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AOA Critical Issues in Education

Match Rates Among Underrepresented Minority and Female Applicants to Orthopaedic Surgery Residency Programs from 2011 to 2021

How Are We Doing?

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Background: Orthopaedic surgery residency programs have traditionally had less representation of underrepresented minority (URM) and female trainees compared with other medical specialties. Widespread efforts have been implemented to increase the diversity of orthopaedic surgery residency programs; however, it is not known whether URM and female applicants are increasingly likely to match as a result. Thus, we aimed to study the independent association between URM and female applicants and matching into orthopaedic surgery over the past decade.

Methods: Applicant-level data from the Electronic Residency Application Service were reviewed from 2011 to 2021 with variables including demographic variables, URM status, and matriculation to an orthopaedic surgery residency program. Multivariate logistic regression was used to identify the likelihood of matriculating into orthopaedic surgery when controlling for number of applications, top 40 medical school status, AOA status, and MD/other degree.

Results: Twelve thousand one hundred eleven applicants were identified from 2011 to 2021 with a match rate of 70% overall. Two thousand fifty-six applicants (17%) were female and 1,926 (16%) classified as URM. The total number of applications increased from 1,074 in 2011 to 1,229 in 2021. The adjusted odds ratio (OR) associated with matching among all applicants decreased from 0.75 in 2011 to 0.64 in 2021, $p < 0.001$, and the OR of non-URM male and female applicants also decreased (female: 0.79-0.69, $p < 0.001$; male: 0.78-0.65, $p < 0.001$). The OR of URM male applicants did not change significantly (0.57-0.55, $p = 0.60$). The OR for URM female applicants, however, increased significantly

continued

The study was deemed exempt from institutional review board approval: IRB #00347062.

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from 0.46 to 0.61, $p < 0.001$. Over the entire time frame, the odds of matching were significantly lower for URM applicants compared with non-URM applicants (both male and female).

Conclusions: Overall, the adjusted odds ratio of matching into orthopaedic surgery among female URM applicants has increased over the past decade, indicating successful efforts to improve the diversity of orthopaedic surgery training programs. The odds of URM male applicants have remained relatively constant, and the odds of URM male and female applicants were significantly lower than all non-URM applicants.

Level of Evidence: III.

Introduction

Minority groups and women are underrepresented in orthopaedic surgery. Despite minorities accounting for 38.7% of the US population, the representation of minorities in orthopaedic surgery is low. The 2018 Orthopaedic Practice in the US survey showed that women accounted for 5.8% of all orthopaedic surgeons, and African American, Hispanic, Native American, and multiracial surgeons accounted for only 5.7% of practicing orthopaedic surgeons[1,2]. This underrepresentation is a significant concern as it is known that a diverse physician workforce improves health care access for underrepresented minorities (URMs) and leads to better communication and quality of care[3-5]. Moreover, the American Academy of Orthopaedic Surgeons (AAOS) has established a goal of increasing diversity in orthopaedics in its 2019 to 2023 strategic plan[6].

The minority composition of orthopaedic surgery residents was lower than the minority representation in any of the other 16 training fields of medicine from 2001 to 2008. Factors leading to lower representation of minorities in orthopaedic surgery training programs are not well understood, although it has been suggested that lack of mentorship opportunities and lack of early specialty exposure has led to a "leaky pipeline" for URM applicants[7]. It is possible, however, that such differences stem from lower admission rates of URM candidate applicants to orthopaedic residency programs. Although previous studies have found that race but not sex was associated with matching into orthopaedic surgery[8], it has also been observed that URM applicants have lower rates of entering orthopaedic surgery likely due to an emphasis on USMLE scores and AOA status[10].

To help address issues of underrepresentation in orthopaedics, a number of professional organizations and mentorship networks have been created. The Ruth Jackson Society was founded in 1983 with a goal of increasing the number of women in orthopaedic surgery by providing education, mentorship, and networking opportunities and working to ensure that women in the field have equal opportunities for advancement and recognition[11-13]. The Perry Initiative is a national organization that aims to inspire young women to pursue careers in orthopaedic surgery and engineering[14]. Another program, Nth Dimensions, founded by Dr. Bonnie Mason in 2004, is a pipeline program designed to increase diversity and inclusion in medicine by providing research and longitudinal mentorship opportunities to URM medical students[15]. Most recently, the Black Women Orthopaedic Society (BWOS) was founded in 2020 with the mission to support and empower Black women orthopaedic surgeons through mentoring, activism, and education[16].

