review board exemption, the State Ambulatory Surgery and Services Center (SASD) in New York was queried for all patients undergoing elective hip arthroscopy between 2011 and 2017 using the Current Procedural Terminology codes 29860, 29861, 29862, 29863, 29914, 29915, and 29916. The State Emergency Department Database (SEDD) is a database managed by the Healthcare Cost and Utilization Project that includes encounter-level data of ambulatory surgeries and services retrospectively abstracted from administrative data provided by participating states. Patients without race data were excluded from the analysis. Patient ambulatory encounter data were matched to their emergency department (ED) encounter data obtained from the New York SEDD for the same study period utilizing the unique database level linkage identification provided by the Healthcare Cost and Utilization Project.

Variables and Outcomes

After data curation, patients were categorized into White and racial and ethnic minority races. The decision was made to aggregate racial and ethnic minority patients into a single category based on methods previously described by Amen et al,[3] as treatment with the TMLE can only be performed on a binary intervention. Encounter-level variables were then collected and included as

§Address correspondence to Kelechi R. Okoroha, MD, Department of Orthopedic Surgery, Mayo Clinic, 200 First Street Southwest, Rochester, MN 55905, USA (email: okoroha.kelechi@mayo.edu).

*Department of Orthopedic Surgery, Mayo Clinic, Rochester, Minnesota, USA.

†Orthopedic Surgery Artificial Intelligence Laboratory, Mayo Clinic, Rochester, Minnesota, USA.

‡Orlando Health Jewett Orthopedic Institute, Orlando, Florida, USA.

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follows: age; sex; race and ethnicity; insurance status; quartile income by zip code; residency and community characteristics, including rural-urban classification schemes; surgical diagnosis; medical comorbidities as classified by the International Classification of Disease (ICD)-9 and -10 diagnosis code; anesthesia type, operating room time; and concomitant procedures. Patient health profiles were standardized utilizing the Elixhauser comorbidity index (ECI), a measurement of patient comorbidities utilizing ICD-9 and ICD-10 codes, validated in the prediction of hospital resource utilization.[13] Descriptive statistics were performed to identify intergroup differences between White and racial and ethnic minority patients. Specifically, insurance status was documented as Medicare; Medicaid; private insurance; self-pay; and others, including coverage through Indian Health Services, veterans administration, correctional facilities, worker's compensation, and other local, state, and federal government-sponsored programs.

Trends of Utilization

Crude utilization rates were calculated by dividing the New York SASD-weighted encounters by the number of White and racial and ethnic minority residents in the state of New York each year, respectively. Age- and sex-standardized utilization rates were then obtained according to the 2000 US standard population and using the direct standardization method. Changes over time in the surgical volume of hip arthroscopies were examined utilizing Poisson regressions with surgical year and race as the exposures of interest. This was performed for the total volume of hip arthroscopies and procedural subgroups—including labral repairs, femoroplasties, and acetabuloplasties.

Total Maximum Likelihood Estimation

A second analysis was performed to identify intergroup differences between White and racial and ethnic minority patients in the following outcomes: the rate of revision hip arthroscopy at 1 year; high cost associated with a surgical encounter, defined as the total billed cost of >1 SD of the population mean; and the proportion of patients with 90-day ED visits. Notably, only patients between 2011 and 2016 were included in the analysis of revision surgery to maintain a minimum of 1-year follow-up; similarly, only patients between January 2011 and September 2017 were included in the analysis of 90-day ED admissions. Total charges were adjusted for inflation by converting all costs to 2015 US dollars using the medical care-specific consumer price index provided by the Bureau of Labor Statistics, which adjusts for inflation specific to medical care commodities and medical care services (https://www.bls.gov/cpi/data.htm).

Using machine learning algorithms, comparisons were performed utilizing the TMLE to obtain valid statistical inference.[48,49] As previously described, the TMLE is a double-robust estimator that can simulate the conditions of a randomized controlled study in noncontrolled observational data. Traditionally, outcome regression and treatment assignment models such as propensity scoring are unbiased only with a correctly specified statistical model based on certain causal assumptions about the underlying data distribution. The TMLE, however, utilizes a model-free, semiparametric approach through "data-adaptive" machine learning, which can accommodate high-dimensional data and nonlinear relationships better than classical statistical models without any assumptions.[49] Compared with traditional regression models or propensity weighting, these double-robust methods can consistently provide less biased estimates, especially given the sparsity of data and weak assumptions about the data distribution.[16,32,47] We performed the TMLE using a Super Learner library that compiles the output from a diverse ensemble of algorithms (random forest, Xtreme gradient boosting, elastic net linear regression, and support vector machines) to generate an estimation of the effect of minority race on the outcomes of interest (revision hip arthroscopy at 1 year, high cost associated with a surgical encounter, and rate of 90-day ED visits).

