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AOA Critical Issues in Education

Does Resident Gender or Race/Ethnicity Affect Orthopaedic Surgery Case Volume During Residency Training?

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Introduction: Disparities in case volumes have been reported in some surgical specialties. The objective of this study was to evaluate whether gender or racial/ethnicity disparities exist during orthopaedic surgery residency surgical case log volume.

Methods: Accreditation Council for Graduate Medical Education Case Log Database for orthopaedic surgery residents for 9 years of cohorts graduating in academic years 2013-2014 to 2021-2022 were analyzed to compare case logs between men and women, as well as race/ethnicity, defined by Association of American Medical Colleges as underrepresented in medicine (URiM) and non-URiM groups.

Results: Longitudinal analyses of total required minimum type cases indicate significant gender differences among the initial graduating cohorts with women trainees reporting 33 cases fewer than men; in the most recent years of this study period, women trainees reported 5 cases fewer than men per year. URiM trainees reported 29 cases fewer at baseline, while in the most recent years, there were no significant differences. Significant differences exist for 8 of the 15 case minimum types with fewer women cases at baseline; in the most recent years, women had fewer cases in anterior cruciate ligament Reconstruction, Ankle Fracture Fixation, Closed Reduction Forearm Fracture, Total Hip Arthroplasty, and Total Knee Arthroplasty. There were significant differences for 3 of 15 case minimum types at baseline for URiM trainees with no significant differences in most recent years. Hand was the only anatomic area with women reporting significantly more cases than men, both initially and over the 9 years of study period.

Conclusion: Significant differences exist in case volume and case types during orthopaedic surgery residency based on gender for the initial cohort, albeit lessening in most recent years. Although initial differences in cases volumes based on race/ethnicity exist, no significant differences persist in most recent years of the study period.

Level of Evidence: Level III. See Instructions for Authors for a complete description of levels of evidence.

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Introduction

Orthopaedic surgery is the least diverse specialty in medicine[1]. Women make up 7.4% of practicing orthopaedic surgeons[2] and 20.4% of orthopaedic surgery residents[1]. Gender and racial/ethnic disparities exist in many aspects of medicine. These disparities can be manifested in a multitude of ways, including salary, income, and promotion[3-6]. Among orthopaedic surgeons, gender was a significant predictor of income[7], including reduced referral pattern for female surgeons[8,9].

Further evaluation of gender and racial/ethnic disparity is needed at the level of graduate medical education (GME). Reports demonstrate gender inequality in surgical GME[10-16]. Women residents[10,14,17,18] and fellows[19,20] across different surgical subspecialties have been shown to log fewer surgical procedures, as well as differences in mentorship, professional, and learning environment. In surgical fields, a resident's operative case volume is a surrogate marker for the depth and breadth of surgical educational experience[21]. In addition, exposure to cases in specific subspecialties is one factor that went into the decision regarding future fellowship training[22] and specialty choice[23].

Residents are required to submit Accreditation Council for Graduate Medical Education (ACGME) case logs throughout their training. Recent studies demonstrated gender-based discrepancies in surgical case volume for otolaryngology and ophthalmology residents[18,21]. It is not known whether gender or racial/ethnicity disparities exist during orthopaedic surgery residency training regarding surgical case volume.

The aim of this study was to quantify any disparities in case volume between male and female residents and to assess differences in case volume among residents from racial/ethnic backgrounds that are Under-Represented in Medicine (URiM) vs. non-URiM, as defined by the Association of American Medical Colleges (AAMC).

Methods

The ACGME Case Log Database for orthopaedic surgery residents graduating in academic years 2013-2014 to 2021-3022 (9 total graduating cohorts) was analyzed. Each graduating cohort includes all 5 years of residency case log data as finalized at the time of graduation. We analyzed case logs for 9 graduating cohorts during years 2013-2014 to 2021-2022. For example, the graduating cohort from 2013 to 2014 would be case logs starting from their post graduate year (PGY-1) year in 2009 until they graduate in 2014. Initial graduating cohorts refer to residents who graduated in 2013 to 2014 and serve as a baseline cohort and serve as a comparison for graduating cohorts over the next 8 years. Aggregated records of case logs reported by residents at the time of graduation were organized as (1) case totals across required orthopaedic minimum cases, (2) cases sorted into orthopaedic required minimum categories, and (3) cases sorted into anatomic areas. This study was approved as exempt by the Institutional Review Board of the University of Minnesota.