Our study aimed to examine the effectiveness of initiatives such as these to increase the diversity of orthopaedic surgery by assessing the association between matching and both URM status and sex over the past 10 years. We examined whether the efforts to increase diversity in orthopaedic surgery have been successful by looking at the trend of representation of URM and sex in orthopaedic surgery residency programs over the past decade.

Materials and Methods

This study was deemed exempt from institutional review board approval (IRB 00347062).

Study Design and Population

The data for this retrospective study were obtained from the Electronic Residency Application Service (ERAS), which is the centralized application service used by orthopaedic surgery residency programs in the United States. The service is administered by the Association of American Medical Colleges (AAMC). The data for this study were obtained from the ERAS applicants from US MD-granting medical schools applying to orthopaedic surgery for academic years 2011 to 2012 through 2021 to 2022 which was provided by a special report obtained from the AAMC. Information on the applicants was collected from ERAS, American Medical College Application Service (AMCAS), Graduation Questionnaire (GQ), and Liaison Committee on Medical Education (LCME). The AMCAS data represented the most recent AMCAS year for each individual. The GQ data are from the GQ for any respondent among individuals in the AMCAS data defined above.

The sample consisted of 12,111 applicants to orthopaedic surgery residency programs. Demographic variables, such as age, sex, and URM status, were collected. URM status was determined by the URIM_IND variable, which was set to "Y" for any ERAS applicants who were a US citizen or permanent resident and self-identified as one or more of the following race/ethnicity categories (alone or in combination with any other race/ethnicity category): American Indian or Alaska Native; Black or African American; Hispanic, Latino, or of Spanish Origin; or Native Hawaiian or Other Pacific Islander.

The top 40 research indicator is based on direct federal grants and contract expenditures for organized research as reported on LCME Part I-A Annual Financial Questionnaire. Alpha Omega Alpha (AOA) status was determined to be a

TABLE I Demographic Characteristics of 12,111 Orthopaedic Surgery Applicants from 2011 to 2021

Characteristics	N (%)	Mean ± SD
Female	2,056 (17)	—
Matched into orthopaedic surgery	8,450 (70)	—
URM	1,926 (16)	—
Top 40 medical school	3,332 (28)	—
Reapplicant	2,718 (22)	—
No. of applications	—	73 ± 38
AOA at time of application	2,920 (24)	—
MD degree only	11,674 (96)	—

SD = standard deviation, and URM = underrepresented minority.
*Data presented as mean ± SD. †Data presented as mean (range).

binary variable and was coded as "yes" if the applicant had been elected to AOA before the time of residency application.

Statistical Analysis

The primary outcome of this study was matriculation into an orthopaedic surgery residency program. Descriptive statistics were reported for all variables. To identify the likelihood of matriculating into orthopaedic surgery when controlling for number of applications, top 40 medical school status, AOA status, and MD/other degree, we used multivariate logistic regression analysis. The variables controlled for in the multivariate analysis were chosen based on known factors affecting the orthopaedic surgery match (number of applications, top 40 medical school, AOA status, and MD degree (vs. MD + additional degree)).

Separate multivariate regressions were performed each for URM female, URM male, non-URM female, and non-URM male applicants. The predictive margins of each of the 4 multivariate models were also plotted for each year from 2011 to 2021 to understand how the independent effect of URM status and sex has influenced the likelihood of matching over time. Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated to assess the strength of the associations. In addition to temporal trends over time, we also performed analyses of the overall adjusted odds of matching among male/female and URM/non-URM groups, also controlling for the same variables previously mentioned. Given the potential for significant disruptions in the residency match process associated with COVID-19 in 2020(19), we also performed a subanalysis before (and including) 2019 and after 2019. Again, logistic regression was used with predictive margins at each of the defined population values.

Before conducting the regression analysis, we checked for assumptions of linearity, normality, and multicollinearity between independent variables and outliers in the data. The statistical analysis was performed using STATA, version 15 (StataCorp. 2017. Stata Statistical Software: Release 15: StataCorp LP), and a p value of less than 0.05 was considered statistically significant.