Finally, subgroup analysis was performed utilizing mixed-effect logistic regression modeling to identify any effect modification on the influence of race on the outcomes of interest by other demographic, socioeconomic, and clinical variables (Tables 1 and 2). The mixed-effect models were constructed using race as the fixed effect and the treating hospital identification as the random effect. Effect modification by subgroups was determined by adding an interaction term between the fixed effect and the subgroup to the regression model. Statistical significance was set at $P > .05$. All modeling and statistical analysis was performed using the R Language for Programming in RStudio software Version 1.1.143 (R Foundation for Statistical Computing).

RESULTS

Patient Characteristics and Poisson Regression Projections of Hip Arthroscopic Procedures

A total of 9745 patients underwent hip arthroscopy during the study period, of whom 8664 (88.9%) were White, while the remaining 1081 (11.1%) patients were aggregated into the racial and ethnic minority category. Among the non-White patients, 446 (41.3) were Black, 508 (47%) were Hispanic, 119 (11%) were Asian, and 8 (0.7%) were Native American. The specific breakdown of demographic and operative variables by group is found in Tables 1 and 2. Temporal trends in the incidence rate of total hip arthroscopies and the incidence rate by specific procedures are illustrated in Figure 1.

Poisson regression models demonstrated that White patients underwent hip arthroscopy at 5.68 (95% CI, 4.98-6.48) times the incidence rate of racial and ethnic minority patients; similarly, when broken down by specific procedures, White patients underwent labral repair, femoroplasty, and acetabuloplasty at 6.19 (95% CI, 5.43-7.1), 6.14 (95% CI, 3.38-11.1), and 5.18 (3.16-8.47) times the

TABLE 1
Patient Characteristics by Race[a]

	White (n = 8664)	Racial and Ethnic Minority (n = 1081)	*P*
Age, y	35.3 ± 13.7	37.1 ± 12.8	**<.001**
Female sex	5092 (58.8)	572 (52.9)	**<.001**
Duration in hospital, min	868 ± 666.7	937.8 ± 636.7	**.001**
OR time, min	128.7 ± 60.3	138.2 ± 71.3	**<.001**
Method of anesthesia			**<.001**
Other	290 (3.3)	76 (7)	
General	4553 (52.6)	510 (47.2)	
Regional	3821 (44.1)	495 (45.8)	
Discharge quarter			**.006**
1	3227 (25.2)	270 (25)	
2	3294 (25.8)	281 (26)	
3	2928 (22.9)	281 (26)	
4	3342 (26.1)	249 (23)	
Median household income, state quartile for patient zip code			**<.001**
1	842 (9.7)	324 (30)	
2	1864 (21.5)	218 (20.2)	
3	2348 (27.1)	244 (22.6)	
4	3610 (41.7)	295 (27.3)	
Race			**<.001**
White	8664 (100)	-	
Black	-	446 (41.3)	
Hispanic	-	508 (47.0)	
Asian or Pacific Islander	-	119 (11)	
Native American	-	8 (0.7)	
Hispanic ethnicity			**<.001**
Not Hispanic	6494 (100)	553 (51.2)	
Hispanic, White	-	212 (19.6)	
Hispanic, Black	-	22 (2)	
Hispanic, unspecified race	-	294 (27.2)	
Form of payment			**<.001**
Medicare	312 (3.6)	49 (4.5)	
Medicaid	546 (6.3)	115 (10.6)	
Private insurance	7070 (81.6)	716 (66.2)	
Self-pay	78 (0.9)	13 (1.2)	
Other[b]	658 (7.6)	189 (17.5)	
Median household income quartile of residents in patients' zip code			**<.001**
1	563 (6.5)	284 (26.3)	
2	1482 (17.1)	190 (17.6)	
3	1993 (23)	208 (19.2)	
4	4635 (53.5)	399 (36.9)	
Patient location			**<.001**
Noncore-based statistical area	234 (2.7)	3 (0.3)	
Micropolitan	580 (6.7)	21 (1.9)	
Metropolitan	7841 (90.5)	1057 (97.8)	
Patient location: NCHS urban-rural code			**<.001**
1. "Central" metropolitan, >1,000,000 residents	2980 (34.4)	690 (63.8)	
2. "Fringe" metropolitan, >1,000,000 residents	2504 (28.9)	269 (24.9)	
3. Metropolitan, 250,000-999,999 residents	1906 (22)	83 (7.7)	
4. Metropolitan, 50,000-249,999 residents	407 (4.7)	21 (1.9)	
5. Micropolitan	615 (7.1)	14 (1.3)	
6. Not metropolitan or micropolitan	260 (3)	3 (0.3)	
Patient location: urban-rural designation for the patients' county of residence			**<.001**
1. Large metropolitan area	5623 (64.9)	953 (88.2)	
2. Small metropolitan area	2218 (25.6)	104 (9.6)	
3. Micropolitan area	589 (6.8)	21 (1.9)	
4. Not metropolitan or micropolitan	243 (2.8)	3 (0.3)	