The ACGME Orthopaedic Surgery Residency Review Committee has 15 required case minimum categories, which represents core surgical procedures deemed important for every resident's training experience. Total case volumes may be highly variable based on residents' case logging behavior; to minimize this bias, analysis only examined case logs for the 15 required case minimum categories, that is, "Total required orthopaedic minimum type cases". This was calculated by taking the sum across these 15 categories, including anterior cruciate ligament (ACL) Reconstruction, Ankle Fracture Fixation, Ankle/Hind/Mid Foot Arthrodesis, Carpal Tunnel Release (CTR), Closed Reduction Forearm/Wrist Fractures, Femur/Tibia Intramedullary Fixation, Hip Fracture Fixation, Knee Arthroscopy, Oncology Procedures, Pediatric Procedures, Shoulder Arthroscopy, Spine Decompression/Fusion, Supracondylar Humerus Percutaneous Pinning, Total Hip Arthroplasty (THA), and Total Knee Arthroplasty (TKA).

Further analysis of surgical experience was evaluated separately for each of the 15 different orthopaedic minimum case types, "Orthopaedic Minimum Type Cases".

Case logs were also analyzed by anatomic site using current procedural terminology coding categories: Femur/Knee, Foot/Toes, Forearm/Wrist, Hand/Fingers, Humerus/Elbow, Integumentary System, Leg/Ankle, Pelvis/Hip, Shoulder, Spine, Nervous System, and Other Musculoskeletal.

Demographics

Programs that had no women or no URiM were excluded from the analysis of comparative experiences. Residency programs that trained both men and women during the time under review were analyzed to compare men and women within the same program or to compare URiM and non-URiM learners within the same program.

For gender designation, we used learner self-identified gender classification, obtained from the AAMC as men or women. Nonresponders or nonbinary were excluded from analysis.

For race/ethnicity classification, self-identified race/ethnicity classification obtained from the AAMC was used and supplemented with information provided by the training program. We classified learners into underrepresented in medicine (URiM) and non-URiM groups using AAMC definition, with White and Asian were grouped as non-URiM learners, and all others as URiM. Nonresponders were excluded from analysis.

Statistical Analysis

Descriptive statistics were used to examine trends. Bivariate analyses were conducted using *t*-test and chi-squared tests, with Bonferroni-adjusted p-values to account for multiple-group comparison. Multivariate regression analyses were used to account for simultaneously analyzing multiple case procedures and to control for clustering effects by graduating cohort and residency program. Random effects were specified in the growth-curve regression model to account for clustering at the residency program level and graduating cohorts. Maximum likelihood estimation was used to estimate fixed and random effects. Data compilation and analyses were conducted using Stata 18. Study procedures were completed in accordance with Strengthening the Reporting of Observational studies in Epidemiology (STROBE)[24].

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Results

Demographics

From 2013 to 2022, there were 7,001 graduating residents from 198 residency programs: 701 residents in 2013 to 2014 and 2014 to 2015; 715 in 2015 to 2016; 730 in 2016 to 2017; 775 in 2017 to 2018; 799 in 2018 to 2019; 844 in 2019 to 2020; 861 in 2020 to 2021; and 875 in 2021 to 2022 (Table I).

Nonbinary trainee data were obtained with 3 residents (0.04%) who reported to be nonbinary. Sixty-five residents (0.93%) did not identify their gender; all other residents self-identified as man or woman.