Source of Funding

No external funding was used in this study.

Results

Overall Study Population

Twelve thousand one hundred eleven applicants to orthopaedic surgery residency programs from 2011 to 2021 were included in the final analysis (Table I). Seventeen percent of all applicants were female, 70% of all applicants matched into orthopaedic surgery, and 16% of all applicants were classified as URM. Twenty-eight percent of applicants attended a top 40 medical school, 22% of applicants were reapplicants, with a mean of applications per applicant of 73 ± 38. Twenty-four percent of applicants were AOA, and 4% of applicants had a secondary masters or higher level degree in addition to their MD. From 2011 to 2021, the proportion of non-URM male

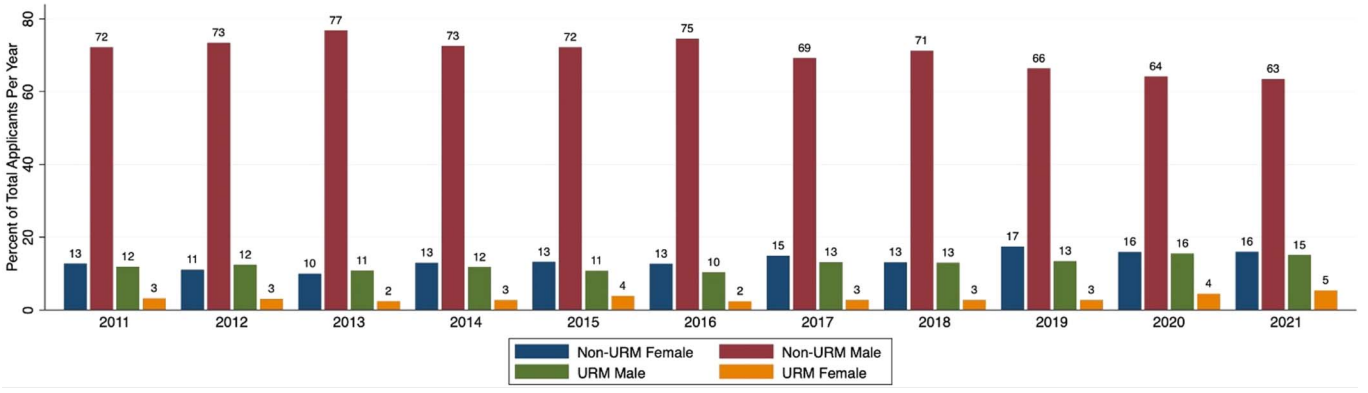

Fig. 1

Percent of total applicants per year stratified by URM status and sex. Bar graph showing year of application to orthopaedic surgery on the x axis and percent of total applications on the y axis. The bars represent the percent total of applicants, with non-URM female applicants represented as dark blue bars, non-URM male applicants as red, URM female applicants as orange, and URM male applicants as green. From 2021, the proportion of non-URM male applicants decreased from 72% to 63%, non-URM female applicants increased from 13% to 16%, URM male increased from 12% to 15%, and URM female increased from 3% to 5%. URM = underrepresented minority.

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applicants decreased from 72% to 63%, non-URM female increased from 13% to 16%, URM male increased from 12% to 15%, and URM female increased from 3% to 5%, (Fig. 1).

Temporal Trends in Match Rates of URM and Female Applicants

The OR associated with matching among all applicants decreased from 0.75 (95% CI 0.73-0.76) in 2011 to 0.64 (95% CI: 0.63-0.66) in 2021. Over the same period, the OR of non-URM male and female applicants decreased (female: 0.79 [95% CI: 0.76-0.83] to 0.69 [95% CI: 0.65-0.73]; male: 0.78 [95% CI: 0.77-0.80] to 0.65 [95% CI: 0.63-0.67]). The OR of URM male applicants did not change significantly (0.57 [95% CI: 0.53-0.61] to 0.55 [95% CI: 0.51-0.59]). The OR for URM female applicants, however, increased significantly from 0.46 (95% CI: 0.40-0.52) to 0.61 (95% CI: 0.56-0.65) (Fig. 2).