[a]Data are presented as mean ± SD or n (%). NCHS, National Center for Health Statistics; OR, operating room. Bold *P* values indicate significance. Dash indicates not applicable.

[b]Coverage through Indian Health Services, veterans administration, correctional facilities, worker's compensation, and other local/state/federal government sponsored programs.

TABLE 2
Clinical Characteristics by Race[a]

	White (n = 8664)	Racial and Ethnic Minority (n = 1081)	*P*
Surgical procedures			
Labral repair	4290 (49.5)	486 (45)	**.005**
Femoroplasty	3158 (36.4)	374 (34.6)	.246
Acetabuloplasty	1377 (15.9)	198 (18.3)	**.046**
Chondroplasty	1996 (23)	281 (26)	**.033**
Synovectomy	657 (7.6)	130 (12)	**<.001**
Surgical pathology	957 (11)	147 (13.6)	**.014**
Loose body	666 (7.7)	87 (8)	.72
Diagnostic arthroscopy	27 (0.3)	7 (0.6)	.136
Comorbidities			
Osteoarthritis	393 (4.5)	62 (5.7)	.092
Asthma	380 (4.4)	62 (5.7)	.053
Hypertension	317 (3.7)	53 (4.9)	.053
Substance use	384 (4.4)	34 (3.1)	.059
Diabetes	101 (1.2)	25 (2.3)	**.003**
Allergy	453 (5.2)	28 (2.6)	**<.001**
Arrhythmias	37 (0.4)	1 (0.1)	.16
Anemia	29 (0.3)	9 (0.8)	**.027**
Hyperlipidemia	251 (2.9)	39 (3.6)	.229
Tobacco use	54 (0.6)	5 (0.5)	.664
Hypertension without complications	317 (3.7)	53 (4.9)	.053
Chronic obstructive pulmonary disease	850 (9.8)	141 (13)	**.001**
Diabetes without complications	101 (1.2)	25 (2.3)	**.003**
Obesity	363 (4.2)	59 (5.5)	.064
Depression	412 (4.8)	33 (3.1)	**.014**

[a]Data are presented as n (%). Bold *P* values indicate significance.

TABLE 3
Hip Arthroscopy IRRs for White Versus Racial and Ethnic Minority Patients[a]

Outcomes	IRR	95% CI	*P*
Total volume hip arthroscopy	5.68	4.98-6.48	<.001
Labral repair	6.19	5.43-7.06	<.001
Femoroplasty	6.14	3.38-11.1	<.001
Acetabuloplasty	5.18	3.16-8.47	.005

[a]IRR, incidence rate ratio.

TABLE 4
Effect Sizes of Racial and Ethnic minority Status on Outcomes via TMLE[a]

Outcomes	OR	95% CI	*P*
90-d ED visit	1.09	1.01-1.18	.049
High cost	1.30	1.24-1.37	<.001
Revision hip arthroscopy	1.13	0.78-1.62	.53

[a]ED, emergency department; OR, odds ratio; TMLE, targeted maximum likelihood estimation.

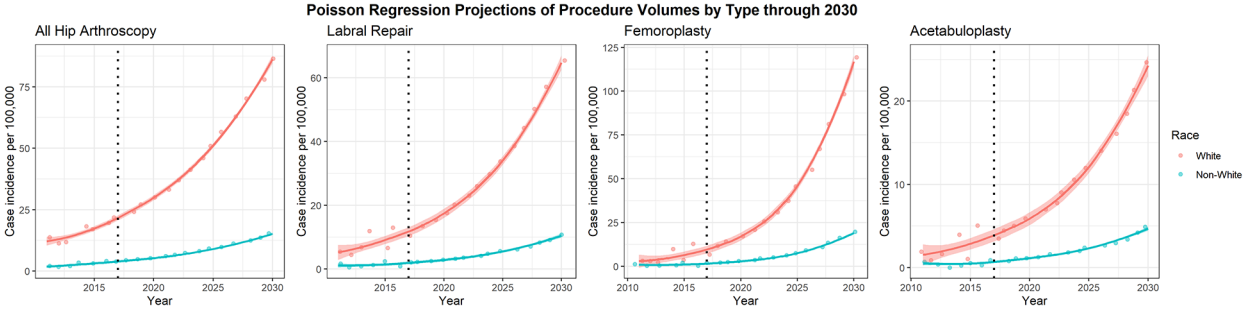

Figure 1. Comparison of hip arthroscopy surgical volume utilization between 2011 and 2017 with projection into 2030 (dashed line) between White and racial and ethnic minority patients.