In any given year between 2013 and 2022, the percentage of graduating women orthopaedic surgery residents ranged between 12% and 18%. In any given year between 2013 and 2022, the percentage of programs with at least one graduating woman orthopaedic surgery resident ranged between 37% and 46%; that is, between 53% and 64% of programs in any given year studied had no graduating women residents.

In any given year between 2013 and 2020, 68% to 80% of graduating orthopaedic surgery residents self-identified as White, 8% to 17% Asian, 2% to 7% Hispanic/Latinx/Spanish, 2% to 4% Black/African American, 0.2% Hawaiian/Pacific Islander, 0.3% American Indian/Alaskan Native, and 1.3% Other. Graduating residents preferring not to report were 0.06%.

Total Orthopaedic Minimum Type Cases

Across the 9 graduating cohorts between 2013 to 2014 and 2021 to 2022, the mean total cases for the 15 orthopaedic surgery required minimum categories was 1,029 cases (SD = 333) as shown in Table II. A significant increase in total cases completed was recorded during the 9 academic years; on average, case totals increased by 44 cases per year (95% confidence interval (CI): 40-48), $p < 0.001$. During the 2013 to 2014 graduating cohort, the total case mean was 881 (SD = 242), which increased to 1,208 cases (SD = 271) by the 2021 to 2022 graduating cohort.

Longitudinal analyses of total volume of required minimum type cases indicate significant gender differences at baseline during the initial graduating cohorts, with women trainees reporting 33 cases fewer than did men (95% CI: 10-57), $p = 0.004$. In most recent years of the study period, women trainees also had fewer reported cases than men, with 5 fewer cases per graduating cohort per year (95% CI: 0-10), $p = 0.037$.

As shown in Table III, trainees identifying as URiM, reported 76 cases fewer than non-URiM trainees at baseline in the initial graduating year (95% CI: 2-56), $p = 0.001$. In most recent years of the study period, there were no significant differences in longitudinal trends for URiM vs. non-URiM trainees, $p = 0.950$.

TABLE I Demographic Characteristics of Graduating Orthopaedic Residents by Year of Graduation (Demographic Characteristics [Gender and Race/Ethnicity])

Graduating Cohort n = Residents	Gender Female n (%)	Race/Ethnicity* White n (%)	Asian n (%)	Black, African n (%)	Hispanic, Latino, Spanish n (%)
2013-2014 n = 701	85 (12)	484 (69)	78 (11)	29 (4)	29 (4)
2014-2015 n = 701	92 (13)	505 (72)	64 (9)	15 (2)	22 (3)
2015-2016 n = 715	101 (14)	522 (73)	65 (9)	29 (4)	22 (3)
2016-2017 n = 730	95 (13)	526 (72)	73 (10)	22 (3)	22 (3)
2017-2018 n = 775	109 (14)	566 (73)	101 (13)	31 (4)	31 (4)
2018-2019 n = 799	120 (15)	640 (80)	128 (16)	32 (4)	40 (5)
2019-2020 n = 844	127 (15)	650 (77)	152 (18)	34 (4)	60 (7)
2020-2021 n = 861	121 (14)	689 (80)	130 (15)	35 (4)	52 (6)
2021-2022 n = 875	158 (18)	700 (80)	105 (12)	44 (5)	53 (6)
Mean†	14	75	13	4	5

*More than one race/ethnicity may be chosen. †This is the overall mean (weighted by the sample size by year).

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TABLE II Total Number of Orthopaedic Minimum Type Cases for Graduating Cohorts by Gender*

	Male		Female		Overall		Male > Female	
Graduating Cohort	Mean (SD)		Mean (SD)		Mean (SD)		Mean Difference	p-value
2013-2014	884	243	860	237	881	243	24	0.398
2014-2015	958	220	871	180	947	217	87	**<0.001**
2015-2016	996	225	921	246	986	230	75	**0.002**
2016-2017	1,022	284	985	209	1,017	276	37	0.217
2017-2018	1,041	326	957	332	1,029	328	84	**0.012**
2018-2019	1,037	409	998	348	1,031	400	39	0.330
2019-2020	985	458	988	391	985	449	–4	0.935
2020-2021	1,143	349	1,047	348	1,129	350	95	**0.005**
2021-2022	1,229	278	1,111	210	1,208	271	118	**<0.001**

*p-value based on *t*-test. Bolded entries represent statistically significant values.

