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How Long Will It Take to Reach Gender Parity in Orthopaedic Surgery in the United States? An Analysis of the National Provider Identifier Registry

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Abstract

Background Although previous studies have evaluated how the proportion of women in orthopaedic surgery has changed over time, these analyses have been limited by small sample sizes, have primarily used data on residents, and have not included information on growth across subspecialties and geographic regions.

Question/purpose We used the National Provider Identifier registry to ask: How have the (1) overall, (2) regional, and (3) subspecialty percentages of women among all currently practicing orthopaedic providers changed over time in the United States?

Methods The National Provider Identifier Registry of the Centers for Medicare and Medicaid Services (CMS) was

One of the authors certifies that she (AFC) has received or may receive payments or benefits, during the study period, in an amount of less than USD 10,000 from Slack Inc; in an amount of less than USD 10,000 from Joint Purification Systems; in an amount of less than USD 10,000 from ACI; in an amount of less than USD 10,000 from DePuy; in an amount of less than USD 10,000 from Sonoran Biosciences; in an amount of less than USD 10,000 from Graftworx; in an amount of less than USD 10,000 from Pfizer; in an amount of less than USD 10,000 from Avanos; in an amount of less than USD 10,000 from Irrimax; in an amount of less than USD 10,000 from Convatec; in an amount of less than USD 10,000 from 3M; in an amount of less than USD 10,000 from Recro; in an amount of less than USD 10,000 from Heraeus; in an amount of USD 10,000 to USD 100,000 from Stryker; and in an amount of USD 10,000 to USD 100,000 from bOne.
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queried for all active providers with taxonomy codes pertaining to orthopaedic subspecialties as of April 2020. Women orthopaedic surgeons were identified among all physicians with subspecialty taxonomy codes. As all providers are required to provide a gender when applying for an NPI, all providers with queried taxonomy codes additionally had gender classification. Our final cohort consisted of 31,296 practicing orthopaedic surgeons, of whom 8% (2363 of 31,296) were women. A total of 11,714 (37%) surgeons possessed taxonomy codes corresponding with a specific orthopaedic subspecialty. A univariate linear regression analysis was used to analyze trends in the annual proportions of women who are active orthopaedic surgeons based on NPI enumeration dates. Specifically, annual proportions were defined using cross-sections of the NPI registry on December 31 of each year. Linear regression was similarly used to evaluate changes in the annual proportion of women orthopaedic surgeons across United States Census regions and divisions, as well as orthopaedic subspecialties. The national growth rate was then projected forward to determine the year at which the representation of women orthopaedic surgeons would achieve parity with the proportion of all women physicians (36.3% or 340,018 of 936,254, as determined by the 2019 American Medical Association Physician Masterfile) and the proportion of all women in the United States (50.8% or 166,650,550 of 328,239,523 as determined by 2019 American Community Survey from the United States Census Bureau). Gender parity projections along with corresponding 95% confidence intervals were calculated using the Holt-Winters forecasting algorithm. The proportions of women physicians and women in the United States were assumed to remain fixed at 2019 values of 36.3% and 50.8%, respectively.

Results There was a national increase in the proportion of women orthopaedic surgeons between 2010 and 2019 ($r^2 = 0.98$; $p < 0.001$) at a compound annual growth rate of 2%. Specifically, the national proportion of orthopaedic surgeons who were women increased from 6% (1670 of 26,186) to 8% (2350 of 30,647). Assuming constant growth at this rate following 2019, the time to achieve gender parity with the overall medical profession (that is, to achieve 36.3% women in orthopaedic surgery) is projected to be 217 years, or by the year 2236. Likewise, the time to achieve gender parity with the overall US population (which is 50.8% women) is projected to be 326 years, or by the year 2354. During our study period, there were increases in the proportion of women orthopaedic surgeons across US Census regions. The lowest growth was in the West (17%) and the South (19%). Similar growth was demonstrated across census divisions. In each orthopaedic subspecialty, we found increases in the proportion of women surgeons throughout the study period. Adult reconstruction (0%) and spine surgery (1%) had the lowest growth.

Conclusion We calculate that at the current rate of change, it will take more than 200 years for orthopaedic surgery to achieve gender parity with the overall medical profession. Although some regions and subspecialties have grown at comparably higher rates, collectively, there has been minimal growth across all domains.