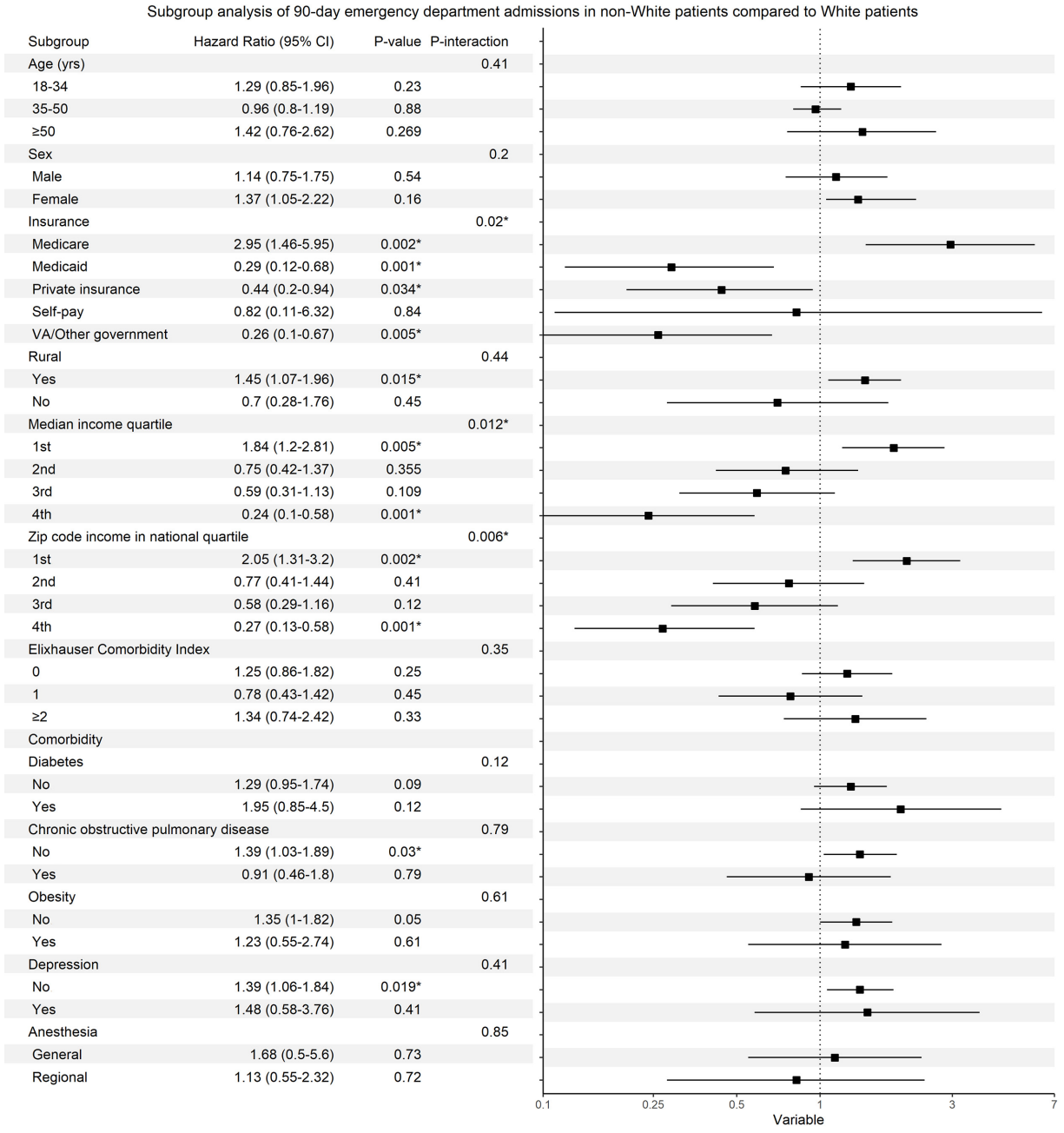

Figure 2. Subgroup comparisons of 90-day emergency department admissions utilizing a mixed-effects model with hospital identification from the New York State Ambulatory Surgery and Services Database as the random effect and race and the variable of interest as the fixed effect. An interaction term between race and the variable of interest was introduced into the model to detect any effect modification of the variable of interest on outcome differences between White and racial and ethnic minority patients. *Statistical significance. yrs, years; VA, veterans administration.

incidence rate of racial and ethnic minority patients, respectively (Table 3). In addition, there was an annual increase of 1.11 in the total incidence rate ratio of hip arthroscopy among White patients, significantly higher than the rate of increase among racial and ethnic minority patients (1.03; $P < .001$).