As shown in Table IV, in the combined multivariate analyses incorporating both gender and race/ethnicity, results remain consistent—women and URiM trainees had significantly lower cases reported at baseline (women = 33 fewer cases [95% CI: 11-57]; URiM = 29 fewer cases [95% CI: 2-56]), p = 0.034; in most recent years, women trainees reported fewer cases than men per graduating cohort (female = 5 [95% CI: 0-10]). In most recent years, there were no significant differences in URiM trainees completing cases, p = 0.908.

Case Minimum Types

Among specific case types, significant differences were present at baseline by gender with women trainees reporting fewer cases than men trainees for ACL Reconstruction ([95% CI: 1-3], p = 0.002), femur/tibia intramedullary fixation ([95% CI: 2-5], p < 0.001), hip fracture fixation ([95% CI: 2-6], p < 0.001), knee arthroscopy ([95% CI: 1-8], p = 0.017), shoulder arthroscopy ([95% CI: 0-8], p < 0.033), spine ([95% CI: 0-5], p < 0.026), THA ([95% CI: 4-10], p < 0.001), and TKA ([95% CI: 4-11], p < 0.001). There were significant decreases in most recent years with women reporting fewer cases of ACL reconstruction ([95% CI: 0-1], p = 0.029), ankle fracture fixation ([95% CI: 0-1], p = 0.012), closed reduction forearm/wrist fracture ([95% CI: 0-1], p = 0.007), THA ([95% CI: 0-1], p = 0.036), and TKA ([95% CI: 0-2], p = 0.005).

Among specific case types, there were significant differences at baseline by race/ethnicity with URiM trainees reporting fewer cases than non-URiM trainees for ACL reconstruction ([95% [CI: 1-3], p = 0.005), CTR ([95% CI: 1-4], p = 0.012), and hip fracture fixation ([95% CI: 0-5], p = 0.048). There were no significant differences in most recent years associated among URiM trainees, with resolution of the case differences seen at baseline.

TABLE III Total Number of Orthopaedic Minimum Type Cases for Graduating Cohorts by Race/Ethnicity (White/Asian vs Under-Represented in Medicine)*

	White/Asian (Non-URiM)		Underrepresented in Medicine (URiM)		Non-URiM > URiM	
Graduating Cohort	Mean	SD	Mean	SD	Mean Difference	p-value
2013-2014	898	223	822	295	76	**0.001**
2014-2015	950	206	935	258	15	0.465
2015-2016	989	233	971	216	18	0.425
2016-2017	1,023	268	993	307	30	0.253
2017-2018	1,027	328	1,036	329	−9	0.783
2018-2019	1,033	404	997	347	36	0.539
2019-2020	984	454	1,000	390	−16	0.793
2020-2021	1,134	344	1,065	426	69	0.142
2021-2022	1,215	269	1,133	284	82	**0.012**

*p-value based on *t*-test. Bolded entries represent statistically significant values.

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TABLE IV Total Number of Orthopaedic Minimum Type Cases for Graduating Cohorts by Gender and Race/Ethnicity*

Graduating Cohort	Female URiM		Female White/Asian		Male URiM		Male White/Asian		p-value
2013-2014	796	139	871	250	825	305	902	219	**0.005**
2014-2015	799	260	886	158	952	254	960	211	**0.002**
2015-2016	882	256	929	245	985	207	999	229	0.154
2016-2017	988	247	984	201	994	316	1,029	276	0.378
2017-2018	1,025	346	946	330	1,038	328	1,042	325	0.071
2018-2019	752	503	1,016	330	1,044	295	1,036	416	0.242
2019-2020	975	368	990	395	1,007	399	983	462	0.986
2020-2021	889	520	1,063	326	1,104	397	1,145	346	**0.013**
2021-2022	1,016	197	1,118	210	1,153	293	1,236	276	**<0.001**

*p-value based on analysis of variance. Bolded entries represent statistically significant values.