Clinical Relevance Given this meager growth, we believe that substantive changes must be made across all levels of orthopaedic education and leadership to steepen the current curve. These include mandating that all medical school curricula include dedicated exposure to orthopaedic surgery to increase the number of women coming through the orthopaedic pipeline. Additionally, we believe the Accreditation Council for Graduate Medical Education and individual programs should require specific benchmarks for the proportion of orthopaedic faculty and fellowship program directors, as well as for the proportion of incoming trainees, who are women. Furthermore, we believe there should be a national effort led by American Academy of Orthopaedic Surgeons and orthopaedic subspecialty societies to foster the academic development of women in orthopaedic surgery while recruiting more women into leadership positions. Future analyses should evaluate the efficacy of diversity efforts among other surgical specialties that have achieved or made greater strides toward gender parity, as well as how these programs can be implemented into orthopaedic surgery.

Introduction

Although gender disparities continue to be seen across surgical subspecialties [31, 48], the largest of these imbalances are experienced by women in orthopaedic surgery [9, 37, 48]. Studies have shown that these disparities occur across various domains, with marked differences found between men and women orthopaedic surgeons in terms of salaries [14], industry payments [41], authorship [19, 30], and leadership positions [49]. Although reducing this gender gap and encouraging diversity is important in terms of fairness to women, it is also important because studies have found that a more diverse, gender-balanced workforce may improve clinical care [1, 46]. Specifically, gender parity has been demonstrated to increase patient satisfaction [26] and patient-centered communication [42], while additionally enhancing the collective intelligence and performance of care teams [55]. Despite these potential benefits, gender imbalances continue to pose a major challenge to current surgeons who are women while additionally limiting the recruitment of women to the orthopaedic workforce. Even though there are many causes for this imbalance, the disproportionately low number of women who are currently practicing orthopaedic surgeons is a large contributing factor behind these ongoing disparities [48].

Although numerous studies have attempted to evaluate and propose solutions to the large gender disparities in orthopaedic surgery [18, 22, 31, 32, 43, 52], one projection found it will take the field of orthopaedic surgery approximately 117 years to reach women trainee representation that is comparable to representation in the overall trainee population in the United States [15]. However, this projection was based solely on data pertaining to the numbers and proportions of women in training programs, and it failed to evaluate growth rates for women orthopaedic surgeons across geographic regions and orthopaedic subspecialties. Additionally, these authors did not evaluate how long it would take for each surgical specialty to achieve gender parity based on the proportional representation of women across all of medicine. Furthermore, previous analyses evaluating growth in the proportion of women orthopaedic surgeons have been limited by small sample sizes and response rates [2, 8, 22, 31, 36]. Thus, more detailed information that captures the growth of the entire orthopaedic workforce across multiple domains is needed to highlight specific targets for future growth and help close the gender gap in orthopaedic surgery at rates more comparable to those observed in other surgical fields [15, 22, 47].

Therefore, to facilitate continued and equally distributed growth for women in orthopaedic surgery, we used the National Provider Identifier (NPI) registry to ask: How have the (1) overall, (2) regional, and (3) subspecialty percentages of women among all currently practicing orthopaedic providers changed over time in the United States?

Materials and Methods

Data Source

The National Plan and Provider Enumeration System (NPPES) of the Centers for Medicare and Medicaid contains a registry of all actively practicing healthcare providers organized by NPI numbers that are updated daily. The NPI is unique 10-digit identification number for all healthcare providers who are considered Health Insurance Portability and Accountability Act–covered entities, including all providers using electronic transmission of health information [25]. When applying for an NPI, healthcare providers are required to self-report identification information such as gender (man/woman) as well as clinical specialty and subspecialty as indicated by a list of discrete provider taxonomy codes [17]. Most providers apply for their NPI during residency or fellowship training; the NPPES requires providers to update any information, such as practice location and subspecialty, within 30 days of any changes [21].