TMLE Analysis

Subsequent analysis with the TMLE utilizing an ensemble of machine learning models found that racial and ethnic minority patients were significantly more likely to visit the ED within 90 days (odds ratio [OR], 1.09 [95% CI,

1.01-1.18]; $P = .049$) and incur higher costs (OR, 1.30 [95% CI, 1.24-1.37]; $P < .001$) after hip arthroscopy (Table 4). The TMLE did not demonstrate significant differences in reoperation rates between racial and ethnic minority and White patients (OR, 1.13 [95% CI, 0.78-1.62]; $P = .53$) at 1 to 6 years of follow-up.

Subgroup Analyses of ED Admissions, Reoperation Rates, and Encounter Cost

Subgroup analysis via mixed-effects modeling found that Medicare insurance status (OR, 2.95 [95% CI, 1.46-5.95]; $P = .002$), habitation in rural and low-income domiciles (OR, 2.05 [95% CI, 1.31-3.2]; $P = .006$), and median income in the lowest quartile (OR, 1.84 [95% CI, 1.2-2.61]; $P = .012$) were significant predictors of 90-day ED admissions in racial and ethnic minority compared with White patients (Figure 2). ECI, comorbidities, and anesthesia type used intraoperatively did not approach significance in predicting 90-day ED admissions in racial and ethnic minority patients.

Subgroup analysis of revision hip arthroscopy and encounter cost in racial and ethnic minority compared with White patients was performed (Appendix Figures A1 and A2) but did not approach significance. Specifically, age, sex, insurance status and type, rural and/or low-income habitation, income, zip code income, ECI, comorbidities, and anesthesia type used intraoperatively did not compound reoperation rates or encounter cost.

DISCUSSION

The main findings of this investigation are as follows: First, patients of White race were found to undergo ambulatory hip arthroscopy at a significantly greater rate annually compared with racial and ethnic minority patients, with this disparity projected to increase over the next decade likely. Second, the TMLE identified an increased likelihood of 90-day ED visits and an increased risk of incurring higher costs per encounter among racial and ethnic minority patients. Third, subgroup analysis through mixed-effects modeling found that disparity in 90-day ED visits between White and racial and ethnic minority patients was exacerbated by lower income levels and Medicare insurance.

There is a shortage of literature comparing differences in the incidence of FAI between White and racial and ethnic minority patients, and at least a component of the disparities we identified in surgical utilization may be driven by baseline differences in incidence. Indeed, authors have pointed to differences in osseous hip anatomy between Chinese and White patients, which may influence predilection to under- or over-coverage.[17,50] In contrast, others have demonstrated differences in the prevalences of select FAI morphologies between White and African American patients.[12,33] However, these differences are modest and are unlikely to account entirely for the observed disparities.

Sociodemographic disparities in utilization and outcomes have been documented almost universally across every orthopaedic subspecialty, from hip and knee to pediatrics.[3,10,11,19,40,41,44] Likewise, we observed a similar difference in utilization between the 2 groups. Reasons for the disparities in utilization are likely multifactorial, including difficulties accessing health care,[8] lower socioeconomic status,[9] lower health literacy,[23] worse physician-patient communication,[21] and higher risk aversion[35] among racial and ethnic minority patients when compared with White patients. Barriers to health care access, higher rates of insurance through government-funded programs, and lower socioeconomic status result in minority patients having limited access to both the diagnostic and treatment modalities for sports medicine-related hip pathologies. These include the availability of advanced imaging, such as magnetic resonance imaging and computed tomography scans, physical therapy services,[5] injectables or regenerative medicine,[34] and subspecialty-trained hip arthroscopists. Indeed, Brown et al[6] found that Black patients were less likely to receive a surgical recommendation compared with White patients. In addition, studies have demonstrated that ambulatory surgical centers, which are more likely to perform procedures such as hip arthroscopy, are more likely to select patients with private insurance[46] and that a minority of patients are more likely to be referred to large hospital systems instead of ambulatory centers.[52] Therefore, it is possible that patients undergoing hip arthroscopy on a hospital inpatient basis were not captured with the SASD database. However, there is likely a significant overlap in the influence of socioeconomic status and race on access, and patients with less desirable insurance coverage may not be able to afford the same availability of surgeons and facilities regardless of race. A degree of overindication of hip arthroscopy among White and more affluent patients may also exacerbate disparities in utilization.