Overall Match Rates Between URM Applicants and Female Applicants Compared With Male Non-URM Applicants

Overall, the OR of matching among all applicants throughout the study period was 0.72 (95% CI: 0.71-0.72). When looking

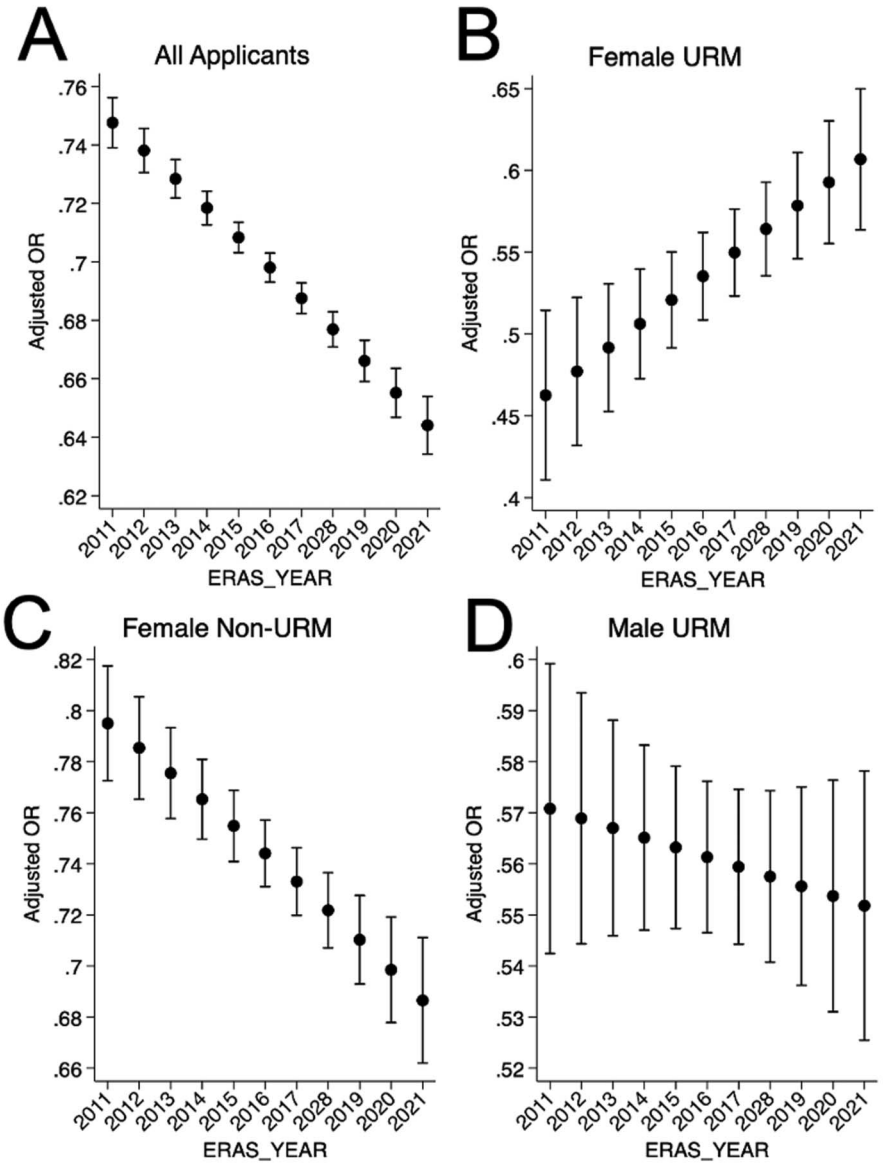

Fig. 2

Adjusted odds of matching into orthopaedic surgery over time, stratified by URM status and sex. Four panels (**Figs. 2-A through 2-D**) depicting the odds ratio (OR) of matching into orthopaedic surgery residency while controlling for number of applications, top 40 medical school, Alpha Omega Alpha (AOA) status and MD degree (vs. additional graduate degree). The OR of all applicants (**Fig. 2-A**) matching decreased significantly from 0.75 in 2011 to 0.64 in 2021 ($p < 0.001$). The OR of female non-URM applicants (**Fig. 2-C**) decreased from 0.79 in 2011 to 0.69 in 2021 ($p < 0.001$), while the OR for female URM applicants (**Fig. 2-B**) increased from 0.46 to 0.61 ($p < 0.001$). The OR of male URM applicants matching did not change significantly ($p = 0.572$) (**Fig. 2-D**). URM = underrepresented minority.