Data Collection

We retrospectively evaluated the publicly available NPPES NPI registry by querying for all active providers with taxonomy codes pertaining to orthopaedic subspecialties as of April 2020. We identified surgeons whose most recently provided taxonomy codes pertained to one of the following orthopaedic subspecialties: 207XS0106X (hand surgery), 207XX0801Z (orthopaedic trauma), 207XS0117X (spine surgery), 207XX0005X (sports medicine), 207XS0114X (adult reconstruction), 207XX0004X (foot and ankle), and 207XP3100X (pediatric orthopaedics) [33]. The NPI records of surgeons with code 207X00000X (orthopaedic surgery) who did not have a subspecialty code were manually reviewed by two authors (AJA, LTS) to determine whether other provided taxonomy codes would be deemed appropriate for our analysis. For example, surgeons with taxonomy code 2086S0127X (trauma surgery) or 2086S0105X (surgery of the hand) were allocated to the orthopaedic trauma and hand surgery cohorts, respectively. Profiles with taxonomy codes related to other healthcare professions (including athletic trainers, physician assistants, nurse practitioners, and dieticians) were excluded. Similarly, we excluded trainees who had the subspecialty code 390200000X (trainee in an organized healthcare education or training program) as their most recently provided taxonomy code. Self-reported gender was also collected and summarized across each orthopaedic subspecialty, as well as across all orthopaedic surgeons. As all providers are required to provide a gender when applying for an NPI, all providers with queried taxonomy codes additionally had gender classification [21]. Regional analyses of the most recently reported practice location of women orthopaedic surgeons were calculated based on US Census regions (Northeast, Midwest, South, and West) and corresponding census divisions (New England, Middle Atlantic, East North Central, West North Central, South Atlantic, East South Central, West South Central, Mountain, and Pacific) [50].

Most Recent Data

As of April 2020, there were 31,296 practicing orthopaedic surgeons. Among this study cohort, 8% (2363 surgeons) were women. The West had the highest proportion of women orthopaedic surgeons throughout the study period (9% [603 of 7020] in 2019) (Table 1). Conversely, the South had the lowest proportion of women throughout the study period (6% [646 of 10,126] in 2019) (Table 1). The West and Northeast had proportions that were consistently above the national proportions of women in the workforce, while the Midwest and South had proportions that were consistently below national proportions (7% [527 of 7252] and 6% [646 of 10,126], respectively, in 2019) (Table 1). Overall, 37% (11,714 of 31,296) of surgeons possessed

Table 1. Growth in the proportion of women orthopaedic surgeons between 2010 and 2019 by US census region

Parameter	Year	Midwest	Northeast	South	West	National
Proportion of women who are orthopaedic surgeons	2010	6% (339 of 5919)	7% (374 of 5273)	5% (472 of 8831)	7% (453 of 6163)	6% (1670 of 26,186)
	2019	7% (527 of 7252)	8% (531 of 6249)	6% (646 of 10,126)	9% (603 of 7020)	8% (2350 of 30,647)
Change (2010 to 2019)		27%	20%	19%	17%	20%
Compound annual growth rate (2010 to 2019)		3%	2%	2%	2%	2%
r^2		0.98	0.98	0.97	0.94	0.98
p value		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001

taxonomy codes corresponding with a specific orthopaedic subspecialty. The largest percentage of women with subspecialty taxonomy codes were found to be in pediatric orthopaedics (26% [207 of 795] in 2019) and foot and ankle surgery (14% [118 of 840] in 2019) (Table 3). Adult reconstruction (3% [46 of 1437] in 2019) and spine surgery (3% [57 of 2078] in 2019) had the lowest proportion of women during the study period.

Ethical Approval

This study was considered exempt from institutional review board approval because of the use of publicly available, deidentified physician workforce data.