Anatomic Areas

Significant differences existed at baseline by gender with fewer women reporting cases for femur/knee ([95% CI: 12-27], $p < 0.000$), pelvis/hip ([95% CI: 11-21], $p < 0.001$), and shoulder ([95% CI: 2-14], $p = 0.007$). Women reported significantly more cases at baseline for nervous system ([95% CI: 0-5], $p = 0.023$). Differences in reported cases between women and men for femur/knee, continued to increase in most recent years ([95% CI: 0-3], $p = 0.040$). Differences between women and men in reported hand/finger cases, with women reporting more cases, continued to increase in most recent years ([95% CI: 0-2], $p = 0.035$).

For URiM trainees, significant differences existed at baseline, compared with non-URiM trainees for hand/fingers ([95% CI: 3-10], $p < 0.001$), forearm/wrist ([95% CI: 1-10], $p = 0.009$), integumentary system ([95% CI: 2-10], $p = 0.001$), and nervous system ([95% CI: 0-5], $p = 0.020$). There were no significant differences in most recent years associated among URiM trainees with resolution of the differences seen at baseline.

Discussion

This study was intended to examine differences in case log volumes for orthopaedic residents based on gender or race/ethnicity. Table V summarizes the findings of this study, demonstrating that at baseline (academic year 2013-2014), women and URiM orthopaedic surgery residents logged fewer surgical cases during training than did their non-URiM men peers, and these differences have lessened in most recent years of the study period. In 2013, women trainees reported 33 less cases than men but during the most recent years women trainees reported only 5 fewer cases. Although this is statistically significant, the practical significance of 5 fewer cases is arguable. Similar findings were seen when analyzing by race/ethnicity. In 2013, URiM trainees logged 29 fewer cases than non-URiM trainees, but in most recent years, no significant differences persisted. These results support improved efforts over the last 10 years of increasing gender and racial/ethnic diversity and awareness of unconscious biases within the field of orthopaedics.

While initial differences in total cases logged by URiM residents were no longer evident in the most recent cohort examined, differences remained for women in terms of cases with minimum requirements and cases in specific anatomic areas. Of the 15 case minimum categories, there was a significant difference with women trainees completing fewer cases than men trainees at baseline for 8 categories. While this improved in most recent years of the study period, there were still significant differences, with women reporting fewer cases in 5 categories: ACL reconstruction, ankle fracture fixation, closed reduction of forearm/wrist fractures, THA, and TKA.

When reviewing total cases in the 11 anatomic/specialty areas of orthopaedics, there were significant differences by gender with women at baseline reporting fewer cases in 3 areas: femur/knee, pelvis/hip, and shoulder. Women reported more cases for the nervous system and hand/fingers. While differences in cases for pelvis/hip and shoulder were no longer significant in the most recent cohort of residents evaluated, femur/knee differences by gender continue over the 9 year study period. These differences demonstrate gender differences that exist for joint arthroplasty, trauma, or sports, which includes pelvis/hip and femur/knee. This potentially can impact technical competence, as well as future subspecialty career choice. The anatomic areas of femur/knee reflect subspecialty areas in which women are less likely to pursue fellowships (e.g., arthroplasty, trauma, and sports/shoulder)[13]. Higher case volumes in hand/fingers may translate into the relatively higher number (25%) of females pursuing hand fellowships[21].