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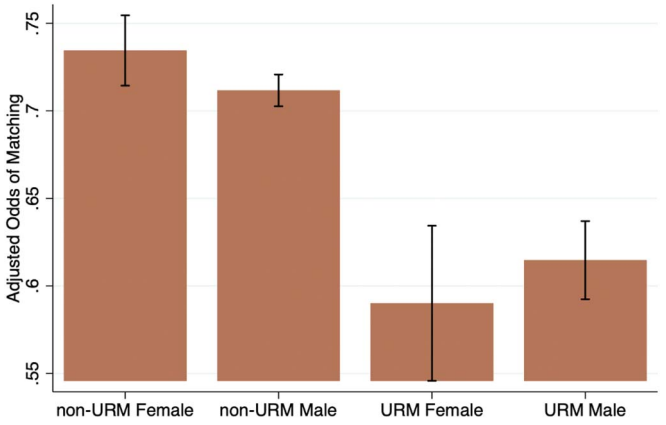

Fig. 3

Overall adjusted odds of matching into orthopaedic surgery, stratified by URM status and sex. Bar graph showing adjusted odds of matching into orthopaedic surgery, with 95% confidence intervals (CIs). All analyses were adjusted for number of applications, top 40 medical school, Alpha Omega Alpha (AOA) status, and MD degree (vs. additional graduate degree). The overall odds of matching for male applicants was 0.71 (95% CI: 0.70-0.72), compared with female applicants who had a nonsignificantly higher odds of matching (OR 0.73 [95% CI: 0.71-0.75]). Female URM applicants specifically had 0.59 odds of matching (95% CI: 0.55-0.63), and male applicants had a nonsignificantly higher odds of matching overall (OR 0.61 [95% CI: 0.59-0.64]). URM = underrepresented minority.

at male applicants only, the overall OR of matching was 0.71 (95% CI: 0.70-0.72), compared with female applicants who had a nonsignificantly higher odds of matching (OR 0.73 [95% CI: 0.71-0.75]). The overall OR of matching for URM applicants was 0.61 (95% CI: 0.59-0.63), which is notably significantly lower than both male and female non-URM applicants. Female URM applicants specifically had 0.59 odds of matching (95% CI: 0.55-0.63), and male applicants had a nonsignificantly higher odds of matching overall (OR 0.61 [95% CI: 0.59-0.64]) (Fig. 3).

Analysis of Adjusted Match Rates Before and After 2019

Compared with 2019 and previous years, there was no significant difference seen in adjusted match rates for all applicants or any URM/sex subgroup. Among all applicants, the OR of matching after 2019 was 0.95 (95% CI: 0.82-1.10). This was similar to male non-URM applicants (OR 0.98, 95% CI: 0.82-1.18) and female non-URM applicants (OR 0.87, 95% CI: 0.59-1.3). Similarly, there was no significant difference in the OR of matching after 2019 for male URM applicants (OR 0.72, 95% CI: 0.50-1.1) or female URM applicants (OR 1.7, 95% CI: 0.81-3.68).

Discussion

In our study, we aimed to examine the association between matching into orthopaedic surgery and both URM status and sex over the past 10 years. Our results showed that overall, 70% of applicants matched into orthopaedic surgery, with 17% being women and 16% being URM. The independent OR associated with matching among all applicants has decreased over the past decade, with the OR of non-URM male and female applicants also decreasing over time. However, the OR for URM male applicants did not change significantly and OR for URM female applicants increased over time, which may suggest that recent initiatives aimed at increasing diversity in orthopaedic surgery have had the greatest impact on increasing the representation of URM female applicants in orthopaedic surgery residency programs. Despite these recent trends, when data from 2011 to 2021 was examined overall, the odds of URM male and female applicants matching overall were still significantly lower than non-URM applicants. Importantly, we studied the independent odds of matching which we believe reflect a combination of individual applicant strength and program acceptance of URM applicants. This may reflect a more accurate portrayal of applicant match characteristics compared with simply studying URM match rates, which may be changing for other reasons such as a higher number of total orthopaedics applicants or an increasing number of programs.