Statistical Analysis

We used a univariate linear regression analysis to analyze trends in the annual proportions of women who are active orthopaedic surgeons based on NPI enumeration dates. Specifically, annual proportions were defined using cross-sections of the NPI registry on December 31 of each year. The statistical analysis was chosen based on the expectation of linear trends in increased gender diversity. This expectation is based on previous reports of linear workforce expansion and the assumption that efforts to raise awareness for and address the lack of gender diversity within the field will continue [22, 43, 44]. Because the NPI registry was created in 2007, we chose 2010 to 2019 as our study period to limit fluctuations in the number of providers added to the registry during its initial years. Trends in the proportion of the workforce who are women were analyzed both nationally and at the level of United States Census regions. We calculated Compound Annual Growth Rates (CAGR) between 2010 and 2019 nationally, as well for each census region, census division, and orthopaedic subspecialty. The CAGR is a metric often used in economic analyses to track the growth of investments and assumes that any generated returns are reinvested at the end of each calendar year. CAGR figures have also been used by the US Bureau of Labor Statistics to derive workforce projections across a variety of industries. In this case, CAGR figures were considered appropriate due to reports that increased representation of women orthopaedic surgeons has had a compounding impact on the training of new women orthopaedic surgeons. The national growth rate was then projected forward to determine the year at which the representation of women orthopaedic surgeons would achieve parity with the proportion of all women physicians (36.3% [340,018 of 936,254], as determined by the 2019 American Medical Association Physician Masterfile) and the proportion of all women in the United States (50.8% [166,650,550 of 328,239,523], as determined by 2019 American Community Survey from the US Census Bureau) [10, 51]. Gender parity projections along with corresponding 95% confidence intervals were calculated using the Holt-Winters forecasting algorithm. The proportion of women physicians and women in the United States was assumed to remain fixed at 2019 values of 36.3% and 50.8%, respectively. All statistical analyses were conducted using RStudio version 3.6.2 (RStudio Inc), with a significance threshold set at a p value < 0.05.

Results

Change Over Time in Overall Percentage of Women in Orthopaedic Surgery

There was a national increase in the proportion of women orthopaedic surgeons between 2010 and 2019 ($r^2 = 0.98$; $p < 0.001$) at a compound annual growth rate of 2% (Table 1). Specifically, the national proportion of orthopaedic surgeons who were women increased from 6% (1670 of 26,186) to 8% (2350 of 30,647) (Fig. 1). Assuming constant growth at this rate after 2019, the time to achieve gender parity with the overall medical profession is projected to be 217 years, or by the year 2236 (36% [95% CI 18% to 55%]). Likewise, the time to achieve gender parity with the overall US population is projected to be 326 years, or by the year 2354 (51% [95% CI 18% to 84%]) (Fig. 2).

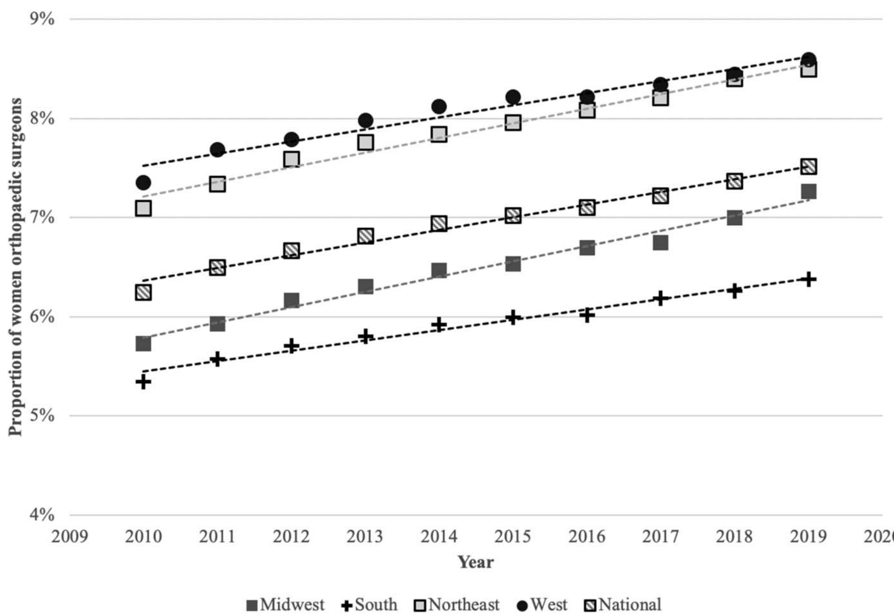

Fig. 1 This graph shows the proportions of women who are orthopaedic surgeons nationally and by census region.

Changes Over Time by Region

Between 2010 and 2019, there were increases in the proportion of women orthopaedic surgeons in the Midwest ($r^2 = 0.98$; $p < 0.001$), South ($r^2 = 0.97$; $p < 0.001$), Northeast ($r^2 = 0.98$; $p < 0.001$), and West ($r^2 = 0.94$; $p < 0.001$). The greatest growth in the proportion of the orthopaedic workforce who are women was in the Midwest (27%) and Northeast (20%). Conversely, the lowest growth was in the West (17%) and the South (19%) (Table 1). Similar increases were demonstrated for all census divisions during this study period (Table 2).