The ACGME case log system is intended, in part, to assure that residents in training have adequate operating room experience to successfully transition to safe, competent surgeons[25]. We need to assure that during residency training all residents be allowed appropriate levels of autonomy that ideally progresses with advancing years in training. In general surgery,

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TABLE V Summary of Significant Findings

	Female		URiM	
	Baseline	Over Time	Baseline	Over Time
Total cases differences	33 (p = 0.004)	5 (p = 0.04)	29 (p = 0.03)	0
Case minimums	ACL reconstruction	ACL reconstruction	ACL reconstruction	None
	Intramedullary Nail	Ankle Fracture	Carpal Tunnel release	
	Hip Fracture	Closed Reduction of forearm/wrist	Hip Fracture	
	Knee Scope	Total Hip arthroplasty		
	Shoulder Scope	Total Knee arthroplasty		
	Spine			
	Total Hip arthroplasty			
	Total Knee arthroplasty			
Anatomic areas	Femur/Knee	Femur/knee	Forearm/wrist	None
	Pelvis/Hip	Hand/finger (+)*	Hand/finger	
	Shoulder		Integumentary	
	Nervous (+)		Nervous	

*(+) indicates that females had more than males.

ratings of autonomy were lower among women compared with men surgical residents and that this difference became greater in later stages of training and for more complex cases[26] with gender identified as an independent indicator of resident autonomy in the operating room[27]. Although no gender-based differences in levels of autonomy have been noted at the start of training or among medical school applicants to orthopaedic surgery residency[28], this has not been investigated for orthopaedic surgery residency training.

For general surgery training, when residents should be becoming more confident in their skills and in related autonomy, they are actually being given less autonomy or thought to be less independent. Differences in case log volumes or in autonomy may be related to unconscious biases on the part of more senior residents or faculty. Salles found that among general surgery residents, women who had greater degrees of stereotype perception had worse psychological health[29]. Unfortunately, biases that may be present during training can extend into practice, as women orthopaedic surgeons are less likely to have patients referred to them for elective procedures than are men orthopaedic surgeons[29], despite reports of better outcomes for women surgeons[30].

Regarding racial/ethnicity differences investigated in this study, total case numbers differed between URiM and non-URiM residents at baseline and resolved in the most recent years. Differences were noted at baseline in core procedures, with URiM trainees reporting fewer cases than non-URiM trainees for 3/15 categories: ACL reconstruction, CTR, and hip fracture fixation. However, there were no significant differences among the URiM trainees in most recent years which differs from what was seen with women trainees. There were also significant differences at baseline for 4/11 anatomic areas: hand/fingers, forearm/wrist, integumentary system, and nervous system. However, unlike the differences based on gender, there were no significant differences in most recent years among the URiM trainees. The resolution over the 9 year study period of differences in numbers of cases logged based on resident race/ethnicity is heartening and may reflect increasing awareness of unconscious biases and microaggressions faced by URiM residents. In a survey study of Black orthopaedic surgeons and trainees, Ode found that only 22% had experienced little or no workplace discrimination during training and that half had received at least one devaluing statement during their training[31]. Black women especially noted receiving devaluing or exclusionary feedback during training[31,32].

The primary limitation in this study is that the data rely on resident reporting of cases and relies on the integrity of the databases used. Also, this study looked at cases across all orthopaedic programs, rather than individual programs, as these differences of case volume in women and URiM trainees may differ when comparing specific residency programs. Future research may assess if there is a difference in case log experience with women and URiM trainees on a program level, as well as level of autonomy during orthopaedic surgery training. Future studies should also assess the impact of interventions at the training program and specialty level, especially how more equal distribution of case volume impacts fellowship applications across subspecialties.

Conclusion

Orthopaedic surgery has made progress over the last 10 years, assuring more equitable operative experiences during orthopaedic surgery training. However, discrepancies still exist in specific case minimum and anatomic categories for women and URiM trainees. We need to better understand the drivers of the gender disparities that exist in orthopaedic surgery residency

training in the United States. Residency program directors and faculty need to assure that all residents have access to and are encouraged to participate in all orthopaedic cases, not only to assure their technical competence and confidence, but also to allow them exposure to the wide range of subspecialties within orthopaedic surgery that may ultimately impact their career choices. ■

NOTE: Gender, Race and ethnicity data were provided by the Association of American Medical Colleges (AAMC). The views expressed herein are those of the authors and do not necessarily reflect the position or policy of the AAMC.

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