Moreover, patients from higher socioeconomic strata are more likely to have both social support and access to newer procedures such as hip arthroscopy,[43] while patients from lower strata have been found to more frequently utilize alternative or nonsurgical management strategies, such as prayer or homeopathic pain-relieving modalities, in their treatment of joint pain.[34] This may be motivated by lower health literacy, worse physician-patient relationships, or mistrust of the medical establishment. Regardless, a minority of patients may delay presentation until their degenerative hip pathology is no longer amenable to arthroscopic intervention.

While investigators have previously evaluated interracial differences in utilization and outcomes of orthopaedic surgery procedures using parametric methods, these approaches require strict assumptions regarding the underlying data structure to hold. The TMLE is a semiparametric method that is much more tolerant of model misspecification, is less susceptible to the influence of outliers and sparsity, and can flexibly incorporate a large range of models, including machine learning libraries; specifically, it has proven to be more robust and accurate in head-to-head comparisons with parametric models or propensity scores.[32,38] Through the TMLE, we also observed a slight increase in the likelihood of a 90-day ED admission among racial and ethnic minority patients, but it is unclear whether this effect may be clinically significant given the

small effect size (95% CI, 1.01-1.18); similar findings have been reported in the literature.[1,3,51] In a single-institution series, Volaski et al[51] observed an increased number of 30-day ED visits among patients of Hispanic ethnicity compared with non-Hispanic patients after transforaminal lumbar interbody fusions.[51] The authors suggested this observation may be secondary to limited English proficiency among Spanish-speaking patients and, consequently, incorrect dosing of discharge medications, as previously demonstrated.[24]

Finally, Medicare insurance was found to have a significant effect modification on the non-White race as a risk factor for increased 90-day ED visits. Specifically, we observed that non-White patients with Medicare insurance were even more likely to have a related ED visit during the 90-day postoperative period. Interestingly, federally subsidized insurance, such as Medicaid and Medicare, was identified as a direct risk factor for worse outcomes in a systematic review of patients undergoing rotator cuff repair.[26] The authors observed in their synthesis of the evidence that patients with federally subsidized as opposed to private insurance were more likely to have surgery with low-volume orthopaedic surgeons. Likewise, they observed a similar relationship between Black race and Hispanic ethnicity with a propensity to receive treatment from low-volume surgeons. Somewhat expectedly, low-income residence was identified as another effect modifier, with low-income non-White patients at the greatest likelihood for 90-day ED admission; as noted previously, patients residing in low-income areas often have delayed presentation and increased severity of pathology at presentation because of reduced channels for access to care.[7] The higher frequency of ED visits among racial and ethnic minority patients is also a likely driver of the increased cost of care we observed. In addition, an increasing number of baseline comorbidities among underrepresented patients[15] and inappropriate billing of government insurance (for either unnecessary services or extraneous diagnosis) have also been identified as potential drivers in interracial cost differences after a care episode.

Limitations

This study is not without its limitations. This includes limitations to the data provided by the SASD and SEDD databases. Most importantly, the generalizability of New York state-level data at the national level is not guaranteed. Even though we chose the New York SASD because of the assumption that its heterogeneity in patient characteristics would most closely mimic the population of the United States, this assumption may represent an oversimplification. In addition, the SASD provides data from ambulatory surgery and other outpatient services from hospital-owned facilities, while the SEDD is from state-specific ED databases that do not result in an admission. However, most hip arthroscopies are done in the outpatient setting. We only acquired data between 2011 and 2016 and were limited to this period. Second, we attempted to control for socioeconomic determinants of health that can influence access and utilization among segments of the patient population through TMLE. While these have been shown to outperform parametric regressions in obtaining a less biased and more accurate estimate of the quantity of interest, level 1 evidence may be needed to reinforce the observed findings. Likewise, we did not investigate the effects of intersectionality between other demographic factors such as sex, nor was the racial breakdown of hip arthroscopists who serve the New York state population available from the database. These factors could exert additional influences on outcomes. Third, we chose to categorize race into White and racial and ethnic minority given the limited numbers of Asian and Native American patients, as well as the absence of mixed-race documentation in the SASD; nevertheless, nuances specific to these populations may be lost and the results should be extrapolated with caution. This is an especially salient limitation to consider because the risk of hip dysplasia among eastern Asian populations is significantly increased compared with White populations,[17] and it is possible for rates of FAI to also be race-specific. Fourth, while we identified a statistically significant increased risk of 90-day ED admissions among racial and ethnic minority patients, the OR of 1.09 and the *P* value of .049 are fragile and may not represent discernible differences on a populational basis.