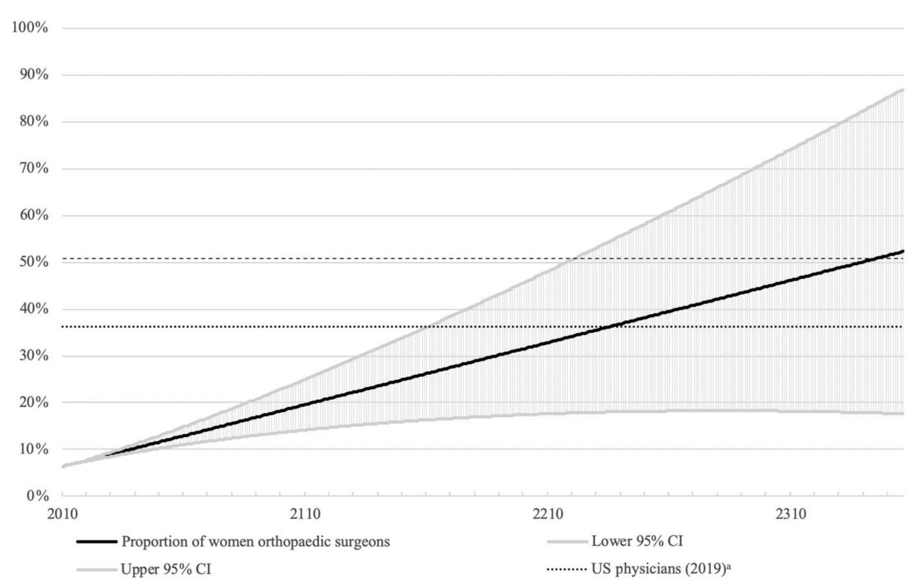

Fig. 2 Projection for how long it will take before orthopaedic surgery achieves gender parity. [a]36.3% or 340,018 of 936,254, as determined by the 2019 American Medical Association Physician Masterfile. [b]50.8% or 166,650,550 of 328,239,523 as determined by 2019 American Community Survey from the United States Census Bureau.

Table 2. Growth in the proportion of orthopaedic surgeons who are women between 2010 and 2019 by US Census division

Parameter	Year	East North Central	East South Central	Middle Atlantic	Mountain	New England	Pacific	South Atlantic	West North Central	West South Central	National
Proportion of women orthopaedic surgeons	2010	5% (208 of 3978)	4% (56 of 1399)	7% (235 of 3584)	6% (135 of 2132)	8% (139 of 1689)	8% (318 of 4031)	6% (296 of 5158)	7% (131 of 1941)	5% (142 of 2666)	6% (1670 of 26,186)
	2019	7% (317 of 4803)	5% (82 of 1626)	8% (336 of 4211)	8% (189 of 2426)	10% (195 of 2038)	9% (414 of 4594)	7% (404 of 5882)	9% (210 of 2449)	6% (190 of 3057)	8% (2350 of 30,647)
Change (2010 to 2019)		26%	26%	22%	23%	16%	14%	20%	27%	17%	20%
Compound annual growth rate (2010 to 2019)		3%	3%	2%	2%	2%	2%	2%	3%	2%	2%
r^2		0.94	0.98	0.98	0.96	0.94	0.90	0.94	0.98	0.99	0.98
p value		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001

Changes Over Time by Subspecialty

In each orthopaedic subspecialty, the linear regression analysis revealed increases in the proportion of women surgeons throughout the study period (Fig. 3). The subspecialties of foot and ankle surgery (2%) and pediatric orthopaedics (2%) experienced the highest growth. Conversely, adult reconstruction (0%) and spine surgery (1%) had the lowest growth (Table 3).