Several initiatives have been implemented in recent years to increase diversity in orthopaedic surgery, such as the BWOS, Ruth Jackson Society, the Perry Initiative, Nth Dimensions, and the Robert Gladden Orthopaedic Society, and increasing URM representation in orthopaedic surgery is part of the AAOS 2019 to 2023 Strategic Plan[6,14,16]. Our results suggest that altogether, the initiatives and focus on diversity in orthopaedic surgery during recent years have been impactful, although there is still significant progress to be made. Specifically, we found that the adjusted OR of male URM applicants did not change significantly over time, and although the OR of female URM applicants matching has increased significantly from 2011 to 2021, the percent of total applicants remains very low at 5% overall. Both URM male and female applicants also still have a significantly lower OR than their non-URM colleagues.

When examined over the entire study time frame, URM applicants of both sexes remain at significantly lower odds of matching into orthopaedic surgery. Although it is important to encourage positive changes taking place, it should also be recognized that we are far from achieving equal opportunity in orthopaedic surgery residency, and this has also been echoed by other authors. At the residency level, Adelani et al. examined the number of residency programs with >1 URM resident and found that from 2002 to 2016 the number of programs with >1 URM resident actually decreased from 61 to 53[18]. At the postresidency level, forward progress seems to be present but at an alarmingly slow pace. Acuña et al. performed a protectional analysis of data from the National Provider Identifier Registry and determined that it would take more than 200 years to achieve sex parity in orthopaedic surgery[21].

Given the known disruptions to the orthopaedic surgery residency match related to COVID-19[17] and founding of the BWOS (18), we also performed a subanalysis of data before/after 2019. Interestingly, we found that adjusted match rates were not significantly different before/after 2019. Notably, the OR for URM female applicants after 2019 was highest compared with all groups (OR 1.7, 95% CI: 0.81-3.68) but not statistically significant. We believe that our study may be underpowered to detect

differences after 2019 because we only have 2 years of data after this time and future studies should continue to examine these trends.

In a previous study by Poon et al. using AAMC data from 2005 to 2014, it was found that race, but not sex, was associated with matching into orthopaedic surgery and that URM applicants have lower rates of entering orthopaedic surgery likely due to an emphasis on United States Medical Licensing Examination (USMLE) scores and AOA status[8]. Our study adds to this literature by showing that the match rate for URM female applicants has increased over the past decade and adds 7 years of data to the previous work by Poon et al. Together, our results indicate that recent efforts to increase diversity in orthopaedic surgery have been successful particularly with increasing odds of URM female applicants.

It is important to note that the underrepresentation of minorities in orthopaedic surgery is not limited to the United States but is a global phenomenon. The British Orthopaedic Association found that only 7% of orthopaedic surgeons in the United Kingdom identify as women[22]. This underrepresentation is particularly concerning in light of the growing ethnic diversity of many countries, including the United States and United Kingdom. Moreover, 30% has been suggested as the percentage of minority population needed to "disrupt bias," and there is no country that has over 30% of women in orthopaedic surgery[20]. As the population of these countries becomes more diverse, we believe it is crucial that the physician workforce mirrors the population.

There are several limitations that exist in our study. The study design is a retrospective analysis of a prospectively collected database, so the study is limited to the data that are available in the database and cannot include any data that were not recorded or not available. Another limitation to consider is that the study used self-reported data from the applicants, which may be subject to misrepresentation at a rate that is not currently known. It is also important to consider that the study focuses on the URM status and sex of the applicants but does not take into account other factors that may have affected the results, such as socioeconomic status, premedical education level, family background, or academic metrics such as USMLE scores and clerkship grades, which may contribute to these disparities and should be further examined. This study also has several strengths such as using the entire orthopaedic surgery match aggregated cohort for a decade facilitates enhanced generalizability. Furthermore, the data are the most recently available data from the AAMC, amplifying the validity of our conclusions.

In conclusion, URM status and female sex are associated with an increase in the independent odds of matching into orthopaedic surgery residency over the past 10 years. From 2011 to 2021, the overall odds of URM male and female applicants was still significantly lower than non-URM applicants despite recent trends. Together, these results indicate that current efforts to increase diversity within the field may have plateaued and may not be effectively addressing the underrepresentation of these groups. Future research should focus on identifying and implementing strategies to increase diversity in orthopaedic surgery residency programs. ■

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