CONCLUSION

Irrespective of insurance status, non-White patients undergo hip arthroscopy at a lower incidence and incur higher costs per surgical encounter.

ORCID iDs

Yining Lu https://orcid.org/0000-0002-3967-645X
Mario Hevesi https://orcid.org/0000-0001-6208-878X
Aaron J. Krych https://orcid.org/0000-0003-3248-8007

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APPENDIX

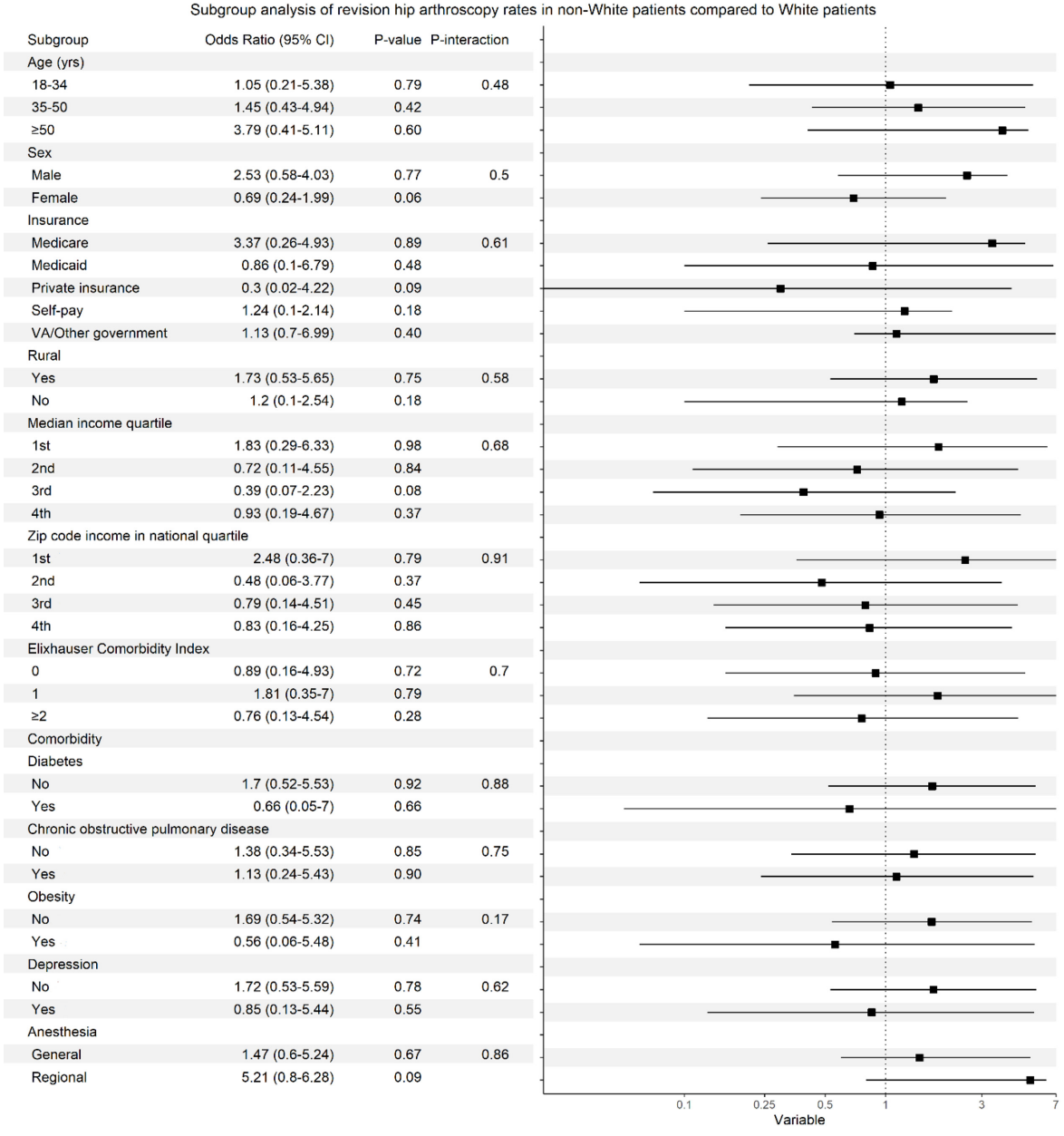

Figure A1. Subgroup comparisons of revision hip arthroscopy rates utilizing a mixed-effects model with hospital identification from the New York State Ambulatory Surgery and Services Database as the random effect,race, and the variable of interest as the fixed effect. An interaction term between race and the variable of interest was introduced into the model to detect any effect modification of the variable of interest on outcome differences between White and non-White races. *Statistical significance. yrs, years; VA, veterans administration.