Discussion

Although previous studies have evaluated how the proportion of women in orthopaedic surgery has changed over time, these analyses have been limited by small sample sizes, have primarily evaluated changes in the proportion of woman trainees, and have failed to include information on growth across subspecialties and geographic regions [2, 8, 15, 22, 31, 36]. Therefore, analyses using data on the entire orthopaedic workforce remain essential to comprehensively understand how this growth has changed over time as well as to more accurately determine how long it will take to achieve gender parity at the current rate. At a 2% annual growth rate, we calculate that it will take 217 years for orthopaedic surgery to achieve gender parity with the overall medical profession. Similarly, although some regions and subspecialties have grown at higher rates, collectively, there has been little growth across all domains. Given this meager growth, substantive changes must be made across all levels of orthopaedic education and leadership to steepen the current curve. Our findings support the need for changes in medical schools, orthopaedic residency programs, as well as at the level of professional specialty and subspecialty societies.

Limitations

Our analysis must be considered in light of its limitations. We were unable to verify the accuracy of each provider profile available in the NPI registry. However, because providers provide their own information, it is unlikely that a substantial amount of inaccurate data was included in our analysis. Additionally, given the requirement by the NPPES to update any changes in provided information within 30 days of changes, our data were most likely current. Similarly, not every provider with an NPI number provided a subspecialty taxonomy code, which limited our dataset by approximately one-third for the subspecialty analysis. However, our analysis of 1051 women surgeons with these codes remains the largest study of the distribution of women across subspecialties of which we are aware. The NPI variables for gender are only "male" and "female" according to the NPPES user files, and therefore we were

Table 3. Growth in the proportion of orthopaedic surgeons who are women between 2010 and 2019 by subspecialty

Parameters	Year	Adult reconstruction	Sports medicine	Spine surgery	Pediatric orthopaedics	Orthopaedic trauma	Hand surgery	Foot and ankle
Proportion of women orthopaedic surgeons	2010	3% (35 of 1236)	5% (138 of 2837)	2% (39 of 1855)	24% (158 of 657)	8% (54 of 682)	12% (278 of 2286)	12% (84 of 710)
	2019	3% (46 of 1437)	6% (206 of 3184)	3% (57 of 2078)	26% (207 of 795)	10% (81 of 836)	13% (331 of 2534)	14% (118 of 840)
Change (2010 to 2019)		0%	2%	1%	2%	2%	1%	2%
Compound annual growth rate (2010 to 2019)		0.04%	0.2%	0.1%	0.2%	0.2%	0.1%	0.2%
r^2		0.41	0.97	0.83	0.83	0.87	0.62	0.82
p value		0.03	< 0.001	< 0.001	< 0.001	< 0.001	0.004	< 0.001

unable to collect information regarding which providers may self-identify as nonbinary. We additionally were unable to evaluate how our findings related to overall changes in the proportion of women physicians across medical and surgical specialties. However, the primary focus of our analysis was to highlight orthopaedic surgery, and therefore we believe this was not necessary. The decision to forgo multivariable analyses in favor of univariate linear regressions was based on the limited availability of covariates, which could be logically correlated with the outcome of interest. Our analysis was therefore unable to adjust for potential confounding variables, including but not limited to regional differences in the gender pay gap, parental leave policies, and opportunities for professional advancement. This limitation may be evidenced by the markedly low r^2 values seen in the subspecialty analyses, most notably for the field of adult reconstruction. In addition, the subspecialty codes we evaluated were limited in that they were unable to delineate between orthopaedic subspecialties such as shoulder and elbow. Despite this limitation, findings related to marked disparities in the percentages of women, especially in adult reconstruction and spine, continue to demonstrate the importance of ensuring gender parity across subspecialties. Additionally, we acknowledge that we were unable to determine a causative link between our findings and the various factors we propose to contribute to limited growth among regions and subspecialties; however, in most regards—including the low proportions of women we observed and the slow rate of change of these proportions over time—the findings seem to speak for themselves.

Change Over Time in Overall Percentage of Women in Orthopaedic Surgery

Although Bennett et al. [15] previously projected that orthopaedic surgery would achieve gender parity by 2150, our analysis demonstrated that our field will not reach this goal until 2236 at the current growth rate. Given that our study accounts for the proportional growth of practicing women orthopaedic surgeons nationally rather than the proportion of women among incoming residency classes, we believe that our projection is more robust and thus can be considered more accurate. Although our projection demonstrates that we are even further from achieving parity than previously expected, previous analyses have found that other surgical fields dominated by men, such as neurologic surgery and thoracic surgery, are making strides toward gender parity at much faster rates [15, 22, 47]. Therefore, to help bend the current growth curve up and achieve parity sooner, we believe specific changes should be made at early levels of training to attract more women to orthopaedic surgery [48]. Although improved coverage of musculoskeletal anatomy and pathology in preclinical curricula has been associated with increased interest in

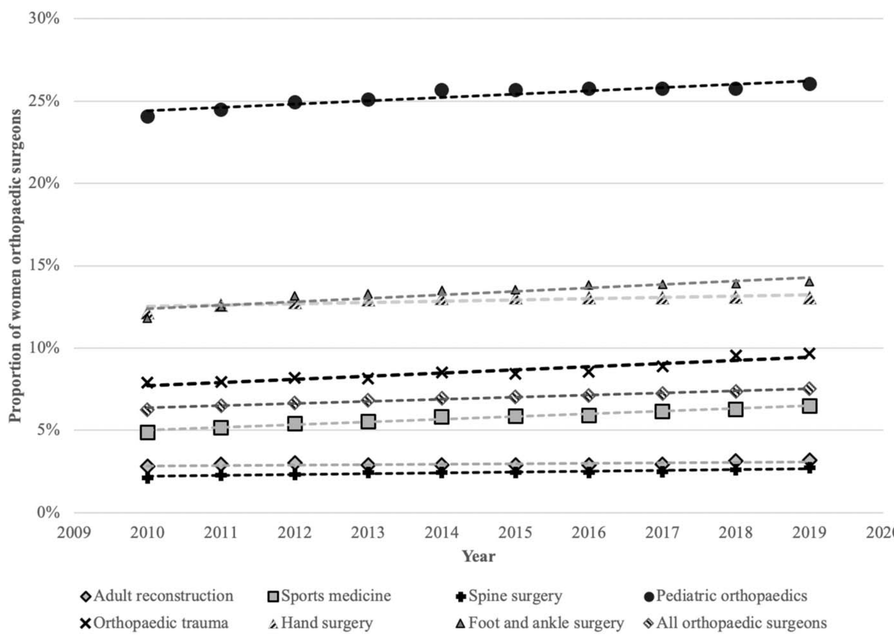

Fig. 3 This graph shows the proportion of women providers among orthopaedic subspecialties.

orthopaedics among medical students who are women [13, 16], one study demonstrated that medical students who are men develop an interest in orthopaedic surgery before their clerkships while women students are more likely to be influenced after clinical rotations [34]. Therefore, we propose that medical school curricula should include a dedicated orthopaedic surgery rotation to help foster interest among women students earlier and to help curb concerns related to lifestyle and the view that the culture is dominated by men [13, 28, 48]. This suggestion is supported by a recent study [38] that demonstrated substantial changes in women medical students' perceptions of orthopaedic surgery after an orthopaedic clinical rotation. Specifically, the authors found that women believed the field of orthopaedic surgery was friendlier, more diverse, and less sexist after this rotation [38]. In light of this, some amount of required exposure to orthopaedic surgery during clinical rotations in medical schools should serve as a first step toward achieving gender equality more rapidly.