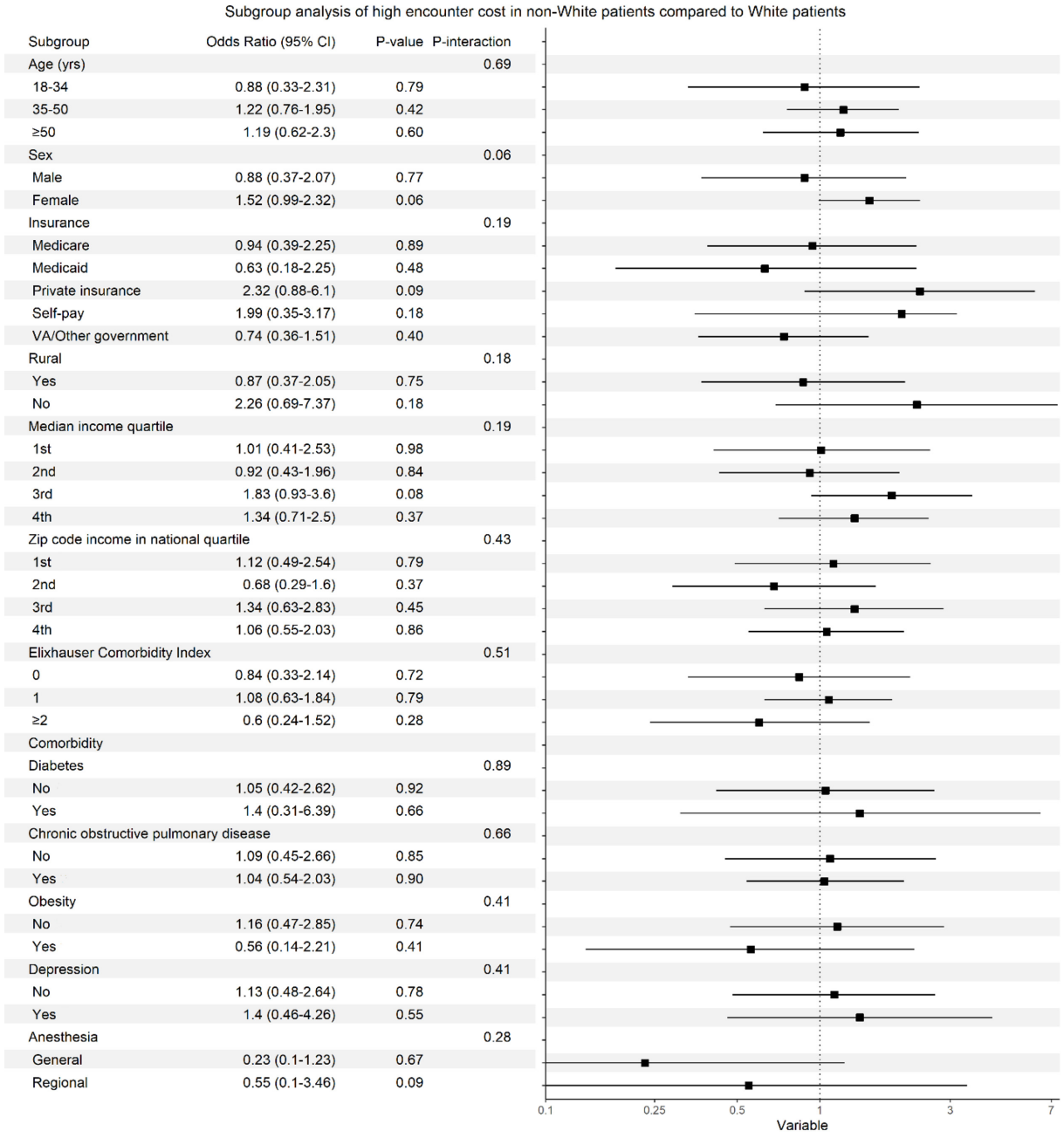

Figure A2. Subgroup comparisons of differences in encounter costs utilizing a mixed-effects model with hospital identification from the New York State Ambulatory Surgery and Services Database as the random effect, race, and the variable of interest as the fixed effect. An interaction term between race and the variable of interest was introduced into the model to detect any effect modification of the variable of interest on outcome differences between White and non-White races. *Statistical significance. yrs, years; VA, veterans administration.