Changes Over Time by Region

Although we found that the Midwest (27%; 339 of 5919 in 2010 to 527 of 7252 in 2019) and Northeast (20%; 374 of 5273 in 2010 to 531 of 6249 in 2019) had the greatest change in the percentage of women orthopaedic surgeons during our study period, our analysis demonstrated less growth in the South (19%; 472 of 8831 in 2010 to 646 of 10,126 in 2019) and West (17%; 453 of 6163 in 2010 to 603 of 7020 in 2019). Additionally, we identified various census divisions that have had lower growth rates over this time period. We believe the largest contributing factor to these geographic differences relates to the number of women applying to residency programs in these regions [11]. Previous analyses have reported low numbers of women residents in the South and West regions [39, 53, 54], with one study reporting a lower number of women applicants to orthopaedic surgery in the South than in other geographic regions [39]. Similarly, because mentorship opportunities and gender diversity among orthopaedic faculty have been shown to influence where women apply to orthopaedic surgery residency [28, 35, 40], regional differences in orthopaedic faculty who are women likely contribute to the variation in growth proportions demonstrated in our analysis. Notably, a recent study [29] demonstrated lower proportions of women who are academic orthopaedic faculty members across geographic regions, with the lowest proportion in the South Atlantic division (8%). Given our findings that the South and West had the least growth during our study period, we propose the following solutions for the proportion in these regions to grow more quickly. We believe that programs in these regions should aim to exceed the national average percentage of women in their incoming residency classes. According to the most recent data from the Association of American Medical Colleges, this goal should be set at approximately 15% [12, 54]. Similarly, based on the national average (11.9%) and average across census divisions (13.9%) [29], programs in these regions should aim for at least 15% of their orthopaedic faculty to be composed of women orthopaedic surgeons. Even though these benchmarks may not be achievable given the low proportion of women currently in the field, they should serve as future goals as the national proportion continues to grow. Our findings should also encourage various organizations, such as the American Academy of Orthopaedic Surgeons (AAOS), Accreditation Council for Graduate Medical Education (ACGME), and the American College of Surgeons (ACS) to prioritize resources allocated for diversity and inclusion initiatives to help these regions achieve equity more quickly [3, 5, 6]. Specifically, we believe that the ACGME should adjust their Common Program Requirements for orthopaedic surgery residencies based on the above recommendations [4]. Similarly, we think the AAOS should fund research aimed at recruiting more women to these highlighted regions while additionally mandating that residents and faculty belong to organizations, such as the Ruth Jackson Orthopaedic Society, that have consistently increased rates of women going into orthopaedic surgery [25, 53].

Changes Over Time by Subspecialty

Regarding the distribution of women in orthopaedic subspecialties, we found that the subspecialties of spine and adult reconstruction experienced the smallest amount of growth during our study period. Although our findings are supported by the low proportions of women fellowship applicants in these fields [20], this lack of growth can likely be attributed to the limited number of women orthopaedic surgeons who are fellowship directors or academic faculty in these subspecialties. In their analysis, Hoof et al. [29] found that the lowest national proportions of academic orthopaedic faculty were in spine (4.3%) and adult reconstruction (3.4%). Recent analyses have also reported that 100% of adult reconstruction fellowship program directors are men, with high rates reported for spine fellowships [27, 45]. Additionally, limited representation of women in the membership and leadership of related subspecialty societies has likely further limited the gender diversity in these fields. In a study of 23 subspecialty societies analyzed, the authors [44] found that there were no women on the board of directors of the Hip Society, Knee Society, the American Academy of Hip and Knee Surgeons, and the Scoliosis Research Society. These societies additionally had the lowest percentage of women as members [44]. Collectively, the unequal representation of women orthopaedic surgeons across these various leadership positions limits the exposure and mentorship opportunities for incoming residents and medical students. Therefore, to ensure parity across subspecialties at an accelerated rate, we believe specific changes are needed at the fellowship and subspecialty level. Specifically, because the average percentage of orthopaedic faculty who are women across subspecialties is 10.5% [29], programs should aim to have 10% to 15% of their facility in each specialty be women. Additionally, we feel the national proportion of program directors who are women, as well as the proportion of women who hold leadership positions among orthopaedic subspecialty societies, should align with the national proportion of women in that subspecialty. Based on our findings, this goal should be 2% to 4% for spine and adult reconstruction fellowship programs. Furthermore, to further emphasize the academic and professional development of women orthopaedic surgeons [23, 43], it seems important to us that more women should be included on the organizing committees of orthopaedic conferences as their increased involvement has been associated with a greater proportion of women speakers at these academic meetings [7].

Conclusion

We found that at the current rate of change, it will take more than 200 years for gender parity to be achieved in the field of orthopaedic surgery. Because the change was observed to be slow across all geographic regions and subspecialties, we believe changes are needed at all levels of orthopaedic training, as well as at the level of professional societies. We suggest that medical school curricula require dedicated exposure to orthopaedic surgery to bolster the number of women coming through the orthopaedic pipeline. Additionally, we believe that the ACGME and individual programs should set specific benchmarks for the proportion of orthopaedic faculty, fellowship program directors, and incoming trainees who are women. Furthermore, we would like to see a national effort led by the AAOS and orthopaedic subspecialty societies to foster the academic development of women in orthopaedic surgery while recruiting more women into leadership positions. Future analyses should evaluate the efficacy of diversity efforts that have been used by other surgical specialties that have achieved (or made greater strides toward) gender parity and how these programs can be implemented into orthopaedic surgery.

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